

Keep the Thumb in Mind

The Influence of Psychosocial Factors
on the Outcomes of Treatment for
Thumb Base Osteoarthritis



M.J.W. van der Oest

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Thumb Base Osteoarthritis

Houd de duim in gedachte

De invloed van psychosociale factoren op de uitkomst van de
behandeling van duimbasisartrose

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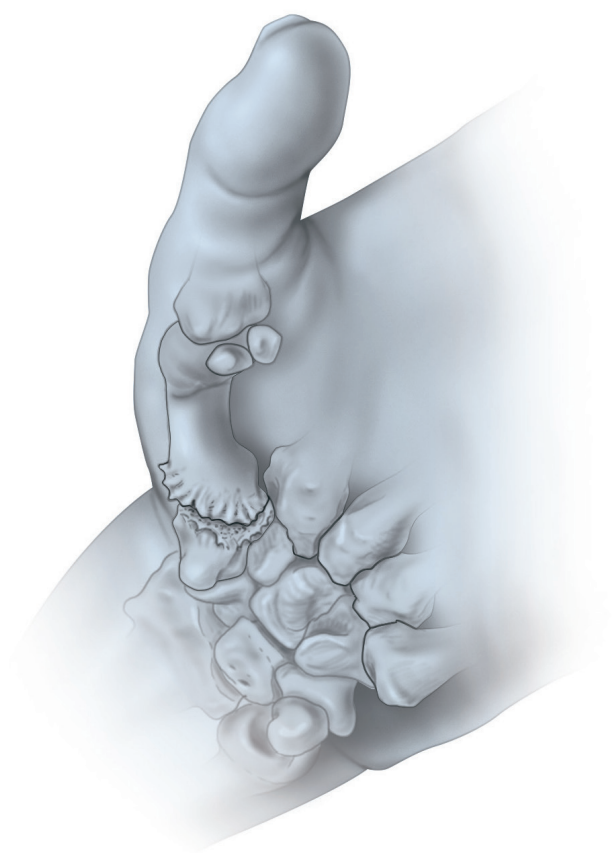
Drs. J. Legen

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CHAPTER 1

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Patients with thumb base osteoarthritis (OA) generally experience the same combination of symptoms, however the severity of these symptoms varies. While some patients only experience mild pain and have no functional impairment, others have severe pain and are unable to use their thumb. The discrepancy between patients could be due to disease characteristics (e.g. OA grade), but also due to the patients' mindset. The biopsychosocial model (figure 1) explains how biological, psychological and social factors contribute to symptoms¹.

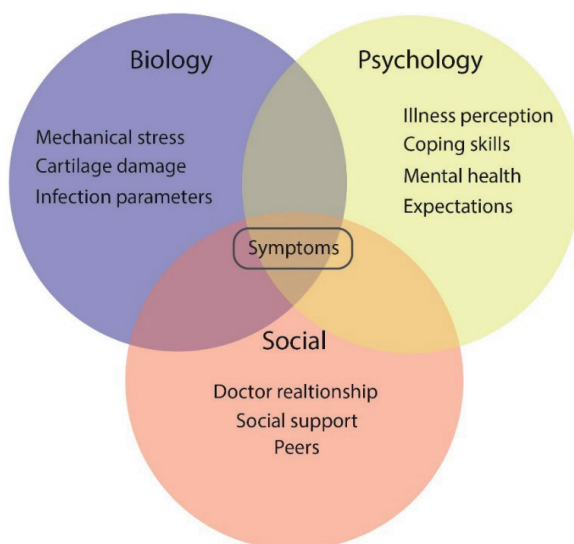


Figure 1. The biopsychosocial model for patients with thumb base OA.

This thesis will explore to what extent the biopsychosocial model is present in hand surgery patients. To study a homogeneous population we studied patients with thumb base OA, during both surgical and nonsurgical treatment.

THE BIOPSYCHOSOCIAL MODEL

The biopsychosocial model proposes how the patient's mindset might explain the outcome of treatment, in addition to biological factors. In 1977, George Engel proposed the biopsychosocial model. He stated that no two patients with

the same disease are the same and that biomedical processes cannot explain all differences between patients¹. For example, a patient is diagnosed with diabetes based on high glucose levels because of a distorted function of the pancreas. How much symptoms the patient experiences is partly due to biological differences (i.e., pancreas function). Engel proposed that on top of these biomedical processes, psychological (i.e., patient mindset) and cultural factors also affect how much symptoms a patient experiences. Since 1977 numerous authors have stressed the importance of the biopsychosocial model in healthcare and the improvement in outcomes^{2, 3}. More specifically, Ayers et al², proposed that the patient mindset could influence the outcomes of hand conditions.

We consider the patient mindset to consist of (at least) outcome expectations, illness perceptions, pain catastrophizing, and psychological distress. Why we selected these specific parts of the patient mindset and how we hypothesis these constructs will influence outcomes will be discussed below.

OUTCOME EXPECTATIONS

Expectations regarding treatment outcomes are often hypothesized to be a good proxy for the potential placebo effect of treatments and could therefore explain differences in outcomes. Most doctors think that placebo effects are a bad thing and should be avoided. However, some have proposed that doctors could harness those effects and use it enhance treatment outcomes⁴.

The placebo effect (or context effect) is the difference between the specific treatment effect and the total treatment effect (see figure 2). However, this effect is not only present in intervention studies. All routine treatments have a (hidden) context effect. Zou et al.⁵ showed that overall 75% of the treatment effect for osteoarthritis is due to the context effect. Furthermore, they showed that more invasive treatments of the same substance have a higher (placebo) effect. Surgery is a very invasive treatment, thus patients will most likely have higher expectations. Measuring outcome expectations and examining their relationship to outcomes might provide insight in this hidden placebo effect.

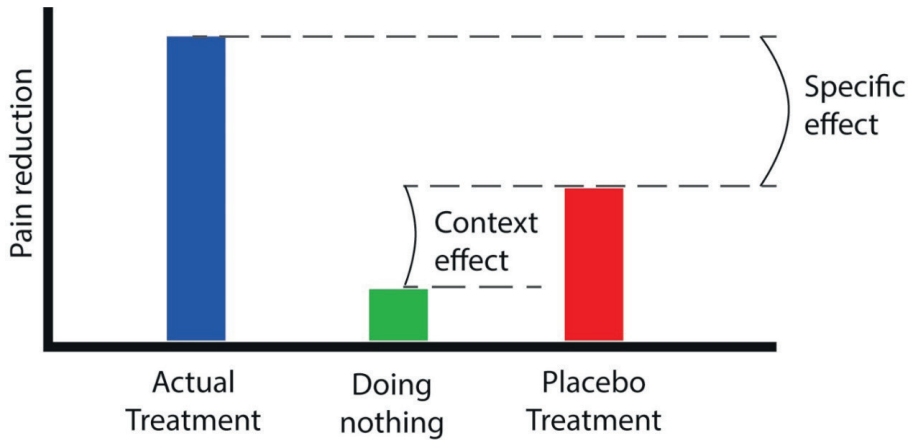


Figure 2. Shows how studies with placebo's and waitlists ("doing nothing") can identify which part of the treatment is a specific effect and which part is a context effect.

Several studies have shown that higher expectations were associated with better outcomes. For example, in patients adhere better to therapy if they believe the therapy helps and patients with higher expectations in general had a higher chance of success⁶.

ILLNESS PERCEPTIONS

Another important part of the patient mindset is illness perceptions; they represent the context of the disease itself and quantifies the effect of the disease on daily life. Illness perceptions are proposed to be part of a constant feedback loop (see figure 3) in which the illness invokes a certain perception. The patients coping mechanism mediates, either enhances or represses, this perception into health outcomes. These outcomes provide feedback to all previous mentions parts of the feedback loop. Leventhal et al.^{7, 8} proposed the illness perception questionnaire to measure that specific part of the feedback loop. It provides caregivers with additional information, on top of the reported symptoms.

Some studies have previously studied these illness perceptions in orthopedic patients. We know that patients with chronic hand arthritis have a relatively negative perception of their illness. In patients scheduled for a total knee arthroplasty, we see that patients with a more negative perception of illness have more pain⁹.

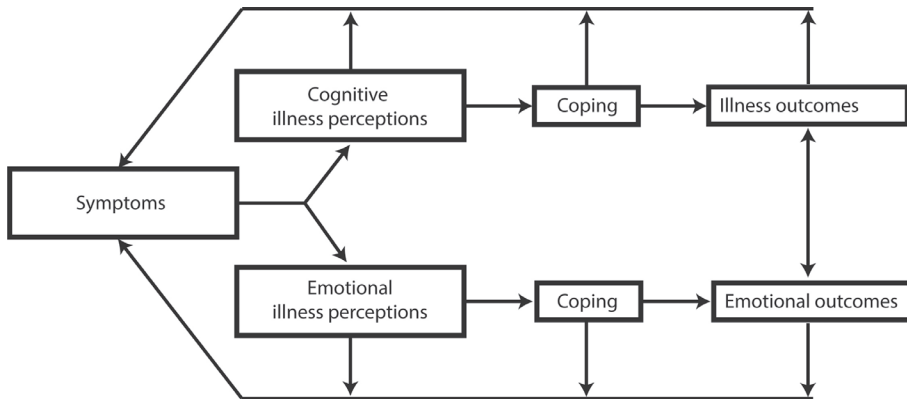


Figure 3. The Illness perceptions model. All patients start with a disease that gives symptoms. This figure shows the constant feedback loop that is proposed in the illness perceptions model.

PAIN CATASTROPHIZING, ANXIETY AND DEPRESSION

We already know that pain catastrophizing, anxiety and depression are associated with outcomes of thumb base OA. Pain catastrophizing describes how patients cope with pain. Pain is a subjective outcome, not all patients report the same level of pain with the same stimulus. The level of pain the report is dependent on how they appraise the pain stimulus. Anxiety and depression are general terms for the overall state of mind of a patient. Patients with a negative state of mind respond poorly to pain and have higher risks of developing chronic pain.

We already know that pain catastrophizing, anxiety and depression are associated with outcomes in patients with thumb base OA. For example, pain catastrophizing and anxiety are associated with physical function and hand specific disability¹⁰. Although patients experience similar effectiveness of treatments, patients with high anxiety and depression scores report more pain and hand function¹¹.

To ensure that our biopsychosocial model contains as little confounding as possible, we are also interested in the effects of pain catastrophizing, anxiety and depression. Because these construct can measure overlapping constructs it is essential to include them all in the same model. This allows us to draw conclusion based on the entire patient mindset.

TREATMENT CONTEXT

The way doctors and therapists deliver care could also greatly influence the patient mindset and possibly the outcome of the treatment itself. The context of any treatment influences the outcome of that particular treatment. Partially because a better context is associated with a better mindset. For example, studies have shown that if patients rated their doctor as more professional, their outcome was better. However, an overall better experience with the treatment will also influence outcomes, without influencing the mindset. In patients that received a total hip implant, a better overall experience of the treatment was associated with higher Oxford Hip score.

THUMB BASE OSTEOARTHRITIS

Osteoarthritis (OA) of the thumb base is a common condition that affects a large portion of the population. It is therefore an ideal hand condition to evaluate the biopsychosocial model. Thumb base OA can be seen on radiographs in 36% of the general population that is 55 years or older¹². The age-adjusted and sex-adjusted prevalence estimates for symptomatic hand OA in adults vary between 2.0% and 6.2%¹³. Women are usually more affected than men and the prevalence increases with age. Patients are generally treated non-surgically first, but if that is ineffective surgery can be considered. In the Netherlands, yearly about 1500 patients require surgical treatment for thumb base osteoarthritis (open dis data).

ANATOMY AND PATHOPHYSIOLOGY

The thumb base is a biomechanical complex joint. More specifically, it is a saddle joint between the metacarpal of the thumb and the trapezium (see Figure 4). This allows the joint to be more mobile and also ab/adduct instead of just flexing and extending.

OA is defined as loss of cartilage, synovitis, subchondral cysts and the development of osteophytes. The etiology of thumb base OA is multifactorial, systemic and biomechanical factors are both associated with the development of thumb base OA. One study found that females, older patients, patients with a positive family history and obesity had a higher risk to develop hand OA.

The evidence regarding workload is conflicting; studies have found that high workload is both a risk factor and a protective factor. Biomechanical stress on the joint surface or surrounding ligaments are also risk factors. Studies have found that forces in the joints of patients with thumb base OA differ from healthy subjects. Furthermore, patients with laxity of the ligaments surrounding the thumb base have a higher prevalence of thumb base OA.

TREATMENT

Usually, thumb base OA is treated with a splint and/or hand therapy first, if that is not successful surgery can be considered. Dutch guidelines specify that all patients should be treated non-operatively before surgery is considered¹⁴. We know that 85% of patients do not require surgery after initial non-surgical treatment and that patients benefit more from a splint combined with hand therapy¹⁵. On average, patients improve from 49 to 36 on a visual analog scale for pain¹⁵.

If non-surgical treatment is not successful, numerous surgical options exist. These surgical options are arthrodesis, an implant, denervation, or trapeziectomy with or without a reconstruction (Figure 4). This last option is most common in the Netherlands. However, no surgical options has been proven to be superior¹⁶. Furthermore, studies have tried to find factors that predict treatment success, because not all patients are treated successfully. While sex and radiographic staging explain a small part of the variance of outcomes, prognostic factors for the outcome of treatment are still largely unknown. In other words, surgeons do not have information that can tell them if the treatment will be successful.

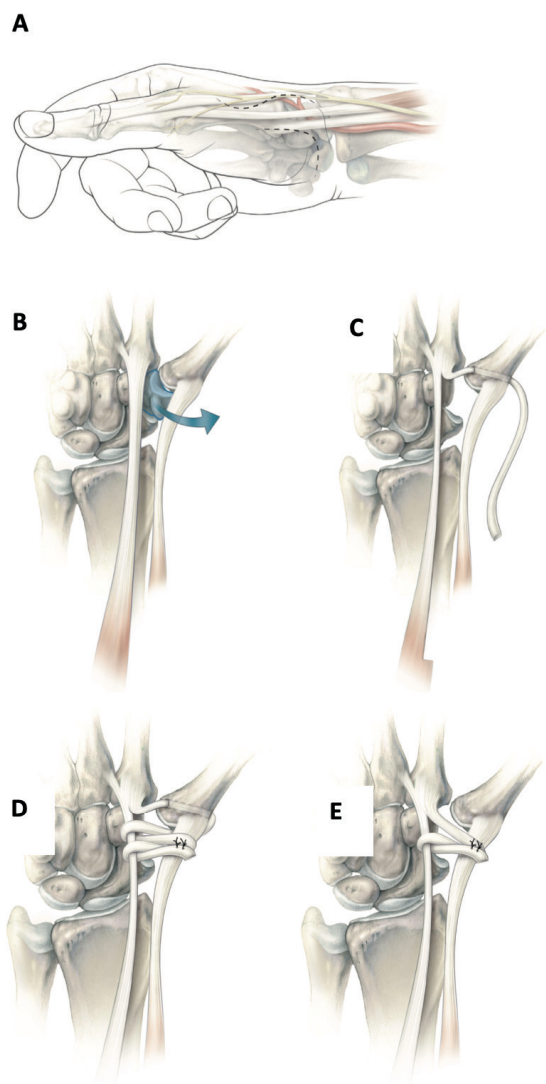


Figure 4. Trapeziectomy with ligament reconstruction. A) shows the two common types of incisions; a lazy-S over the dorsal side of the thumb base and a Wagner incision on the volar side of the thumb base. B) after dissection, the trapezium (in blue) is removed. For a reconstruction described by Burton, a borehole is made through the base of the first metacarpal (C) and a strip from the FCR is passed through the hole, wrapped around the FCR and APL (D). The other option is a reconstruction as described by Weilby. In this method the FCR strip is wrapped around the APL and FCR and secured (E). Made possible by Esser Masterclass.

AIM AND OUTLINE OF THIS THESIS

In this thesis, we set out to uncover to what extent the patient mindset influences patient reported outcomes in patients with thumb base OA. Patients with low expectations, a negative perception of their illness, or patients who catastrophize their pain might not achieve a successful outcome. It could also imply that interventions on the patient mindset will result in better outcomes.

Therefore, this thesis has several objectives. First, we want to describe the prevalence of the disease, describe the data collection and optimization of data collection and describe how much patients contribute their complaints to their illness (i.e., their illness perception). Second, we want to examine the effect of the patient mindset on the outcomes of conservative treatment for thumb base OA. Finally, we want to examine the effect of the patient mindset on the outcomes of surgical treatment for thumb base OA. This thesis is structured accordingly, as seen below.

Part 1: Introduction to the cohort

In **Chapter 2**, we reviewed all available literature regarding the prevalence of radiographic thumb base OA and how age and sex influence the prevalence. We aimed to provide a more precise estimate of the prevalence of thumb base OA in the general population. In **Chapter 3**, we described in detail how data is collected as part of routine outcome measurements and how this data is used in various studies. The goal was to illustrate how careful measurement of routine outcomes can be used to improve care and serve as a basis for scientific research. **Chapter 4** elaborates on this routine outcome measurement system. We described how routine outcome measurements are used in daily clinical care and help improve shared decision making and help doctors improve their outcomes. **Chapters 5 and 6** describe the development and validation of shorter, decision tree version of two common hand outcome measurements. Shorter questionnaires save patients time and might even increase compliance in collecting routine outcome measurements. **Chapter 7** described how different surgical populations perceive their illness. While most doctors know that not all diseases have the same impact, we wanted to quantify these perceptions for the four most common illnesses in our cohort.

Part 2: Psychosocial effects in nonsurgical treatment for thumb base OA

In **Chapter 8**, we explored the association between patient, radiological, and psychosocial characteristics and pain before non-surgical treatment for thumb base OA. The goal of this study was to see how much of the variance in pain can be explained by psychosocial factors, over and above patient characteristics. In **Chapter 9**, we examined how baseline psychosocial factors are associated with pain and hand function 3 months after treatment. If these associations exist, a case could be made for implementation of a psychosocial intervention. **Chapter 10** explores how patients' psychosocial factors are associated with satisfaction after treatment. Because if we would implement an intervention on psychosocial factors, the downside could be that patients are less satisfied. In **Chapter 11**, we approach the hypothesis that change in psychosocial factors causes a change in pain during non-surgical treatment for thumb base OA. If the natural change of psychosocial factors during non-surgical treatment is associated with change in pain, enhanced change of psychosocial factors could result in more pain relief.

Part 3: Biopsychosocial and occupation effects in surgical treatment for thumb base OA

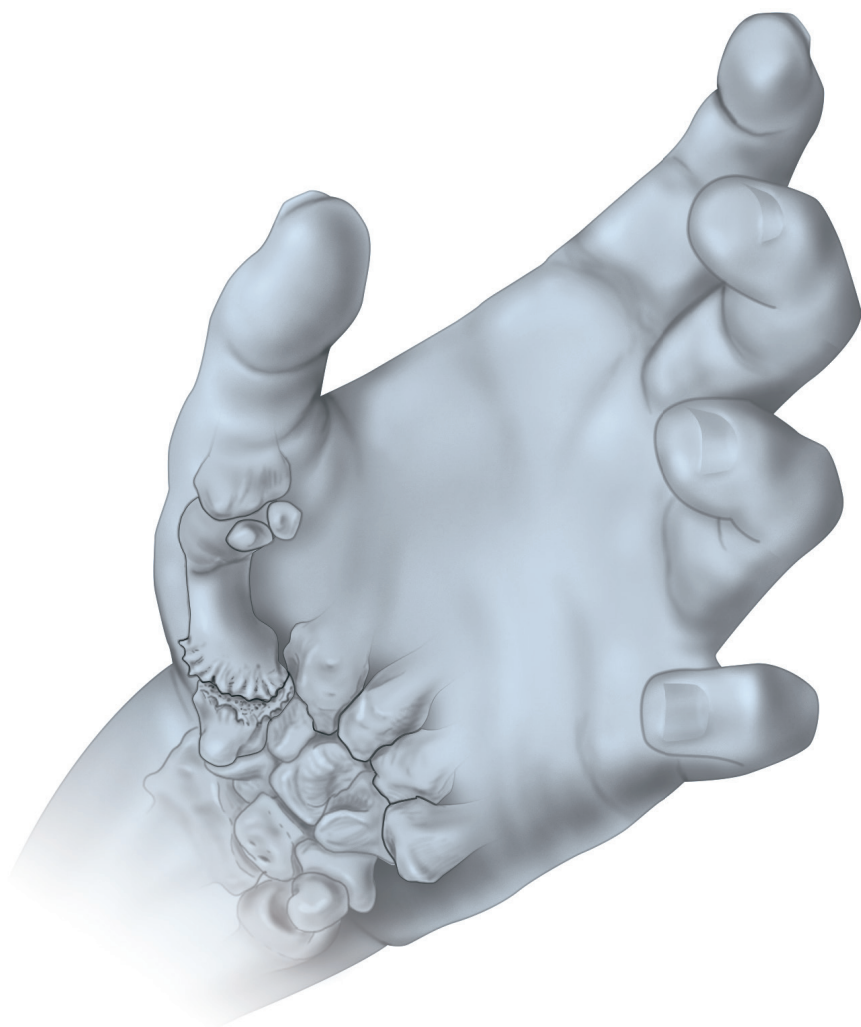
In **Chapter 12**, we compared baseline patient and psychosocial characteristics between patients at the start of non-surgical or surgical treatment for thumb base OA. We were interested to see if patients that elect to undergo surgery have a different psychosocial profile. This could also influence their patient reported outcomes. **Chapter 13** aimed to find how psychosocial factors and pain and hand function are associated before surgery. In this study we were interested in the contribution of psychosocial factors to preoperative pain and hand function, relative to patient characteristics. **Chapter 14** explores how pre-operative patient and psychosocial factors influence acute post-operative pain. Direct post-operative pain is a relative unknown subject for thumb base OA. We aimed to gain insight in factors associated with pain one day post-surgery. In **Chapter 15**, we examined how baseline psychosocial factors are associated with pain and hand function one year after surgical treatment for thumb base OA. If baseline psychosocial factors are associated with the outcome of surgery, it could make the case for a psychosocial intervention. In **Chapter 16**, we studied how patient characteristics are associated with return to work after surgical treatment for

thumb base OA. Many patients want to know when they can return to work; this study aims to provide the surgeon with a more patient specific prediction. In **Chapter 17**, we examined how the delivery of care was associated with patient-reported outcomes after surgical treatment for thumb base OA. How the patient experiences the treatment, the interaction with the doctor and the clinic has shown to be an influence in other elective surgical treatments. We were interested to confirm this for patients with thumb base OA.

The thesis will end with a general discussion and future perspectives based on the presented findings.

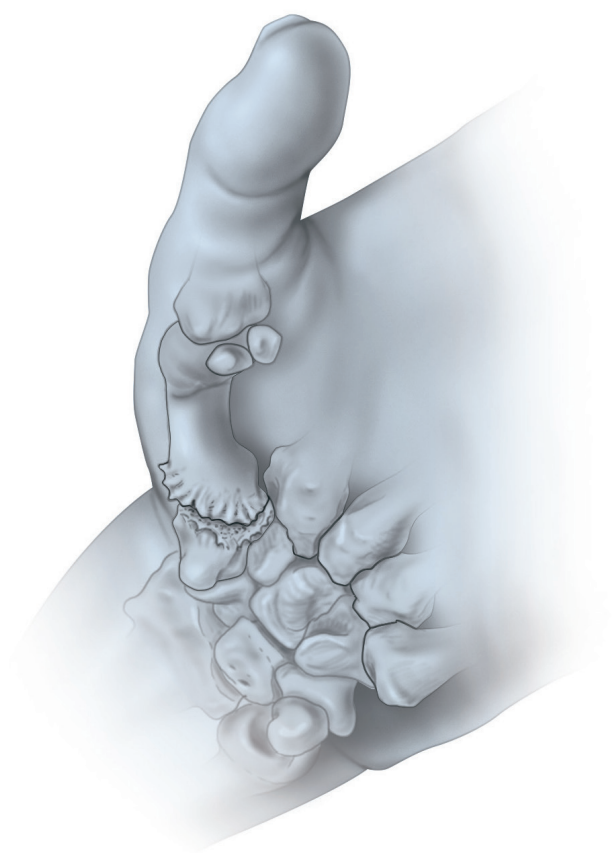
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PART 1

PSYCHOSOCIAL EFFECTS IN PATIENTS WHO RECEIVE NONSURGICAL TREATMENT FOR THUMB BASE OSTEOARTHRITIS



CHAPTER 2

THE PREVALENCE OF RADIOGRAPHIC THUMB BASE OSTEOARTHRITIS: A META-ANALYSIS

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Under review: Osteoarthritis & Cartilage

ABSTRACT

Introduction: Osteoarthritis (OA) affects millions of people worldwide. In hand OA, the thumb base is the most affected single joint. The reported radiographic prevalence ranges from 0 to 100%, making the true radiographic prevalence unclear. Hence, we conducted a meta-analysis on the age and sex-specific prevalence of radiographic thumb base OA.

Methods: We performed a search in Embase, Medline Ovid, Web of Science Core Collection, Cochrane Central Register of Trials, and Google Scholar. We included studies of the general population that reported thumb base OA for males and females separately based on a hand radiograph and reported the age of these groups. Using meta-regression, we estimated the odds ratio (OR) of having radiographic thumb base OA for age and sex, while adjusting for within-study correlation.

Results: The initial search yielded 4,278 articles; we finally included 16 studies that reported the age- and sex-stratified prevalence. Taken together, there were 104 age and gender specific-prevalence rates that could be derived from the 16 studies. The prevalence of radiographic OA for the 50-year-old male and female participants was 5.8% and 7.3%, respectively, while the respective prevalence for 80-year-old male and female participants was 33.1% and 39.0%. We found an OR for having radiographic OA of 1.06 (95%CI[1.055 – 1.065], $p < 0.001$) per increasing year of age, and 1.30 (95%CI: 1.05–1.61], $p=0.014$) for females.

Conclusion: In the general population, radiographic thumb base OA is more prevalent in females and is strongly associated with age.

INTRODUCTION

Osteoarthritis (OA) is the second-most common musculoskeletal disorder, leading to pain and functional limitations with a high social and economic burden^{1,2}. OA can affect every joint in the body, but it is most common in the knee, hip, spine, and hand³. Within the hand, the thumb base is the most affected single joint⁴. Risk factors for developing thumb base OA are considered to be radial subluxation, white ethnic groups, increased body mass index (BMI), and Ehlers–Danlos syndrome^{5–8}. However, the most well-known risk factors are age and female sex^{9,10}.

There is a large variation in the reported prevalence of radiographic thumb base OA, varying from 0% to 100%^{4,9,11,12}. Although age differences in study populations can often explain these differences, age-standardized prevalences also differ. For example, Haugen et al. found an age-standardized prevalence of 9.9% and 3.3% for female and male participants, respectively, with a 9-year incidence of 17% and 21% for male and female participants, respectively⁹. Becker et al. reported that, eventually, all people seem to get thumb base OA¹².

Female sex has been an undisputed risk factor for the development of thumb base OA. Kessler et al. showed an association between female sex and radiographic thumb base OA (OR=1.8, 95%CI: 1.2–2.7) independent of age¹³, and other studies have confirmed this association^{14,15}. However, as with age, the reported magnitude of this association varies from very small to large, making it difficult to conclusively state the influence of female sex on thumb base OA^{11,14}.

One study pooled all the results of reported prevalences of hand OA³. However, this study neither specified the type of hand OA nor adjusted for the effect of age. To the best of our knowledge, no study thus far has pooled all the prevalence data on radiographically confirmed thumb base OA in the general population.

Therefore, we conducted a systematic review and meta-analysis to assess the radiographic prevalence of thumb base OA in the general population. As it is already known that age and sex play an important role, we specifically aimed to examine the effect of age and sex on the prevalence of thumb base OA. The results of this review could provide clinicians with a better reference to know how common abnormal radiographic findings are, given a patient's age and sex.

Methods

Study search

Together with an experienced medical librarian, we performed a search on April 2, 2020, according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement. We employed the exhaustive search method (ESM)¹⁶ to create search strings. The search strings used to search in Embase, Medline Ovid, Web of Science Core Collection, Cochrane Central Register of Trials, and Google Scholar are listed in appendix 1. We included an additional search that was used for previously unpublished work. The protocol for this search, systematic review and meta-analysis is registered in the Prospero database (CRD42019122213).

Study selection

Any study that reported radiographic prevalence of thumb base OA, separate for males and females, in at least one hand was included. Only studies of the general population and those written in English were included (Table 1). Further, if studies reported the same cohort of participants, only the one with the largest sample was included. We excluded studies that described the prevalence of thumb base OA in a population selected based on the presence of specific morbidity that is hypothesized to significantly influence the prevalence of radiographic thumb base OA (e.g., patients presenting with a distal radius fracture or thumb pain). These studies would likely overestimate the prevalence of radiographic thumb base OA, because they do not represent the general population. The type of radiograph (e.g., Anterior posterior or Bett's view) was not an exclusion criterion.

Two independent reviewers (MO and LD) initially screened all titles and abstracts for inclusion. Any disagreement was resolved by discussion; if still in doubt, the full texts of articles were reviewed. Of the remaining studies, the full text was assessed independently by both reviewers. Any disagreements were settled by a third reviewer after the assessment of the full text. We assessed the risk of bias and quality of non-randomized studies using the Newcastle–Ottawa scale (NOS)¹⁷.

Data extraction

Both reviewers independently collected data from all studies that met the inclusion criteria. We collected data on the study type, country of origin, and date of publication. Furthermore, we collected the reported prevalence or calculated the prevalence based on the reported cases relative to the study size. When possible, we collected data stratified by age and sex. If the mean age was not reported, we assumed the mean age to be the subgroup's median. For example, Haara et al.¹⁴ report on a subgroup between 30 and 45 years of age and we assume the average age in this group to be 37.5. Thumb base OA was defined as Kellgren–Lawrence¹⁸ stage 2 or higher in the carpometacarpal joint of the thumb or similar (e.g., Eaton–Glickel). Participants with isolated arthritis of the scaphotrapezotrapezoidal joint were not included in the analysis.

Statistical analysis

To estimate the effect of age and sex on the proportion of radiographic thumb base OA, we performed a meta-regression. For this analysis, we used a log-transformed proportion of radiographic thumb base OA. For age and sex, we estimated the odds ratios (OR) for the odds of having radiographic OA. We adjusted for within-study correlation on both study level and sex level, assuming a multilevel random-effects meta-regression model. We used a random-effect model with a restricted maximum-likelihood estimator due to the considerable heterogeneity between studies. In the basic model, we used a generalized/weighted least-squares extension of Cochran's Q-test, which tests whether the variability in the observed effect sizes or outcomes is larger than one would expect based on sampling variability¹⁹. Additionally, we used a Q_E-test for residual heterogeneity, which tests whether the variability in the observed effect sizes or outcomes not accounted for by the moderators (age and sex) included in the model is larger than expected based on sampling variability alone.

The same model was estimated using a multilevel logistic mixed-effects model to visualize the effect of age and sex. All analyses were performed using the R project for statistical computing (version 3.6.0) and specifically the lme4 version 1.1-26²⁰ and metafor version 2.4-0¹⁹ packages. A p-value <0.05 was considered to indicate statistical significance.

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
The study reports on the general population, irrespective of geographic origin of the study.	Specific patients population (e.g., pain in the hand/thumb)
Radiographic prevalence for males and females	Reported on the same cohort as an already included study.
Written in English	

RESULTS

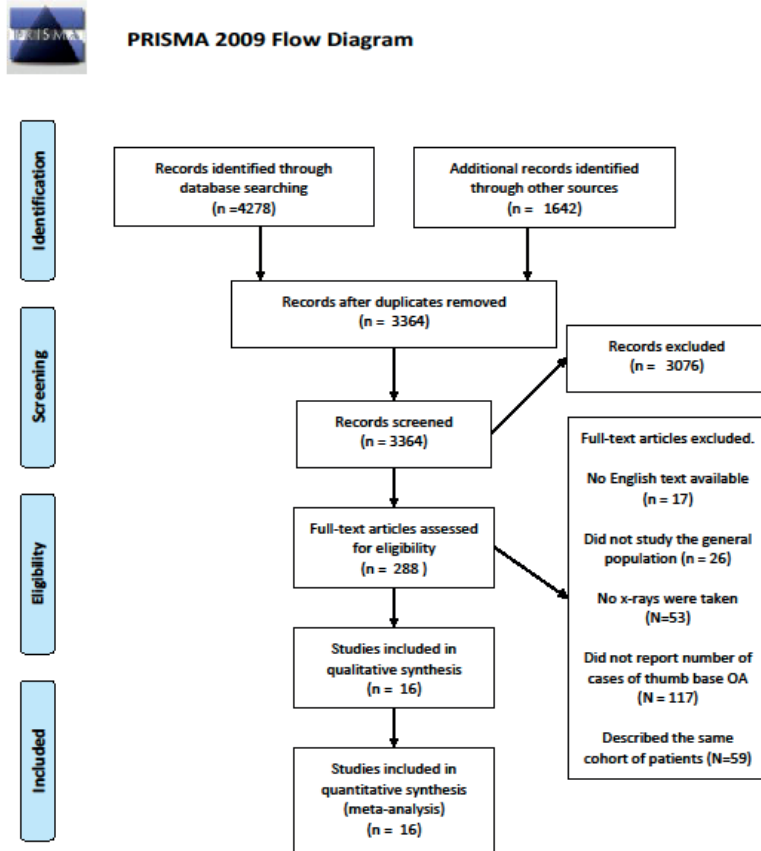
The initial search yielded 4278 articles. After screening the title and abstract, we included 288 articles for full-text review. Of these, 16 studies were included in the final analysis (Figure 1). Table 2 describes the included studies. These studies report the radiographic prevalence of thumb base OA in 29,802 participants. The pooled mean age of participants was 59 years (range: 20–99 years). Taken together, there were 104 age and gender specific-prevalence rates that could be derived from the 16 studies (Supplementary Table 2). There was significant heterogeneity between these studies ($Q(df = 103) = 2504, p < .001$).

The overall risk of bias was very low, with a score of 8 for all studies (Table 2). In some studies, the assessment of radiographs was either not blinded or well protocolled, but this did not affect the overall risk of bias score. All studies used either a Kellgren–Lawrence stage 2 to describe the presence of thumb base OA. Some studies sampled a specific part of the general population (e.g., bank tellers)²¹, but this did not affect the risk of bias score on the NOS (Table 3).

Figure 2 shows the pooled radiographic thumb base OA and the effect of age and sex. At age 50, the pooled radiographic prevalence of thumb base OA was 5.8% for males and 7.3% for females; at age 80, the respective pooled prevalence for males and females was 33.1% and 39%.

The meta-analysis indicated that the prevalence of OA was associated with both age and sex ($QM(df = 2) = 551, p < .0001$), where QM is the test statistic of the omnibus test of moderators. Females had a 1.30 (95% CI 1.05-1.61) higher odds of radiographic thumb base osteoarthritis than males, indicating that females had 30% higher odds of having radiographic thumb base OA than males of the same age. Additionally, for each year increase in age, the odds increased by

1.06 (95% CI: 1.055-1.065), indicating that participants have 6% higher odds of developing thumb base OA than the year before. In this model with age and sex, there still is residual heterogeneity ($QE(df = 101) = 2247, p < .0001$).



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Figure 1. Flow chart displaying when and why studies were excluded

Table 2. Study characteristics

Name	Year of Publication	Age range	Country	Total participants	Grading system
Al-Arfaj ¹¹	2002	>20	Saudi-Arabia	300	Kellgen Lawrence, ≥ 2
Bagge ²²	1992	67–72	Sweden	180	Kellgen Lawrence, ≥ 2
Cho ²³	2015	65–91	South-Korea	696	Kellgen Lawrence, ≥ 2
Cvijetic ²⁴	2004	54–56	Croatia	286	Kellgen Lawrence, ≥ 2
Dahaghin ⁴	2004	>55	The Netherlands	3906	Kellgen Lawrence, ≥ 2
Goekoop ²⁵	2011	>90	The Netherlands	82	Kellgen Lawrence, ≥ 2
Haara ¹⁴	2003	>30	Finland	3575	Kellgen Lawrence, > 2
Haugen ⁹	2011	>40	USA	2301	Kellgen Lawrence, ≥ 2
Hirsch ²⁶	1996	>40	USA	695	Kellgen Lawrence, ≥ 2
Jonsson ²⁷	2009	69–92	Iceland	384	Kellgen Lawrence, ≥ 2
Nelson ²⁸	2011	>45	USA	2083	Kellgen Lawrence, ≥ 2
Sonne-Holm ¹⁰	2006	>45	Denmark	2520	Kellgen Lawrence, ≥ 2
Van Saase ¹⁵	1989	>20	The Netherlands	6518	Kellgen Lawrence, ≥ 2
Verrijdt ²¹	2017	52.9 (5.4)*	Belgium	195	Kellgen Lawrence, ≥ 2
Wilder ²⁹	2006	>40	USA	3327	Kellgen Lawrence, ≥ 2
Zhang ³⁰	2003	>60	China	2507	Kellgen Lawrence, ≥ 2

*mean(SD) age

Table 3. Newcastle Ottawa Scale (NOS). The first column displays the total score. Other columns reflect the scores to the specific questions of the NOS. Because no study contained a non-exposed group selection question 2 cannot be answered.

name	NOS	Selection 1	Selection 2	Selection 3	Selection 4	Comparability	outcome 1	outcome 2	outcome 3
Al-Arfaj ¹¹	8	A	NA	A	A		B*	A	A
Bagge ²²	8	A	NA	A	B*		B*	A	A
Cho ²³	8	A	NA	A	B*		A	A	A
Cvijetic ²⁴	8	A	NA	A	A		A	A	A
Dahaghin ⁴	8	A	NA	A	B*		B*	A	A
Goekoop ²⁵	8	A	NA	A	A		A	A	A
Haara ¹⁴	8	A	NA	A	B*		B*	A	A
Haugen ⁹	8	A	NA	A	A		A	A	A
Hirsch ²⁶	8	A	NA	A	B*		B*	A	A
Jonsson ²⁷	8	A	NA	A	B*		A	A	A
Nelson ²⁸	8	A	NA	A	B*		B*	A	A
Sonne-Holm ¹⁰	8	A	NA	A	B*		B*	A	A
Van Saase ¹⁵	8	A	NA	A	A		A	A	A
Verrijdt ²¹	8	A	NA	A	B*		B*	A	A
Wilder ²⁹	8	A	NA	A	B*		B*	A	A
Zhang ³⁰	8	A	NA	A	A		B*	A	A

* despite imperfect scores, points for the total score are still awarded

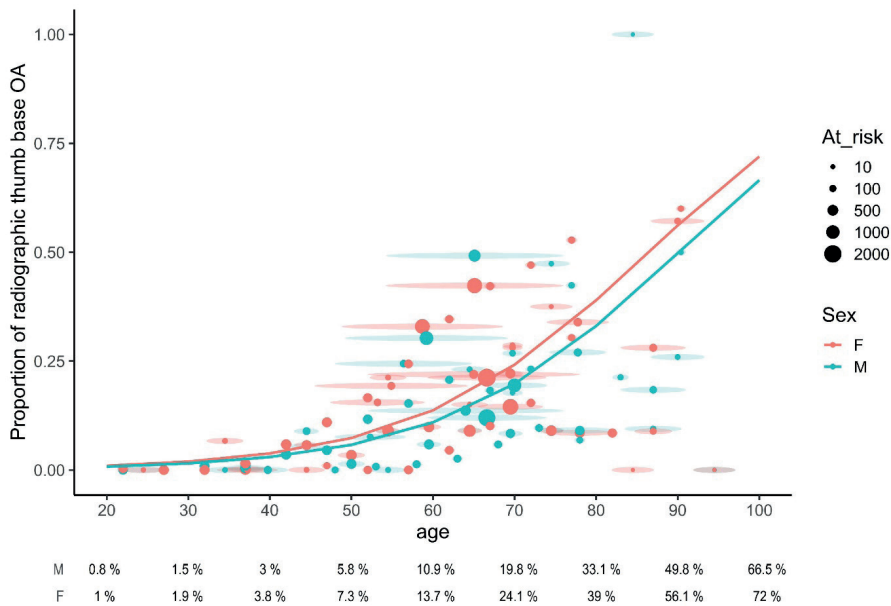


Figure 2. Radiographic thumb base osteoarthritis (OA) prevalence stratified by age and sex. This figure displays the prevalence for all subgroups identified in all included studies. The dots represent the mean age of the subgroup and the ellipse in the corresponding color represents the standard deviation of age in the subgroup. The size of the dots represents the number of participants in the subgroup. Both colored lines are the fitted values of the mixed model for females (red) and males (blue), showing that radiographic prevalence of thumb base OA is associated with age and sex. The table below reports the prevalence for the respective age and sex groups.

DISCUSSION

The results of our meta-analysis showed that in the general population, radiographic thumb base OA is more prevalent in females and is associated with age. The radiographic prevalence of thumb base OA in 50-year-old male and female participants was 5.8% and 7.3%, respectively and the respective prevalence in 80-year-old male and female participants was 33.1% and 39%. This odds of thumb base OA increased with 6% each year in both males and females; overall, females have 30% higher odds of developing radiographic thumb base OA than males.

Most studies showed a similar age trend for the prevalence of radiographic thumb base OA. The reported incidence in studies varied between 0% and 2.5% each year. The highest and lowest prevalence were both reported by Al-Arfaj et al.¹¹.

Due to their low sample size (between 1 and 37 in each group), the finding may have resulted from random variation. The study performed by Haara et al.¹⁴ in Finland reported a lower yearly incidence (0–0.5%) than the study by Haugen et al.⁹ in the USA (9-year incidence: 17.3%), which may indicate a geographic effect of radiographic prevalence of thumb base OA, either due to genetic or environmental differences.

Our meta-analysis showed that females had a higher prevalence of radiographic thumb base OA than males. This is consistent with reports of knee and hip OA. Several hypotheses for this have been put forth. First, hormonal differences could influence the prevalence of radiographic thumb base OA. Some studies found that the prevalence of OA was higher in females who underwent a hysterectomy³¹ and lower in females who had hormone replacement therapy³². However, a systematic review of 16 studies found no clear association between hormonal aspects and OA³³. Second, occupation has been hypothesized to influence the prevalence of thumb base OA. For example, Fontana et al.³⁴ found that the prevalence of thumb base OA was higher in participants who had occupations with repetitive thumb use. By contrast, a study by Wolf et al.³⁵ showed that performing heavy, manual labor is associated with increased radiographic prevalence in males.

While this discrepancy between males and females is not surprising, it is smaller than that reported in clinical studies that report on patients who seek treatment for symptomatic thumb base OA. We found that, in 50-year-old participants, the prevalence of thumb base OA was 26% higher in females than males (7.3% vs. 5.8%), but in 80-year-old participants, thumb base OA was 18% (39% vs. 33.1%) more prevalent in females than males, which does not correspond with reports from cohorts of patients that present with symptomatic thumb base OA. For example, studies by Calfee³⁶, Tsehaie³⁷, and Becker³⁸ reported that 72–75% of patients with thumb OA undergoing treatment were females. All these studies report on patients that have not undergone any prior treatment for thumb base OA. This suggests that there may be sex-related factors that cause patients to seek treatment for thumb base OA; below, we will describe which factors could explain these differences.

Several factors are hypothesized to cause this discrepancy between the radiographic prevalence of thumb base OA and the proportion of male and

female patients treated for thumb base OA. A nationwide Swedish registry study³⁹ found that 5% of females over 70 years old sought treatment for thumb base OA, while this was only 1.8% for males. This factor-three difference between males and females is larger than the difference in radiographic prevalence found in this review (24.1% for females of 70 and 19.8% for males). Changes in bone morphology are reported in patients with thumb base OA compared to patients without thumb base OA, but no difference between male and female patients⁴⁰. Thus, this may not explain why males and females have a different presentation of symptomatic thumb base OA to a doctor. Another hypothesis is that psychosocial factors explain the difference between radiographic and symptomatic prevalence. It is well known that females respond differently to a pain stimulus than males⁴¹. One study found that this difference could be explained by the difference in pain-related anxiety⁴². This hypothesis is supported by an analysis by Hoogendam et al.⁴³ in CMC1 OA, who reported that psychosocial factors are associated with pain, but not the radiographic severity. Studying which factors determine if patients seek care for symptomatic thumb base OA could provide clinicians with an opportunity to simultaneously treat this underlying disease processes alongside the changes in bone morphology. To estimate the prevalence of symptomatic thumb base OA, future research could first determine what constitutes symptomatic thumb base OA. Current literature reports symptomatic thumb base OA, both as patients with radiographic thumb base OA and hand pain⁴ and as patients who are treated for thumb base OA by a clinician³⁹. When uniform definitions are used, future research could determine which factors are associated with symptomatic thumb base OA. This research might also identify a third group of patients with symptoms who do not seek treatment.

This study has some limitations. First, studies that reported a larger subgroup with participants aged >75 years were scarce (shown in Fig. 2). This is likely because most population studies that investigate this elderly group are typically focused on cardiovascular diseases or dementia. This could have influenced our results. To test this hypothesis, we conducted a sensitivity analysis in which we restricted either the upper age limit of the subgroups or the lower limit of the subgroups in the analysis. This did not change the general findings regarding age and sex, indicating that our conclusions hold true for participants aged >75 years. Second, for the most optimal analysis of the effect of age, we would have

preferred to analyze the effect of age using participant-level data. However, this is not possible in a meta-analysis; Different methods of reporting the prevalence in age groups only allowed us to use the average age in a subgroup for our analysis. Third, unfortunately, many studies in the literature did not report data separately for males and females and, therefore, had to be excluded. If we had included these studies, we might have had a better estimate of the overall prevalence of thumb base OA. However, our study found a significant effect of sex on the prevalence of radiographic thumb base OA. Thus, if we had included these studies without sex-specific prevalence, we most likely would have introduced bias into the analysis. In addition, several studies also did not report the prevalence for different age groups. However, based on the remaining studies, we showed that the prevalence of thumb base OA is dependent on age and sex. Fourth, while we show that age and sex explain some of the heterogeneity between studies, there is still substantial residual heterogeneity ($Q = 2504$ vs. $Q_E = 2247$). This shows that while we were able to estimate the prevalence of radiographic thumb base OA for age and sex, other factors might also influence this prevalence. For example, differences in setting (e.g., rural vs. urban), race, or comorbidities might also be associated with the prevalence of thumb base OA. Since our PROSPERO protocol did not include these, we refrained from these analyses. Future studies could examine if these factors explain more of the residual heterogeneity. The final limitation is that our search was limited to English papers only. Due to this limitation, we might have missed cohorts of which no report in English is available. However, since most studies we included are conducted within large cohort studies of the general population, it is unlikely that such a large cohort would not be reported on in English.

In conclusion, our review shows that the prevalence of thumb base OA is highly variable and dependent on age and sex. Future studies may investigate additional factors that explain the difference between radiological and symptomatic thumb base OA. Knowing which factors are associated with the progression from radiological to symptomatic thumb base OA will allow doctors to treat the underlying causes more effectively.

AUTHOR CONTRIBUTIONS

MvdO, SBZ, RS, and JZ collectively designed the study. MvdO and LD selected and scored all papers. MvdO and EA conducted the statistical analysis. All authors wrote, revised, and approved the final manuscript.

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SUPPLEMENTARY TABLES

Supplementary Table 1. Search strategy. This table shows the result of searches in the respective database. Below the table, the exact search term is reported.

Database	Results	After duplicates removed
Embase.com (1971-)	1595	1552
Medline ALL Ovid (1946-)	1521	376
Web of Science Core Collection (1975-)	796	38
Cochrane CENTRAL Register of Trials (1992-)	166	92
Google Scholar	200	159
Total	4278	2217

embase.com (1971-) 1595

((('osteoarthritis'/exp AND ('thumb'/exp OR 'carpometacarpal joint'/de OR 'trapeziometacarpal joint'/de OR 'hand radiography'/de)) OR 'hand osteoarthritis'/de OR (((osteoarthr* OR arthrosis OR arthroses OR arthritis OR oa) NEAR/10 (hand OR hands OR thumb* OR Carpometacarpal* OR trapeziometacarpal* OR Carpo-metacarpal* OR trapezio-metacarpal*))) :ab,ti) AND ('prevalence'/exp OR 'epidemiological data'/de OR 'epidemiology'/de OR 'cohort analysis'/de OR 'population'/de OR 'normal human'/de OR 'population based case control study'/de OR 'population health'/de OR 'geographic names'/exp OR 'population group'/exp OR 'population research'/de OR 'occupation'/de OR 'occupational hazard'/de OR workload/de OR (prevalence* OR epidemiolog* OR cohort* OR population* OR normal-human* OR healthy-adult* OR healthy-human* OR occupation* OR workload OR work-load):ab,ti) NOT [conference abstract]/lim NOT ([animals]/lim NOT [humans]/lim) AND [english]/lim

Medline ALL Ovid (1946-) 1521

((Osteoarthritis / AND (Thumb / OR Carpometacarpal Joints / OR hand)) OR (((osteoarthr* OR arthrosis OR arthroses OR arthritis OR oa) ADJ10 (hand OR hands OR thumb* OR Carpometacarpal* OR trapeziometacarpal* OR Carpo-metacarpal* OR trapezio-metacarpal*))) .ab,ti.) AND (Prevalence/ OR Epidemiology/ OR Cohort studies/ OR Population/ OR Population Health/ OR exp Geographic Locations/ OR exp Population Groups/ OR Occupations/ OR Workload/ OR (prevalence* OR epidemiolog* OR cohort*

OR population* OR normal-human* OR healthy-adult* OR healthy-human*
OR occupation* OR workload OR work-load).ab,ti.) NOT (exp animals/
NOT humans/) AND english.la.

Web of science Core Collection (1975-)796

AB=((((osteoarthr* OR arthrosis OR arthroses OR arthritis OR oa) NEAR/10
(hand OR hands OR thumb* OR Carpometacarpal* OR trapeziometacarpal*
OR Carpo-metacarpal* OR trapezio-metacarpal*)))) AND ((prevalence* OR
epidemiolog* OR cohort* OR population* OR normal-human* OR healthy-
adult* OR healthy-human* OR occupation* OR workload OR work-load)))
AND DT=(article) AND LA=(english)

Cochrane CENTRAL register of trials (1992-) 166

(((((osteoarthr* OR arthrosis OR arthroses OR arthritis OR oa) NEAR/10
(hand OR hands OR thumb* OR Carpometacarpal* OR trapeziometacarpal*
OR Carpo-metacarpal* OR trapezio-metacarpal*)))):ab,ti) AND ((prevalence*
OR epidemiolog* OR cohort* OR population* OR normal-human* OR
healthy-adult* OR healthy-human* OR occupation* OR workload OR work-
load):ab,ti)

Google Scholar

osteoarthritis | arthrosis | arthroses thumb | Carpometacarpal | trapeziometacarpal | prevalence | epidemiology | cohort | population | "normal-humans" | "healthy-adults"

Additional records identified through other sources

Pubmed

"epidemiology"[Subheading] OR "epidemiology"[All Fields] OR "prevalence"[All Fields] OR "prevalence"[MeSH Terms] AND ("hand"[Mesh Terms] OR "hand"[All Fields] OR "thumb"[All Fields]) AND ("arthritis"[MeSH Terms] OR "arthritis"[All Fields] OR "osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields]) AND ("0001/01/01"[PDAT] : "2019/01/31"[PDAT])

Supplementary Table 2. Number of participants with radiological thumb base OA. Displayed are the number of participants at risk and the number of participants with radiographic OA for all subgroups.

name	Year	Country	Mean age	Males	Male cases	Male prevalence	Females	Female cases	Female prevalence
Al-Arfaj	2002	Saudi Arabia	24.5	15	0	0%	14	0	0%
Al-Arfaj	2002	Saudi Arabia	34.5	25	0	0%	30	2	7%
Al-Arfaj	2002	Saudi Arabia	44.5	37	2	5%	26	0	0%
Al-Arfaj	2002	Saudi Arabia	54.5	29	0	0%	33	7	21%
Al-Arfaj	2002	Saudi Arabia	64.5	39	9	23%	20	3	15%
Al-Arfaj	2002	Saudi Arabia	74.5	19	9	47%	8	3	38%
Al-Arfaj	2002	Saudi Arabia	84.5	1	1	100%	1	0	0%
Al-Arfaj	2002	Saudi Arabia	94.5	2	0	0%	1	0	0%
Bagge	1992	Sweden	69.75	63	16	25%	65	18	28%
Bagge	1992	The Netherlands	69.75	35	10	29%	17	3	18%
Cho	2015	Korea	78	298	27	9%	398	34	9%
Cvijetic	2004	Croatia	54.9	126	31	25%	160	31	19%
Dahaghin	2004	The Netherlands	66.6	1805	216	12%	2101	445	21%
Goekoop	2011	The Netherlands	90.4	27	14	52%	55	33	60%
Haara	2003	Finland	37	428	2	0%	558	1	0%
Haara	2003	Finland	50	362	5	1%	472	16	3%
Haara	2003	Finland	59.5	358	21	6%	446	46	10%
Haara	2003	Finland	69.5	287	24	8%	375	83	22%
Haara	2003	Finland	87	125	23	18%	164	46	28%
Haugen	2011	USA	59	1001	303	30%	1300	428	33%
Hirsch	1996	USA	65	426	58	14%	269	59	22%
Jonsson	2005	Iceland	77.75	163	44	27%	221	75	34%
Nelson	2011	USA	65.1	689	339	49%	1394	590	42%
Sonne-Holm	2006	Denmark	39.75	162	0	0%	65	0	0%
Sonne-Holm	2006	Denmark	48	83	0	0%	103	1	1%

name	Year	Country	Mean age	Males	Male cases	Male prevalence	Females	Female cases	Female prevalence
Sonne-Holm	2006	Denmark	53	131	1	1%	198	0	0%
Sonne-Holm	2006	Denmark	58	156	2	1%	246	0	0%
Sonne-Holm	2006	Denmark	63	154	4	3%	222	10	5%
Sonne-Holm	2006	Denmark	68	154	9	6%	228	23	10%
Sonne-Holm	2006	Denmark	73	135	13	10%	195	30	15%
Sonne-Holm	2006	Denmark	78	73	5	7%	112	34	30%
Sonne-Holm	2006	Denmark	83	47	10	21%	283	24	8%
Van Saase	1989	The Netherlands	20	292	0	0%	297	1	0%
Van Saase	1989	The Netherlands	25	338	0	0%	389	0	0%
Van Saase	1989	The Netherlands	30	324	3	1%	375	0	0%
Van Saase	1989	The Netherlands	35	383	4	1%	405	6	1%
Van Saase	1989	The Netherlands	40	395	14	4%	428	25	6%
Van Saase	1989	The Netherlands	45	353	16	5%	375	41	11%
Van Saase	1989	The Netherlands	50	309	36	12%	290	48	17%
Van Saase	1989	The Netherlands	55	216	33	15%	226	55	24%
Van Saase	1989	The Netherlands	60	174	36	21%	182	63	35%
Van Saase	1989	The Netherlands	65	115	21	18%	180	76	42%
Van Saase	1989	The Netherlands	70	82	19	23%	119	56	47%
Van Saase	1989	The Netherlands	75	59	25	42%	108	57	53%
Van Saase	1989	The Netherlands	80	27	7	26%	77	44	57%
Verrijdt	2017	Belgium	53.2	66	5	8%	129	20	16%
Wilder	2006	USA	44.5	146	13	9%	386	22	6%
Wilder	2006	USA	54.5	249	22	9%	656	59	9%
Wilder	2006	USA	64.5	274	25	9%	724	65	9%
Wilder	2006	USA	74.5	262	24	9%	487	44	9%
Wilder	2006	USA	87	53	5	9%	90	8	9%
Zhang	2003	China	70	1004	195	19%	1503	218	15%

APPENDIX – R CODE FOR ANALYSIS

```
#use the date provided in supplementary table 2 as "LM_data"

#CMC_OA are all cases in the male and female columns

#At_risk are all participants in the column

#use the study from which the data originated in the name variable

#use the mean age provide and create a variable sex to designate male or female
participants/cases

library(metafor)

library(nlme)

dat <- escalc(measure = "PLO", xi = CMC_OA, ni = At_risk, data = LM_data)

res <- rma.mv(yi, vi, mods = ~ Sex + age,
              random = ~ 1 | name/Sex,
              data = dat, method = "REML")

#calculate OR

OR_dat <- as.data.frame(exp(res$beta))

OR_dat$ci.lb <- exp(res$ci.lb)

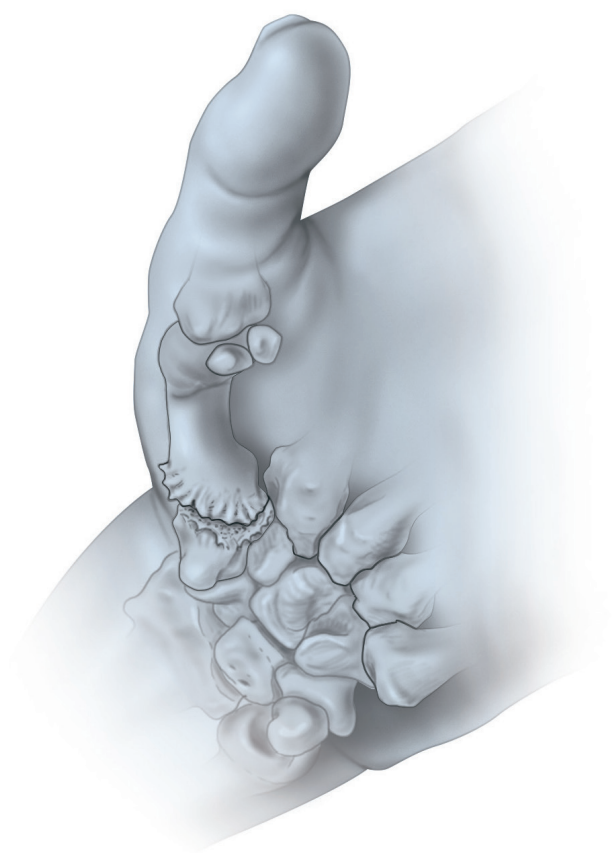
OR_dat$ci.ub <- exp(res$ci.ub)

OR_dat$pvalue <- round(res$pval, 3)

OR_dat

#mixed model for plotting data

fit <- glmer(cbind(CMC_OA, At_risk - CMC_OA) ~ Sex + age +
             (1 | name/Sex),
             control = glmerControl(optimizer = "bobyqa"),
             data = LM_data, family = binomial)
```

CHAPTER 3

ROUTINE HEALTH OUTCOME MEASUREMENT: DEVELOPMENT, DESIGN, AND IMPLEMENTATION OF THE HAND AND WRIST COHORT

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ABSTRACT

Background: Routine measurement of outcome of clinical care is increasingly considered important, but implementation in practice is challenging. This paper describes how 1) we created and implemented a routine outcome measurement cohort of patients with hand and wrist conditions, and 2) these data are used to improve the quality of care and facilitate scientific research.

Methods: Routine outcome measurement was implemented in 2011 at all practice sites (currently 22) of a specialized treatment center for hand and wrist conditions across the Netherlands. We developed five ‘measurement tracks’, including measurements administered at predetermined time points covering all hand and wrist disorders and treatments. An online system automatically distributes measurements amongst patients, which can be accessed by healthcare professionals.

Results: The total number of yearly assigned tracks increased up to over 16.500 in 2018, adding up to 85.000 tracks in 52.000 patients in total. All surgeons, therapists, and other staff have direct access to individual patient data and patients have access to their treatment information using a secure patient portal. The data serves as a basis for studies on, amongst others, comparative effectiveness, prediction modeling, and clinimetric analyses.

Conclusions: We present the design and successful implementation of a routine outcome measurement system in hand and wrist disorders. Implementing such a system was feasible using a highly automated data collection infrastructure, tightly linked to the patient journey and the workflow of healthcare professionals. The system not only serves as a tool to improve care but also as a basis for scientific research studies.

INTRODUCTION

Routine measurement of the outcome of clinical care is increasingly considered important in healthcare. It is a key aspect of value-based healthcare, patient-centered care, and other quality of care initiatives.¹ For example, the Dutch government strives to have objective outcome data on 50% of all healthcare in 2022,² while in Sweden outcome measurements have been part of a national registry for years.³

The goals of routine outcome measurement are multitude, including improving communication and treatment guidance at patient level, as well as benchmarking of outcome at the level of individual clinicians or treatment centers. This benchmark information may help to establish priorities in resource allocation, and provide clinicians and managers with valuable feedback on performance. Furthermore, routine outcome measurement systems generate large datasets that can be used in scientific research. This so-called ‘big data’ can help provide knowledge on, for example, comparative effectiveness, predictive factors of outcome, and psychometric properties of measurement instruments.

While routine outcome measurement has been advocated for years, implementation in clinical practice is limited due to several challenges. These include lack of 1) consensus on which outcome measurements to be collected; 2) appropriate IT infrastructure for data collection; 3) time and financial resources for data collection; 4) compliance of both patients and healthcare providers in data collection; 5) analysis and visualization tools and; 6) knowledge to improve clinical care by using the data.

In 2009, Xpert Clinic, Handtherapie Nederland, and Erasmus MC - University Medical Center Rotterdam started an initiative to collect routine outcome data in all patients with hand and wrist disorders undergoing surgical or non-surgical treatment in their centers. This paper provides an overview of this routine outcome measurement cohort by describing its design, development, and implementation. Furthermore, we describe how the accumulated data are used to improve the quality of healthcare and facilitate ongoing scientific research. By sharing our lessons learned, we hope to help others overcome the hurdles to implement routine outcome measurement.

METHODS

Treatment locations and patient population

Routine outcome measurement was implemented in 2011 at all practice sites (currently N=22) of Xpert Clinic and Handtherapie Nederland across the Netherlands. Presently, 23 European Board certified (FESSH) hand surgeons, multiple hand surgery fellows, and >150 hand therapists are employed within these organizations. The organizations provide non-surgical and surgical treatment for acute and non-acute hand and wrist disorders, excluding emergency care. Patients are referred by either their general practitioner or another medical specialist. Surgical treatment is only performed in patients with an American Society of Anesthesiologists score (ASA) of 1-2. Table 1 shows an overview of the most common disorders and treatments. Prior to any measurement or treatment, all patients are digitally asked for permission to use their data anonymously for scientific research. If a patient does not provide informed consent, the data will only be used for direct healthcare purposes but not for scientific analysis. Patients can always withdraw their consent. Access to all questionnaires, including the one on informed consent, is restricted through the use of a unique secret identifier provided to the individual patient by email. Approval from local medical ethical review board is obtained for each scientific study that uses the data.

Measurements

In 2010, a working group consisting of hand surgeons, hand therapists and researchers from Xpert Clinic, Handtherapie Nederland and Erasmus MC developed a measurement set, based on existing guidelines.⁴ Instruments were considered if they were of direct use for clinical care, quality assessment, or treatment outcome evaluation and had proper psychometric properties. Measurements only relevant for scientific research or analysis of underlying pathology (e.g., radiographic imaging or electromyography) were excluded from routine registration. All measurements were kept to a minimum to reduce the burden and optimize compliance.

Table 1. Overview of the main interventions performed at our treatment center and how they are organized into the measurement tracks. Grouping is based on similar outcome domains and follow-up period needed to capture the health status of the patient after an intervention. If a patient receives multiple treatments, only one track is assigned based on a priority rule. The tracks are ordered from left to right based on this priority. Hence, for example, when Dupuytren surgery (Dupuytren track) and a trigger finger release (Finger Regular track) are performed at the same time, only the Dupuytren track is assigned because it has a higher priority. Moreover, when a treatment is started with a higher track priority (e.g., trapeziectomy with the Thumb Extended track) then the earlier assigned track (e.g., non-surgical treatment for thumb osteoarthritis with Thumb Regular track), the earlier track is stopped and the new track is assigned.

1. Wrist extended	2. Thumb extended	3. Finger extended	4. Dupuytren's Disease	5. Compression neuropathy	6. Wrist regular	7. Thumb regular	8. Finger regular
Corrective	Trapeziectomy	DIP arthrodesis	Limited fasciectomy	Carpal tunnel release	Release 1st extensor compartment	Trigger thumb release	Trigger finger release
osteotomy distal radius	with Burton-Pelegri	DIP prosthesis	tomy	release			
Ulna shortening	Trapeziectomy	PIP arthrodesis	Limited fasciectomy with skin	Guyon tunnel release	Reconstruction 1st extensor compartment	Mallet surgery thumb	Mallet surgery finger
Brunelli / 3 LT	without LRTI	PIP prosthesis	graft	Cubital tunnel release			
LT reconstruction	Hemitrapeziectomy without LRTI	MCP arthrodesis	Percutaneous	release	Wrist arthroscopy (diagnostic)	Mucoid cyst excision	Excision of tumor
Proximal row carpectomy	CMC-1 denervation	Tenolysis flexors finger	needle aponeurotomy (possibly with lipofilling)	Radial tunnel release	Carpal boss wig excision	Nail bed surgery	Nail bed surgery
LC3H-fusion / four corner	CMC-1 arthrodesis	Tenolysis extensors finger	Collagenase closure	Carpal tunnel syndrome treated non-surgically		Excision of tumor	Removal of osteosynthesis material
Total wrist arthrodesis	CMC-1 revision arthroplasty	Neurolysis finger	tridium histolyticum (Xiapex)	Pronator syndrome treated non-surgically	GCD excision	Nail bed surgery	Trigger finger treated
Wrist prosthesis	STT excision	VP reinsertion		Cubital tunnel syndrome treated	Removal of osteosynthesis material	Trigger thumb treated	Trigger finger treated
TFCC reinsertion	CMC-1 instability surgery	MCP		non-surgically	Denervation wrist	non-surgically	non-surgically
				Cubital tunnel syndrome treated	Midcarpal instability / laxity treated	Mallet thumb treated	Mallet finger treated

1. Wrist extended	2. Thumb extended	3. Finger extended	4. Dupuytren's Disease	5. Compression neuropathy	6. Wrist regular	7. Thumb regular	8. Finger regular
Dorsal capsulodesis	UCL reinsertion	VP release PIP		non-surgically	non-surgically	non-surgically	non-surgically
wrist (possibly combined with dorsal ganglion excision)	MCP-1	UCL/RCL reinsertion/reconstruction MCP		Radial tunnel syndrome treated non-surgically	Wrist OA treated non-surgically	CMC-1	MCP/PIP/
	MCP-1	Sagittal band reinsertion			STT OA treated non-surgically	OA treated non-surgically	DIP OA treated non-surgically
Pisiformectomy	VP reconstruction MCP-1	Corrective osteotomy P1 P2			Tendinitis/tendovaginitis wrist treated non-surgically	CMC-1 instability treated non-surgically	UCL/RCL/VP injury
Tenorrhaphy	IP-1 arthrodesis	Fracture finger			Wrist synovectomy		MCP/PIP/
flexors wrist	Tenolysis tendons of the thumb	Fracture finger treated surgically					DIP treated non-surgically
	Fracture thumb treated surgically	treated non-surgically					
		Amputation					

The Clinician Reported Outcome Measurements (CROMs) include grip & pinch strength and range of motion, while Patient Reported Outcome Measurements (PROMs) include pain, hand function, aesthetics, return to work/daily activities, and satisfaction with the outcome. Furthermore, a Dutch Patient Reported Experience Measure (PREM) is used.⁵

Next, we created ‘measurement tracks’ comprising a specific set of measurements administered at predetermined time points for each treatment or condition. We aimed to create as few measurement tracks as possible, based on similarity in the relevance of outcome domains and time points needed to capture the patients’ health status. Eventually, five main measurement tracks were developed: 1) thumb disorders; 2) wrist disorders; 3) finger disorders; 4) Dupuytren’s disease; and 5) compression neuropathy. The thumb, wrist, and finger tracks were further divided into a ‘regular’ track (including shorter follow-up and fewer measurements, e.g., for trigger finger) and an ‘extended’ track (including longer follow-up and more measurements, e.g., for thumb base surgery). For all measurement tracks, selected time points were baseline and combinations of 6 weeks, 3, 6, and 12 months post-treatment. Table 2 shows the content of each measurement track, which is reviewed and updated every two years. If a patient receives multiple concurrent treatments, only one track is assigned at treatment onset by the hand therapist in collaboration with the hand surgeon. To select this single track, we developed a priority rule based on the treatment that we expected, on average, to have the most impact (see Table 1). Although only a single track is assigned in these cases, all concurrent treatments are registered. The same priority rule is applied when a new treatment starts during an already active measurement track, e.g. three months postoperatively to determine if a new track needs to be assigned.

Measurement logistics and data collection

For efficient implementation of routine outcome measurement, measurement time points were aligned with the sequence of care events of typical patients (see Figure 1). For example, when a first consultation is registered in the electronic patient record, this initiates the distribution of baseline questionnaires assessing risk factors (e.g., smoking, comorbidity, and medical history) and patient expectations of the consultation and treatment. Then, during the first consultation, a hand surgeon registers the diagnosis and decides together with

the patient to start either non-surgical or surgical treatment. Based on this information, a hand therapist assigns a specific measurement track. At the same visit, the hand therapist records patient demographics (e.g., hand dominance) and CROMS and informs the patient on the treatment and future measurements. Subsequently, PROMs are e-mailed to the patient. The start of non-surgical treatment or the date of surgery determines the timing of future questionnaires or assessments. To guarantee the validity and reliability of our data, all therapists received specific training on performing the measurements.

All data are collected digitally an online system named Pulse, which was developed using GemsTracker electronic data capture tools.⁶ GemsTracker is a secure, open-source, web-based application for distribution of questionnaires and forms for clinical research and quality registration. GemsTracker uses the open-source software LimeSurvey⁷ for building and storing questionnaires.

To ensure data safety, measurements are administered using methods similar to those in electronic patient records, including annual audits and tests, two-way authentication login, and logging and monitoring of all activity.

Since Pulse is linked to our electronic patient records, it automatically sends invitational emails to patients for completing questionnaires as soon as a diagnosis and treatment onset are assigned to a patient in the electronic patient record. Also, healthcare providers can access Pulse and see which measurements they need to complete for a specific patient.

Pulse directly calculates scores of PROMS and displays an overview of answered, open, and missed measures. When the same measure is administered multiple times within a track, score development over time is displayed. In the case PROM data are missing, the surgeon or therapist can request the patient to complete the missing questionnaires, but treatment can also continue without this information.

Table 2. Overview of the predefined tracks, their measurements and time points. This table shows the measurements performed in all tracks and the additional measurements performed in each specific track. For each type of treatment, it was decided whether patients would be assigned a regular track with a short follow-up of maximally three months or an extended track with a 12-month follow-up and more extensive measurements. Measurements performed only in the extended tracks for a specific time points are underlined and denoted by an Asterix

Track	Baseline	6 Weeks	3 Months	6 Months	12 Months
	<i>Regular &</i>	<i>Regular &</i>	<i>Regular &</i>	<i>Regular &</i>	<i>Regular &</i>
	<u><i>*extended*</i></u>	<u><i>*extended*</i></u>	<u><i>*extended*</i></u>	<u><i>*extended*</i></u>	<u><i>*extended*</i></u>
<i>All tracks</i>	VAS: pain,	VAS: pain,	VAS: pain,	<u><i>*VAS: pain,</i></u>	<u><i>*VAS: pain,</i></u>
	function,	function,	function,	<u>function,</u>	<u>function,</u>
	satisfaction	satisfaction	satisfaction	<u>satisfaction</u>	<u>satisfaction</u>
	PSFS	PSFS	PSFS	<u><i>*PSFS</i></u>	<u><i>*PSFS</i></u>
	EQ-5D	Return to	Return to	<u><i>*Return to</i></u>	<u><i>*Return to</i></u>
	CEQ	Work	Work	<u>Work</u>	<u>Work</u>
	PHQ-4	Satisfaction	Satisfaction	<u><i>*Satisfaction</i></u>	<u><i>*Satisfaction</i></u>
	PCS	treatment	treatment	<u>treatment</u>	<u>treatment</u>
	IPQ	result	result	<u>result</u>	<u>result</u>
			PREM	<u><i>*EQ-5D</i></u>	<u><i>*EQ-5D</i></u>
			EQ-5D		
<i>Thumb</i>	MHQ		MHQ		MHQ
	<u><i>*Thumb ROM</i></u>		<u><i>*Thumb ROM</i></u>		<u><i>*Thumb ROM</i></u>
	<u><i>*Grip & Pinch</i></u>		<u><i>*Grip & Pinch</i></u>		<u><i>*Grip & Pinch</i></u>
	<u>strength</u>		<u>strength</u>		<u>strength</u>
<i>Finger</i>	MHQ	-	MHQ		MHQ
	<u><i>*Finger ROM</i></u>		<u><i>*Finger ROM</i></u>		<u><i>*Finger ROM</i></u>
	<u><i>*Grip strength</i></u>		<u><i>*Grip strength</i></u>		<u><i>*Grip strength</i></u>
<i>Wrist</i>	PRWHE	-	PRWHE		PRWHE
	<u><i>*Wrist ROM</i></u>		<u><i>*Wrist ROM</i></u>		<u><i>*Wrist ROM</i></u>
	<u><i>*Grip strength</i></u>		<u><i>*Grip strength</i></u>		<u><i>*Grip strength</i></u>
<i>Compression</i>	BCTQ	-	BCTQ	BCTQ	
<i>neuropathy</i>					
<i>Dupuytren</i>	MHQ	-	MHQ		MHQ
	Finger and/or		Finger and/or		Finger and/or
	Thumb ROM		Thumb ROM		Thumb ROM

Abbreviations: MHQ: Michigan Hand Outcome Questionnaire; VAS: Visual Analog Scale; VAS Function: Visual analogue scale for hand function; PREM: Patient Reported Experience Measure; PRWHE: Patient Rated Wrist-Hand Evaluation; BCTQ: Boston Carpal Tunnel Questionnaire; ROM: range of motion; Satisfaction: satisfaction with the outcome of treatment; PSFS: patient specific function scale.

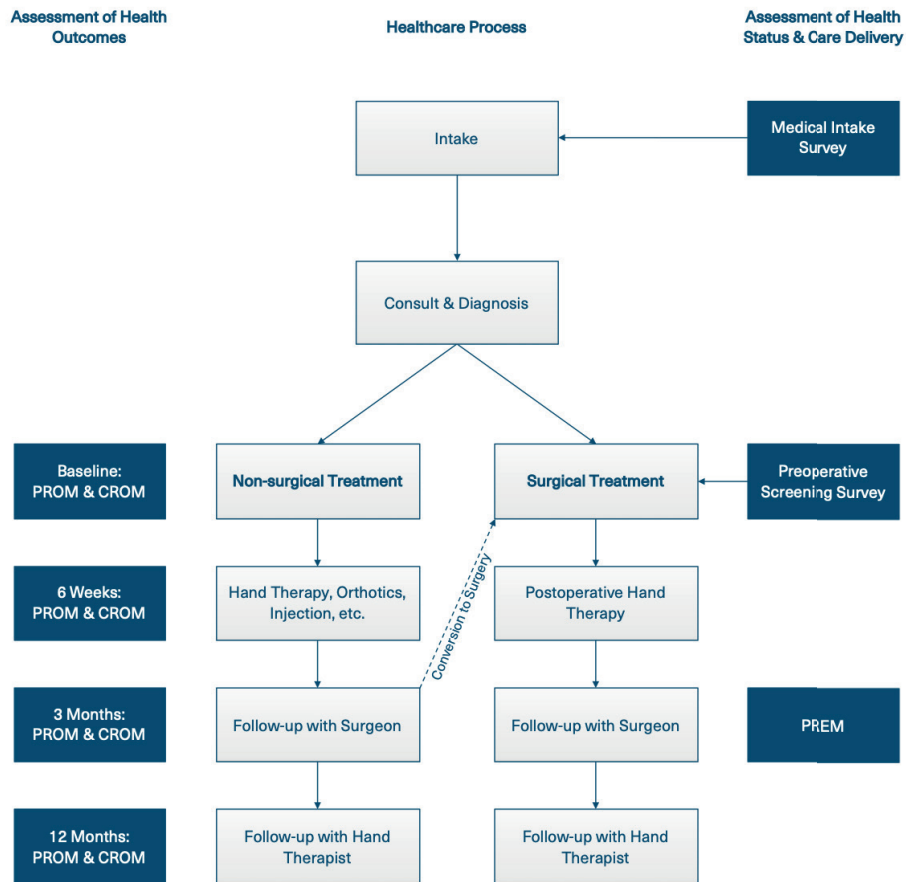


Figure 1. Flowchart of how measurements are timed relative to common care paths of patients. Since the measurement system is coupled to electronic patient records with care information, measurements and questionnaires emailed to patients, it can be fully automated as soon as non-surgical or surgical treatment is entered into the system.

RESULTS

Collected data

Figure 2 shows the number of tracks assigned to patients over the years. The total number of yearly assigned tracks increased up to over 16,300 in 2018, adding up to a total of 85,000 tracks in 52,000 patients. The increase in the track numbers reflects the growth in treatment volume and the opening of new centers. The regular tracks, which include non-surgical treatments (e.g.,

orthotics, exercise therapy, injections) and minor surgical interventions (e.g., trigger finger release), were more often assigned than extended tracks, which include more invasive surgery. Table 3 shows that the Michigan Hand outcomes Questionnaire (MHQ), Patient-Rated Wrist/Hand Evaluation (PRWHE) and our PREM are the most time-consuming measures, with a median of 3-4 minutes to complete. These completion times are lower than initially reported; for example, the MHQ is reported to take ± 15 minutes to complete according to its developers.⁸

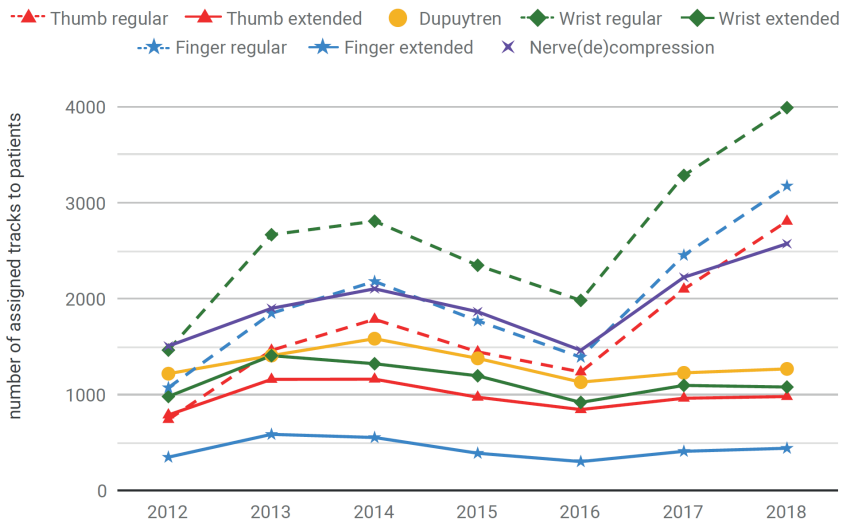


Figure 2. Number of yearly activated measurement tracks. Dashed lines indicate the regular tracks, solid lines the extended tracks. Note that more than one measurement track can be assigned to a patient, for example when a new treatment track (e.g., surgery) is initiated after an initial treatment track failed to obtain sufficient relief of symptoms (e.g., an injection or hand therapy). The decrease in track assignment in 2015 and 2016 was due to organizational problems leading to a significant number of patients where a measurement track was not assigned at the start of treatment. However, as can be seen below, this improved by 2017.

Patient compliance for completing questionnaires was highest at baseline. For example, for pain, hand function, and satisfaction questionnaires, compliance was 73% at baseline and decreased to 62% at 12 months (see Figure 3a). Compliance in extended tracks was 8% higher at baseline and 14% higher at three months compared to regular tracks. Compliance also decreased at follow-up for CROMS (Figure 3b); at baseline, 90% of measurement forms were completed, while at 3 and 12 months these numbers decreased to 50% and 38% respectively.

Table 3. The total number of patient questionnaires (across all tracks) and the median time to complete the questionnaires is shown for the period 2011-2018.

Questionnaire	Number of completed questionnaires	Median time to complete
MHQ	49925	4:15 min
PRWHE	28784	3:43 min
BCTQ	17680	1:54 min
Return to work	40998	0:39 min
Satisfaction with result	81534	0:14 min
VAS pain and function	135074	0:33 min
PREM	25407	4:17 min

Abbreviations: MHQ: Michigan Hand Outcome Questionnaire; VAS: Visual Analog Scale; PREM: Patient Reported Experience Measure; PRWHE: Patient Rated Wrist-Hand Evaluation; BCTQ: Boston Carpal Tunnel Questionnaire.

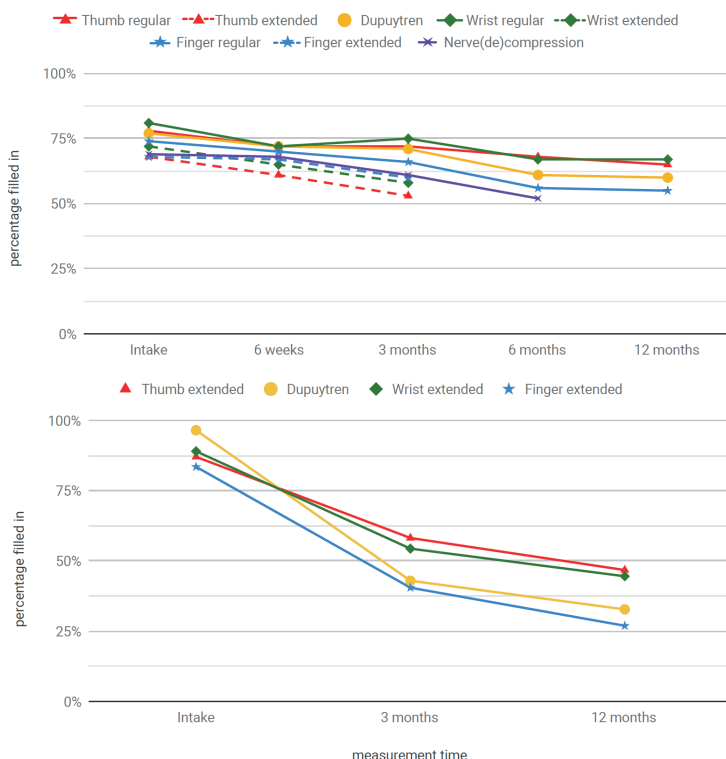


Figure 3. A) Compliance of patients completing the patient-reported outcome measurements, illustrated using the compliance on the Visual Analogue Scale for pain, hand function and satisfaction. There are differences in compliance between measurement tracks, but the most important factor is the decrease in compliance when the treatment is performed longer ago. B) Compliance of hand therapists filling in the clinician-reported outcome measurements, such as goniometry and grip strength.

Using outcome data in clinical practice

From the start in 2011, all surgeons, therapists, and staff had direct access to all scores of individual patients and their development over time. Hence, for example, hand therapists use the measurements to evaluate treatment progress and set new treatment goals. Also, we introduced an integrated secure patient portal (Figure 4) to allow patients to access their treatment information. Within this portal, patients can complete their questionnaires and see their progress over time. Based on the assigned treatment, patient-specific treatment information is provided, e.g., disease-specific instructional videos on postoperative exercises. In 2018, approximately 3100 patients logged into their patient portal each month.

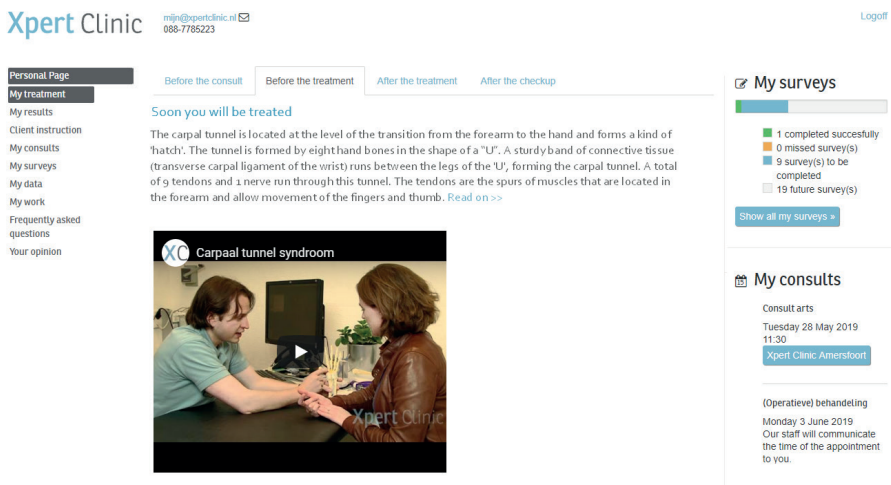


Figure 4. Screenshot of the personalized patient portal, where patients can learn about the treatment, healthcare process, expected outcomes, exercises and can also complete the required questionnaires. As soon as a measurement track is assigned to a patient, disease-specific information is being provided.

From 2017 onwards, we show individual patient outcomes relative to the average outcome from previous patients. For example, patients can see their pain score over time relative to mean scores of previous patients undergoing the same treatment (see Figure 5). Moreover, we introduced a physician dashboard, where physician-specific outcomes for >100 treatments are compared to the average of all other physicians.

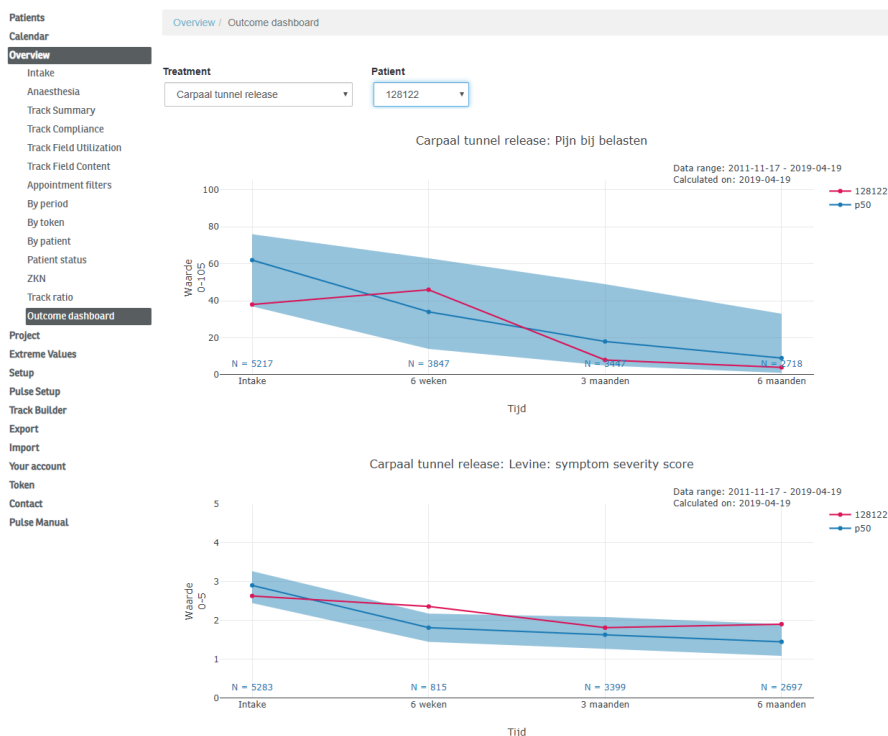


Figure 5. Screenshot of a physician dashboard, showing the individual patient's outcome (magenta line) compared to the 'average patients' outcomes (blue line, p50 and blue area, p25-p75) after a carpal tunnel release. The data shown can be modified by the user; a treatment, a treatment location and a surgeon can be selected. These outcomes will then be plotted over the outcomes of all surgeons, treatment locations for each treatment.

Scientific research with the collected data

While our data collection system was primarily designed to improve and monitor the quality of healthcare of our patients, the system also constitutes a cohort of high-quality data suitable for scientific research: The Hand-Wrist Study Group Cohort.

Comparative effectiveness and prediction modeling

Our first published studies⁹⁻¹³ focused on comparative effectiveness. In these studies, variation in daily clinical practice within our cohort is used to compare different treatments, for example, when different surgeons prefer different

treatments in the same patient population. To correct for baseline differences between treatment groups, we use propensity score matching and mixed models. For example, we showed that collagenase clostridium histolyticum in Dupuytren's disease was not significantly different from limited fasciectomy in reducing metacarpophalangeal joint contractures in short term outcome, whereas proximal interphalangeal joint contractures showed slightly better reduction following limited fasciectomy.⁹ Furthermore, we demonstrated that exercise therapy in addition to an orthosis reduces pain more compared to an orthosis only in patients with thumb base osteoarthritis¹³ and that, following a thumb carpometacarpal resection arthroplasty, shorter immobilization is non-inferior compared to more prolonged immobilization.¹⁰

In addition to comparative effectiveness, we use our data to develop and validate prognostic and clinical prediction models that allow outcome prediction of individual patients, for example on the outcome of non-surgical for thumb base osteoarthritis¹³⁻¹⁶, surgical treatment of primary or recurrent carpal tunnel syndrome¹⁷⁻¹⁹ and surgery in Dupuytren's contracture.^{20, 21}

Healthcare context and treatment outcomes

We also study how outcomes are not only influenced by treatment but also by the process of care delivery and patient experiences. More specifically, we consistently found positive associations between patient experiences on care delivery and improvement in PROMs following surgical treatments.^{5, 22, 23} The strongest associations were found for positive experiences with the communication of the surgeon and providing treatment information, which is in line with other studies.^{5, 22, 23}

Clinimetric studies

The collected data also allows evaluating the psychometric measurement properties. For example, in patients with Dupuytren's contracture, we reported that the Patient-Specific Functional Scale (PSFS) is more responsive than the more generic and standardized MHQ, despite being much shorter to fill in.²⁴ Additionally, we developed decision tree-based versions of the PRWHE²⁵ and the Boston Carpal Tunnel Questionnaire²⁶ to reduce the number of items needed to calculate the total score from 15 and 18 to 6 for both PROMS, without loss of information (see <http://handquestionnaires.org>).

DISCUSSION

We introduce the design, development, and implementation of a routine outcome measurement system in hand and wrist care, describing how our data are collected and used for improving clinical care and performing scientific research. The system was feasible by using a highly automated data collection infrastructure, tightly linked to the patient journey and the workflow of healthcare professionals. With this paper, we intend to share our experiences in designing such a system, our lessons learned, and describe the remaining challenges.

The design and implementation of our routine outcome measurement system were facilitated by the specific expertise of the collaborating parties. The Erasmus MC, as a large academic hospital, contributes extensive scientific knowledge and Xpert Clinic, as a highly specialized clinic, can quickly innovate and integrate the measurements in their workflow. By developing dedicated software,⁶ we could customize the data collection to our specific needs and implement changes efficiently.

Ensuring high compliance of both patients and clinicians remains a big challenge, as in all outcome measurement systems.²⁷ We took several measures to optimize compliance. A first step was to minimize the measurement burden and allow direct measurement feedback to both patients and clinicians. A second step was to improve data integration during consults and therapy. For instance, instead of asking for limitations in daily life during a patient's first visit, clinicians can now see this information beforehand and can discuss these issues directly. As a third step, we visualize individual outcomes relative to other patients, which provides a reference for both patient and clinician to discuss treatment outcomes. At present, we present outcomes as group means plus confidence intervals at the level of specific treatments (e.g., a trapeziectomy) but this can be further personalized to individuals, e.g., a 70-year old female a baseline MHQ score of 50. Hence, in the future, we plan to extend this and present individualized outcome predictions based on existing data.

Although clinicians value outcome information, more research is needed on how to efficiently use outcome data to improve quality of care, while maintaining practical feasibility. Presently, it remains challenging for clinicians to actually

use the data in daily practice, due to a variety of reasons such as lack of time or inexperience in how to use the data in daily clinical practice. Another concern is that a multitude of factors can influence expected outcomes for an individual patient which need to be taken into account when discussing the expected outcome with a patient. Therefore, we are presently developing models that can predict outcome of individual patients. Our current efforts are focused on the implementation of these models in daily clinical practice so that they can be used in real-time during consultation. In addition, in the future, we plan to link outcome data with the cost of treatment as recorded in the electronic healthcare record, providing insight into the quality of care from a value-based healthcare perspective.

We found that efficient data acquisition software allows outcome recording with a relatively small time investment per patient. Further, at present, the main costs include software development and maintenance (approximately 2-3 fte throughout the last years for all participating treatment centers) and the efforts of staff, management and researchers to design the system. By making the GemsTracker software open-source and describing our procedures in detail, we intend to lower the costs for new centers to develop a similar system. However, despite our successful implementation, reimbursement by healthcare insurance companies for outcome measurement remains unusual, despite the wish of insurance companies and the government to collect outcome data. Hence, further collaboration between healthcare providers, scientists, insurance companies, and governments is needed, since these investments are currently being made by healthcare organizations themselves.

When comparing the Hand-Wrist Study Group cohort with other large cohorts and related initiatives, there are significant similarities and differences. For example, registries such as the Swedish hand registry²⁸ have larger patient numbers but less detailed information. Other commonly-used cohorts consist of administrative or claim data on hospital, regional, or national level (e.g.,²⁹⁻³²). To our knowledge, the present cohort is unique within the field of hand and wrist disorders since it contains a large number of patients with relatively great detail of data, covering both outcomes, treatment information and patient characteristics. A limitation, however, is that this cohort is not representative of all hand and wrist patients in the Netherlands, for example, because complex

trauma patients and patients with more severe comorbidities may be treated more often elsewhere. Also, if patients seek treatment elsewhere, no follow-up is available.

For all clinical (e.g., quality evaluation and benchmarking) and scientific analysis, missing data are always an important issue. In several of our research papers, we have performed extensive missing data analysis and have consistently found that our data can be qualified as missing completely at random.³³⁻³⁶ In literature, many statistical analyses and simulation papers have indicated that either multiple imputation techniques or analysis that account for missing data are superior to complete case analyses.³³⁻³⁷ However, we noticed that such techniques are counter-intuitive to many readers. Consequently, we have frequently been asked by journal reviewers to report complete cases, despite that there is literature advising otherwise.

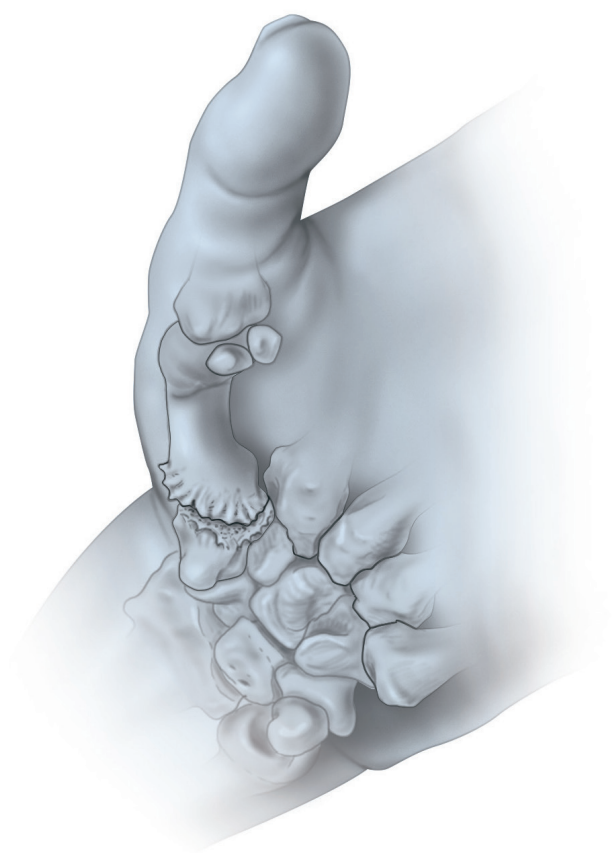
Since measuring outcomes is central in value-based healthcare,¹ it would be of great value if more healthcare providers in hand and wrist care would routinely measure outcomes. Although there have been several consensus initiatives on outcome sets^{28, 38-41}, none has led to widespread implementation. We hope that our example of routine outcome measurement implementation and the development of the hand and wrist standard set by the International Consortium for Health Outcome Measurement⁴² will lead to a common ground for more widespread comparisons of outcomes.

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CHAPTER 4

CLOSING THE LOOP: A 10-YEAR EXPERIENCE WITH ROUTINE OUTCOME MEASUREMENTS TO IMPROVE TREATMENT

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ABSTRACT

Routine outcome measurements as a critical prerequisite of Value-Based Healthcare have received considerable attention recently. There has been less attention for the last step in Value-Based Health Care where measurement of outcomes also leads to improvement in the quality of care. Probably this is not without reason, since the last part of the learning cycle: “Closing the loop”, seems the hardest to implement.

The journey from measuring outcomes to changing daily care can be troublesome. As early adopters of Value-Based Healthcare, we like to share our 10 years of experience in this journey.

Examples of feedback loops are shown based on outcome measurements implemented to improve our daily care process as a focused hand surgery and hand therapy clinic.

Feedback loops can improve shared decision making, monitor or predict treatment progression over time, extreme value detection, improve journal clubs, and surgeon evaluation.

Our goal as surgeons to improve treatment should not stop at the act of implementing routine outcome measurements.

We should implement routine analysis and routine feedback loops, because real-time performance feedback can accelerate our learning cycle.

INTRODUCTION

Routine outcome measurements have been the mantra in healthcare for the past ten years and have been instigated to yield better outcomes¹. However, in order to improve care, the outcome measurements must alter the way treatments are selected, shared decisions are made, or the treatments are executed. This process requires four consecutive steps: collecting the data, valuing the data, interpreting data, and using the data to change patient care².

In 2008, we founded a private hand surgery clinic offering public service in The Netherlands. The startup position allowed for a complete redesign of hand surgery care. Early on, we added Value-Based healthcare (VBHC) principles such as integrated care, healthcare network, focused clinic, and routine outcome measurement³. In addition, management, hand surgeons, and a hand therapist attended Harvard business school in collaborative teams to adopt the VBHC strategy.

While we successfully collected outcome data and used this for analysis and scientific research⁴, the most resilient part of this endeavor was to change our current practice based on these outcomes. Porter stated in his paper on Value-based Healthcare that a feedback loop is essential for improving outcomes³; “Without such a feedback loop, providers lack the requisite information for learning and improving”. We sought precise moments in the regular delivery of care to insert user-friendly feedback loops for patients, surgeons and hand therapists.

In this paper, we review examples of strategies to implement feedback within the care process and describe how this has influenced our daily practice. We demonstrate improvements implemented in the following areas of shared decision making, baseline thresholds, individual prediction, progression over time, journal club, physician evaluation and extreme value detection.

PATIENTS COHORT

Our integrated practice unit works as a fully integrated team of both hand surgeons and hand therapists entirely focused on hand and wrist care. We developed a web-based and open-source information system named Pulse⁵

to collect data from patients, doctors, and therapists. Pulse provided us the necessary platform and tools to follow the outlined VBHC principles.

We started routine outcome monitoring in 2011 and have successfully integrated this with our daily care. Selles et al. describe in our paper in 2020⁴ how we set out to measure the variety of treatments in our clinics. Our clinic currently consists of over 23 level 3 to 5 trained hand surgeons⁶, over 150 hand therapists, and 22 centers for hand and wrist surgery.

We have currently gathered baseline and follow-up information of more than 86,000 surgical and non-surgical treatments, with over 500,000 patient-reported outcomes. Data analysis and peer-reviewed publications are guided by the Hand Wrist Study group, a partnership of Xpert Clinics, Erasmus MC - University Medical Centre Rotterdam, and other national and international collaborators. Currently, we publish over 15 peer-reviewed papers a year.

This review includes data from patients treated conservatively or surgically between December 2011 and December 2020. This data is prospectively gathered on a consecutive cohort of patients treated in daily hand surgery practice. Patients were invited to be part of a routine system for outcome measurement after their first consultation with a surgeon. Upon agreement, they received questionnaires distributed via email. Patients were asked to complete validated Dutch versions of hand specific Patient Reported Outcome Measurements (PROMs) at baseline and after surgery depending on the type of treatment⁷. Amongst other PROMs, we use the Boston Carpal Tunnel Questionnaire (BCTQ), Patient Rated Wrist/Hand Evaluation (PRWE)⁸, and Michigan Hand outcome Questionnaire (MHQ). Additionally, patients receive questionnaires on satisfaction with the treatment results, their return to work, and Patient-Reported Experience Measurements (PREM). This routine system also included measurements by trained hand therapists of the range of motion and grip strength for the more extensive surgical treatments.

We collect the data reported in this review as part of routine clinical care and ask all patients for permission to use their data anonymously for scientific research. If a patient does not provide informed consent, the data is only used for direct health care purposes but not for scientific analysis. Patients can always withdraw their consent. Approval from the local medical ethical review board is obtained for each scientific study that uses the data.

TEAM

To close the loop between the data entered by patients and hand therapists and the provided care, we have constructed a team of IT specialists, epidemiologists, statisticians, and researchers who work with the hand surgeons and hand therapists to provide meaningful analyses of the data. In this collaboration, physicians' questions and requests are translated into research questions, data analyses, and, ultimately, into improvements in care delivery.

RESULTS

Below, we will first illustrate how we use the outcome data to improve care by directly returning outcome data to our patients for shared-decision making, patient selection by baseline thresholds, individual prediction of treatment results, and outcome progression over time for an individual patient. Secondly, we will describe how our surgeons and therapists use feedback loops as part of their ongoing learning process in our journal club and physician evaluation. Finally, we show how we use extreme value detection to intervene when needed to support the role of patients, physicians, and management.

Shared-decision making

In shared-decision making, the healthcare provider discusses the diagnosis and treatment options together with the patient. The patient describes his goals and wishes, and the healthcare provider discusses the outcomes and uncertainties of the different treatment options.

We use our data in various ways to optimise this shared-decision making process. For example, we have developed graphs to show our outcomes for all treatments we provide (see Figure 1). These graphs allow patients to understand the average recovery of previous patients and the variation in results. In this way, we can transparently discuss the outcome based on our actual data and manage the patient's expectations, enabling us to objectively answer the questions that insurers, patient organisations, and patient's family instruct patients nowadays to ask: "What are the expected outcomes?" and "How often do you do this particular surgery?". Formerly, we would answer these questions by citing literature mixed with personal opinion and personal experiences. With these tools, we can give an exact and real-time answer to these questions using our routine outcome measurements.

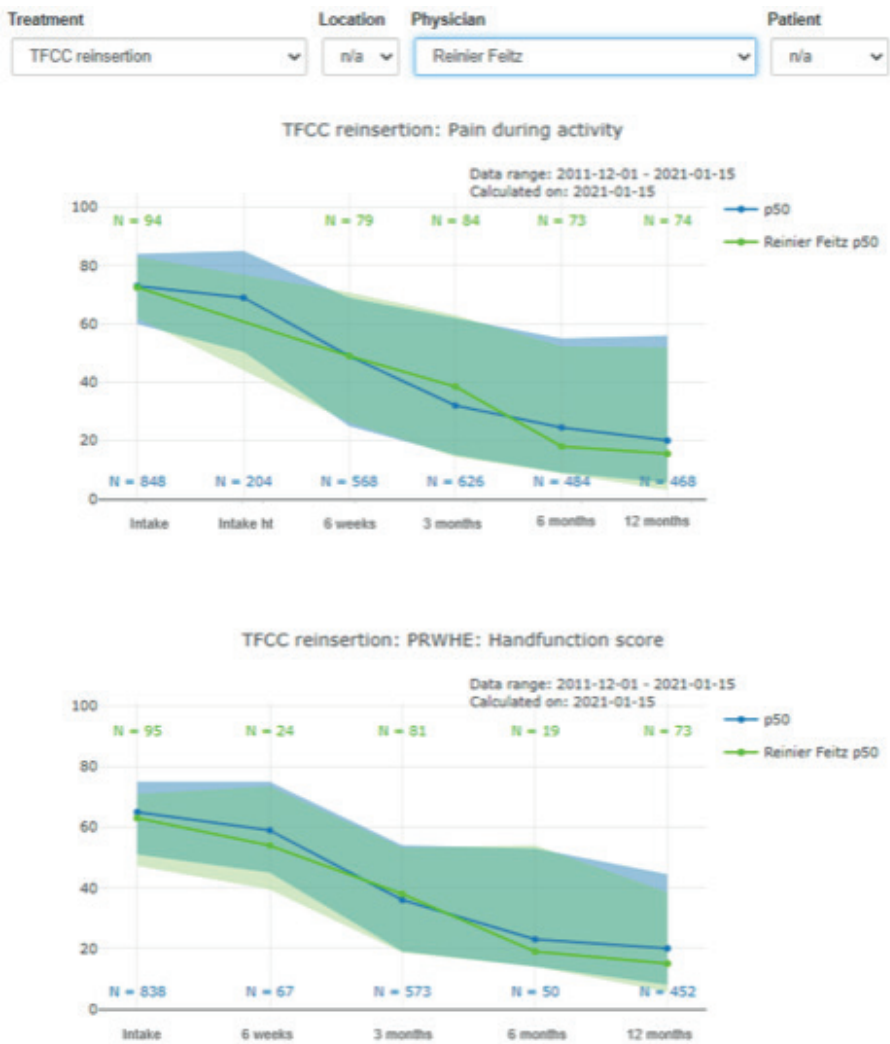


Figure 1. Results of Triangular fibrocartilage complex (TFCC) surgery of one specific surgeon. The graph depicts the outcome for open TFCC surgery from baseline to 12 months post-surgery for pain during activity and function via the PRWE score. The green line is the median (p50) surgeon's personal result (1st author) of his 94 cases versus the total of 848 patients in the database. The shaded areas illustrate the range of the 25th to 75th percentile for both the surgeon and the population. Also shown are the numbers of filled in questionnaires as each time point used to calculate the graph. These outcome pictures are used in shared-decision making to help the patient decide whether or not to opt for this procedure.

Baseline thresholds

Baseline PROM values can guide indication for surgery^{9,10}. Installing thresholds for baseline values that are necessary to obtain a successful outcome of surgical intervention may improve the overall result. For example, a patient may demand a specific surgical procedure while the treating physician thinks that the indication is weak. Arguments against such a demand for intervention can be difficult and often imply weighing a patient's complaints on scales for pain and activity. This process may feel subjective for both patient and physician. However, low baseline levels of pain and slightly impaired function give little room for improvement in pain or function post-surgery. When we looked at the specific situation of open surgery for triangular fibrocartilage complex (TFCC) problems, we found examples of this situation (see Figure 2): The communication of a tear in the TFCC at wrist arthroscopy might provoke a response in the patient that this tear needs to be repaired (11) even though initial complaints might occasionally occur. When we analysed our series of open surgery for TFCC, the baseline PRWE proved to be a good indicator of the outcome. More specifically, chances of reaching a Minimal Clinical Important Difference (>17 points on the PRWE scale) are minimal for a baseline PRWE lower than 34. To select the patients who benefit from our surgical intervention, we designed a warning system that informs our surgeons to reconsider when scheduling a patient with baseline PRWE below 34.

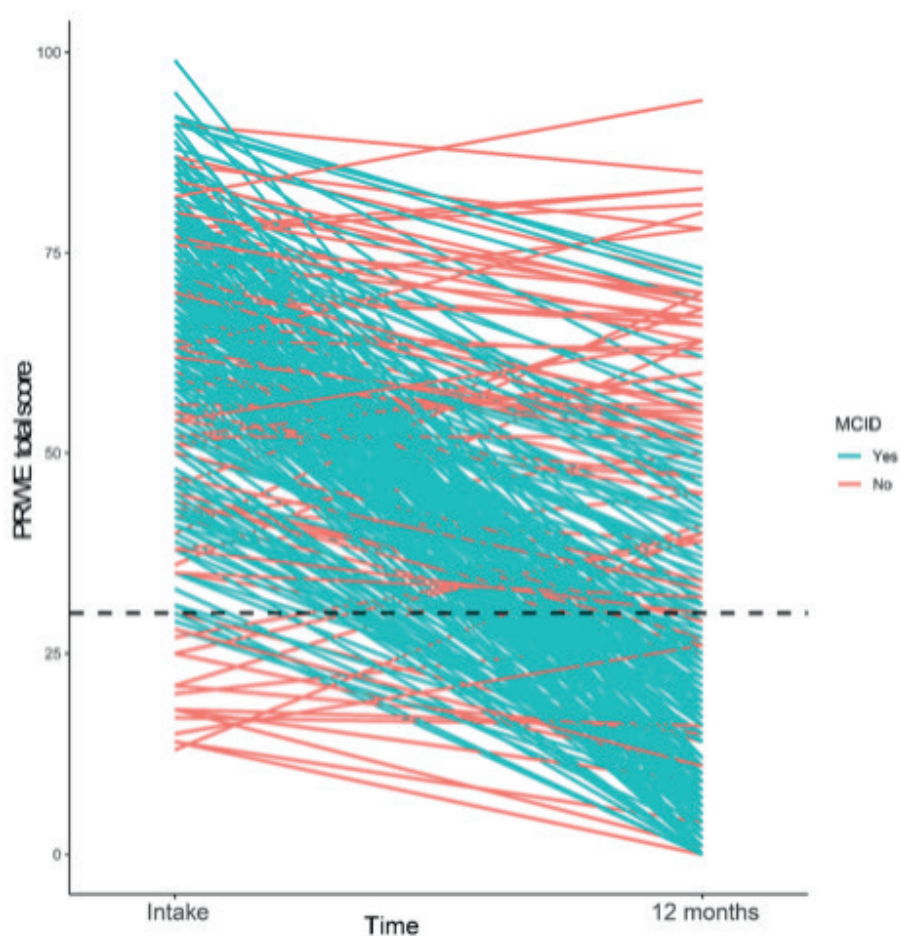


Figure 2. Plot of individual patients on PRWE results after open TFCC surgery. Chances of reaching a Minimal Clinical Important Difference (MCID) are minimal for a baseline PRWE lower than 34. Blue lines are patients who reached MCID, red lines for patients that failed to reach MCID (<17).

Individual prediction of treatment results

As a next step to provide patients with information about the results of previous patients, we are in the process of implementing individual prediction models of expected outcomes based on our data. This will further detail the predictions since it can take other predictive variables into account, such as age, gender, the severity of complaints, and duration of complaints. We have currently developed prediction models for Dupuytren's disease¹¹ and Carpal Tunnel Release (CTR)

¹². While these are at present stand-alone online tools, they will be coupled to our data collection systems and patient dashboards in the near future. This way, the patient's data can be sent directly to the prediction model to predict whether the individual patient will reach the Minimal Clinical Important Difference, for example, on the BCTQ score following a CTR (Figure 3).

Figure 3. Prediction model Carpal Tunnel Release (CTR). Patients and caregivers fill in several items, for example, the Symptom Severity Scale of the BCTQ and the degree of pain. A chance is then displayed that the complaints will improve after CTR. This tool has been made publicly available online: <https://analyse.equipezorgbedrijven.nl/shiny/cts-infographic/>

Outcome progression over time

During follow-up visits at the outpatient clinic, clinicians are on forehand informed about the patient's progress if they have answered all questionnaires. The patient's results are plotted in a graph against all previous patients (see Figure 4). This can help to understand the phase of recovery of the individual patient. For example, many patients will experience some residual pain in the early weeks after surgery and may want to know if that is normal or acceptable. The graph thereby allows discussing and evaluating the patient's goals during the rehabilitation. Based on the results of outcome measurements, therapy can be adjusted. For example, if strength is still clearly reduced compared to the preoperative situation, hand therapists and patients may focus more on strength training. Also, it motivates the patients to keep answering the questionnaires we send them.

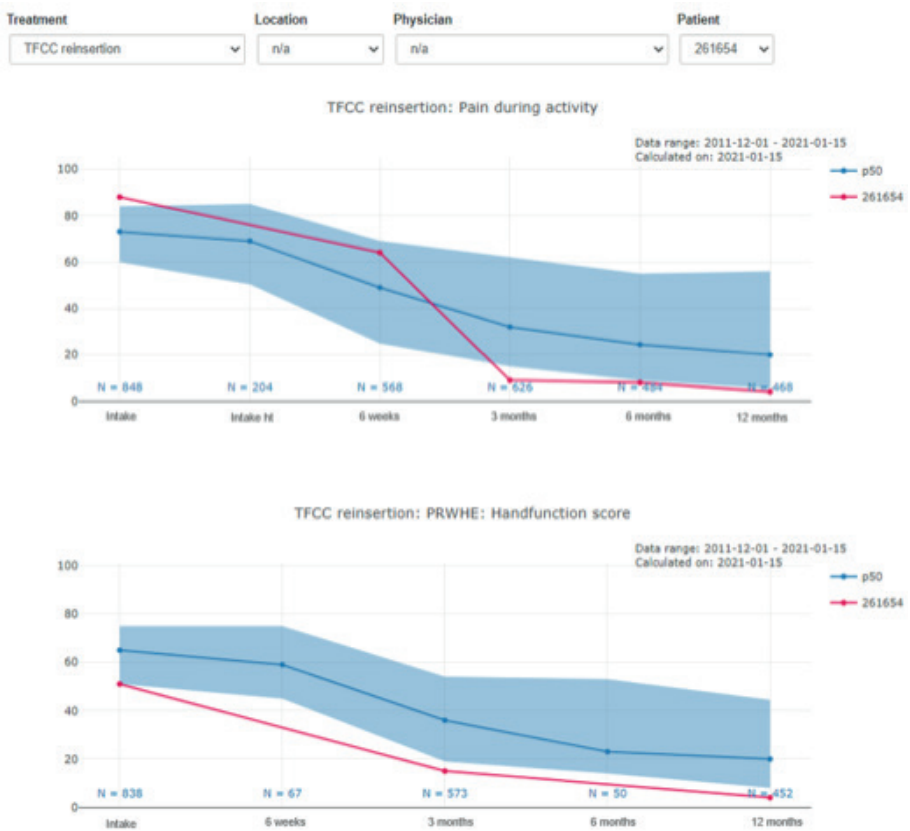


Figure 4. Results of patient 261654 routinely plotted against the overall outcome for TFCC injury. The red line shows the patient's progress for the pain during activity and the PRWE score. The shaded areas illustrate the range of the 25th to 75th percentile for the total population. These outcome pictures are used to evaluate the rehabilitation of each individual patient.

Utilisation of the Journal club

Having the possibility to do real-time or almost real-time analysis of our cohort also created new dimensions for our journal club. Just as other groups of clinicians, we monthly discuss current literature in hand surgery. Typically, clinicians discuss published literature and whether we should alter our treatment algorithms. Personal opinion and experience would direct discussions at large.

We improved learning by adding our own outcomes to the arguments. To do so, one of our PhD candidates or researchers is present at these meetings and can real-time analyse our database or prepare a more complex analysis. For

example, during the journal club about radial tunnel release, the researcher made a plot (Figure 5) to show the BCTQ over time of our results. Another example was during a journal club where we evaluated a change in the postoperative regime. Based on surgeon preferences, patients received a shorter, less postoperative regiment. During the journal club, the researcher showed that both regiments yielded equal outcomes. Based on this, we reached a consensus for immobilisation following surgery for thumb base osteoarthritis. Specifically, we now give patients a cast for three to five days, followed by a removable thermoplastic orthosis. This allowed for earlier onset of hand therapy and more comfort after surgery for our patients. In turn, these discussions led to the publication of a peer-reviewed paper ¹³.

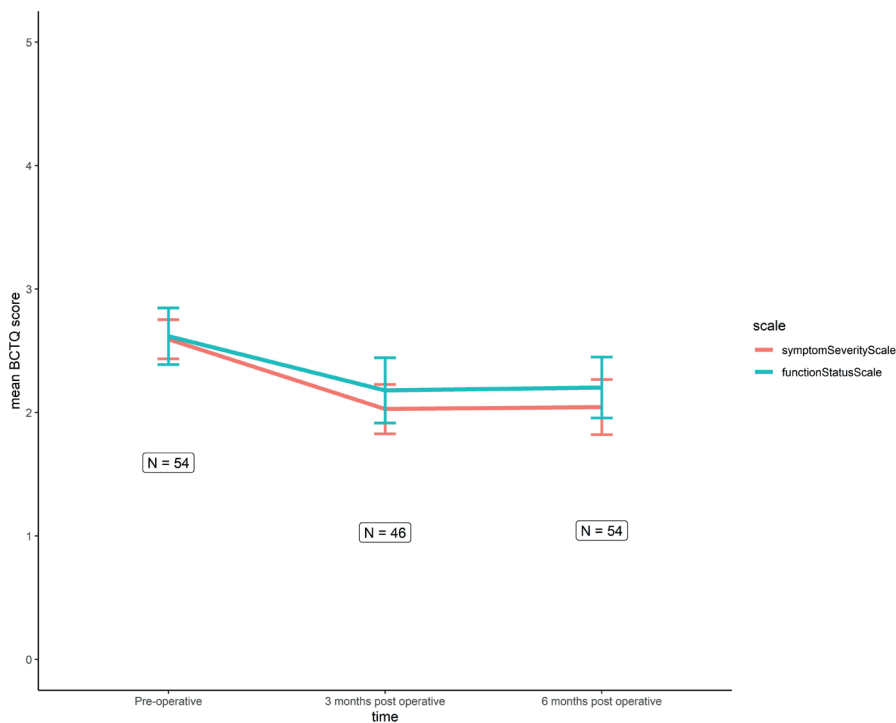


Figure 5. Results of a journal club. Surgeons were interested in the outcomes of radial tunnel releases. This figure depicts the outcome of radial tunnel releases on the BCTQ over time. The researcher made a plot of 54+ patients, of which data was available, and presented this figure at a journal club meeting.

Physician evaluation

The outcome data also provides surgeons with regular updates about their overall performance. To do so, surgeons receive quarterly updates about their performance across the following domains: financial and operational excellence, communication and service, and medical outcomes of three commonly performed surgical procedures. By using a Plan-Do-Check-Act (PDCA) cycle, we can continuously improve on these domains.

In the Financial and operational excellence domain, we provide information on several financial and operational parameters such as the number of new consultations, revenue in the outpatient clinic, revenue in the surgical theatre, number of procedures, total surgical fee, percentage of conservative treatment, and case-mix complexity.

In the communication and service domain, we provide information on PREM outcomes. We decided on the Net Promotor Score (NPS)¹⁴ as a proxy for patient experience. The question asked is: “How likely would you recommend the clinic to other people with the same condition or symptoms on a 0-10 scale?”. The NPS is calculated by subtracting the percentage of detractors (rating 0-6) from the percentage of promoters (rating 9 or 10). Hence NPS can vary between -100 or + 100. Our goal is to stay above +50, whereas the average NPS for Dutch hospitals was +18 in 2019¹⁵. The NPS for the individual doctor (see Figure 6) and regional network (see Figure 7) are shown longitudinally to analyse trends.

Various subdomains for patient experience are also monitored to provide surgeons and regional networks with actionable insights that can boost NPS score. Perception of the surgeon by the patient regarding knowledgeability, seriously listening, taking time, information about expected result, information over the treatment, opportunity to raise questions, understandable explanation, shared-decision making, welcome at the clinic, cooperation between healthcare providers, and waiting time before the consultation are rated. Also, an overview of compliments and complaints are presented.

In the medical outcome domain, we provide information on three commonly performed surgeries: trapeziectomy, CTR, and 3-ligament tendon reconstruction of the wrist. For each treatment, medical outcome is shown for the individual physician relatively to the overall average. The graphs used are

similar to the one shown in Figure 1 for TFCC outcome. These physician scores may appear as the most direct exposure of an individual’s surgical talent but proved to be rather uneventful. The chosen commonly performed procedures are done in high volumes. In the last years, we learned that in our population of highly specialised surgeons, individual patients’ outcome varies widely but that all our surgeons score close to the average with no outliers. Apart from this, an overview of complications is presented.

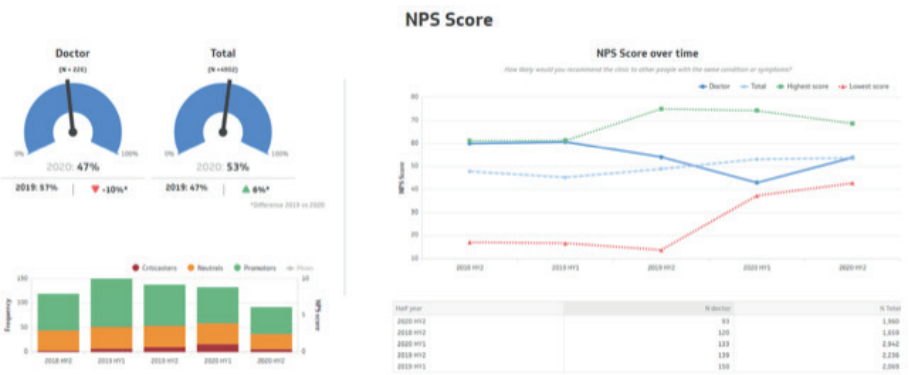


Figure 6. Screenshot of the Net Promotor Score (NPS) dashboard. The NPS is shown per year and overtime per half year. Also, the distribution of promoters, neutrals, and criticsasters is shown.

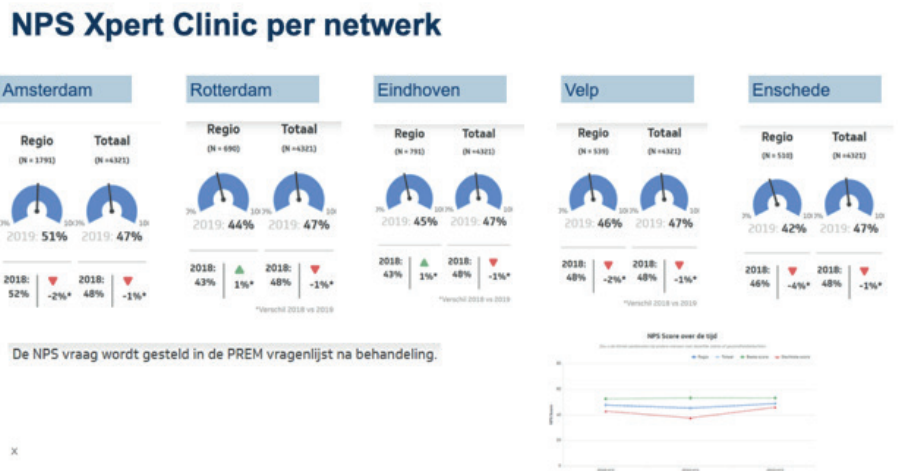


Figure 7. NPS score for each regional network in the Netherlands.

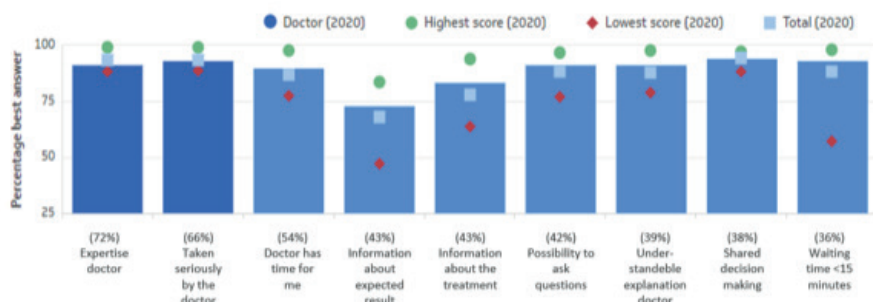


Figure 8. Patient-Reported Experience Measurements (PREM); perception of the surgeon by the patient regarding knowledgeability, seriously listening, taking time, information about expected result, communication over the treatment, opportunity to raise questions, understandable explanation, shared-decision making, waiting time before the consultation.

Extreme value detection

Post-surgery complications that occur after discharge from the hospital or clinic often have a gradual onset. A developing infection or a plaster of Paris that becomes tight due to postoperative swelling are examples of such problems. Therefore, we routinely monitor postoperative pain levels. Whenever a patient enters a visual analog pain at rest score (VAS) equal to or above 70 (Scale 0-100), this will trigger an email to the nursing staff. They will seek contact with the patient as soon as possible to evaluate whether a change in the treatment plan is needed. This module allows for early detection of potential complications. It diverts emergency calls or out of office hours visits into planned visits, early plaster release, or early start with antibiotic therapy. Another effect is that well-trained and knowledgeable medical staff, most commonly a hand therapist or nurse, handle these alerts at an overall lower cost. The same detection system is used for outlier negative experience that can lead to early detection and intervention of miscommunication or other reasons for a negative experience which would otherwise go unnoticed.

DISCUSSION

How can individual patient treatment and outcomes benefit from routine outcome measurements? Outcome registration in general requires participation and altruistic effort from the individual patient to fill out questionnaires to benefit future patients. Our data and feedback have transformed our shared-decision making process. We use our outcome registration to inform patients

transparently about our outcomes in general, for individual prediction of outcome, and for their personal treatment progression over time. Usually, when patients participate in scientific research, it affects future patients' treatment; whereas in our clinic it is an integrated part of their treatment experience. Patients undergo orthopaedic surgery in order to relieve pain or improve function. Therefore, our surgery and conservative treatment results should be monitored, and the results should ideally be fed back to inform our patients¹⁶. Compliance of our patients to answer the questionnaires and the medical staff's compliance to use the feedback information presented have been, and still are, the biggest challenges we face.

In addition to the importance for our patients, the routine outcome measurements support clinicians to discuss expectations with patients and provide information about treatment results. They enable the clinicians to evaluate the rehabilitation progress of their individual patients as well as overall outcome per treatment. Our database helps to reference and guide discussions in our journal club. Surgeon scorecards give our surgical team feedback on their overall and individual performance in various domains. A question that comes to mind is the managerial consequence of the available data on physicians. Upfront, we asked our surgeons whether they wanted the information to be anonymised or to include individual surgeon names. Uniformly they decided on the latter. Up to this moment, the individual scores are only visible to surgeons and the medical director but blinded for overall management or other staff. Literature shows that resistance among the professionals may exist for implementing scorecards or surgeon outcomes¹⁷⁻²⁰. We did not experience any resistance and were, in fact, encouraged by our surgical staff. The intention was to install feedback loops without being judgmental. Surgeons, who experienced over 12 years of medical training, are in general competitive and need no further enhancement other than feedback information.

The last example shared in this paper was the extreme value detection. This feature demonstrated benefits for all parties involved. The patient with an outlier level of pain receives early intervention for this pain. The surgeon profits from early detection and intervention of possible complications or complaints. Management and clinic profit from a decline in hours needed for handling complications by a less costly staff during regular hours.

We believe that there are also disease-independent lessons to be learned. We tend to be more cautious when a patient has low baseline scores (i.e. low pain, good hand function). Another important consideration is a very high baseline score on either pain or low functional score. We now know and can discuss with our patients that they are likely to end up with more than an average improvement on pain and function while they will still experience more than average postoperative pain and function loss. We have shown these effects for scapho-lunate ligament reconstruction (21), carpal tunnel disease(22), thumb osteoarthritis(23), Dupuytren's(24), Quervain's disease(25), and open TFCC surgery(26). Although it is hard to prove that we deliver better care than before the start of registering outcome data, we believe that these feedback loops improved our advice in the shared-decision process.

General evidence supporting PDCA cycles is abundant. Papers on individual surgeon's performance measurements are scarce and especially for data on the positive impact of measuring surgical performance on medical outcome²¹. Thoracic surgeons seem to lead the way¹⁸ with the obvious advantage of large databases and absolute outcome metrics as cardiac failure or death. Direct feedback regarding urologists' percentage of positive resection margins led to an improvement of outcome in a study by R. S. Matulewicz¹⁹. A French study on a nationwide scale demonstrated a positive correlation with the outcome of care after implementing control cards²⁰. Our future goals will be to implement the new International Consortium for Health Outcomes Measurement (ICHOM) set for hand wrist disorders²² (see Figure 9), improve dashboards for patients, surgeons, and therapists. And, finally, to get compliance up to 80% so we can collect data for level I studies continuously.



Figure 9. The handwheel, ICHOM Standard Set for Hand & Wrist Conditions

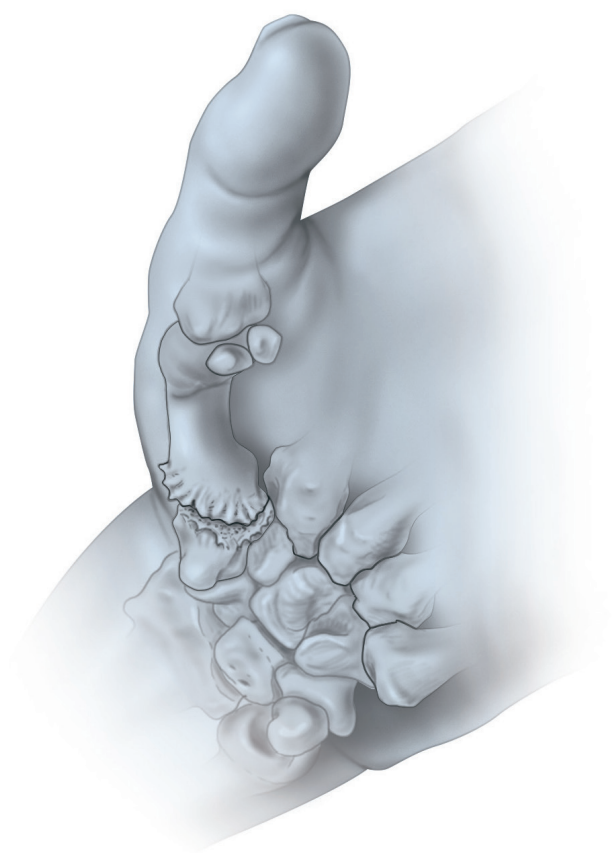
CONCLUSION

Our goal as surgeons to improve treatment should not stop at the act of implementing routine outcome measurements. Just as well, we should implement routine analysis and feedback loops so we accelerate our learning cycle and thus improve treatments. We share some practical examples of how routine outcome measurements with the right feedback loops can improve daily clinical care, which benefits patients, therapists, surgeons, and management. We realise that these examples give no evidence that they improve health outcomes. However, in order to improve outcomes, we first need to be informed about them. Adding real-time performance feedback has accelerated our learning cycle and has convinced us that we better understand our results.

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CHAPTER 5

ITEM REDUCTION OF THE PATIENT-RATED WRIST EVALUATION USING DECISION TREE MODELLING

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ABSTRACT

Background: The aim of this study is to assess the viability of a decision tree version of an often used questionnaire to measure wrist pain and disability, the Patient Rated Wrist Evaluation.

Methods: Patient Rated Wrist Evaluation scores were collected from a cohort of 10394 patients who are part of a routine outcome measurement system. A decision tree version of the Patient Rated Wrist Evaluation (PRWE) was created. The intraclass correlation was used to evaluate the inter-version reliability between the original PRWE and the decision tree version.

Results: The decision tree reduced the number of questions from 5 to 3 for the pain subscale, and from 10 to 3 for the disability subscale. The intraclass correlation between the original PRWE and the decision tree version was 0.97. The mean difference between the Patient Rated Wrist Evaluation and the decision tree Patient Rated Wrist Evaluation total sumscore was 0.35 (95% CI -9.92 – 10.62).

Conclusions: We found that the decision tree was successful at reducing the items of the Patient Rated Wrist Evaluation from fifteen to only six questions with very high similarity to the scores of the full questionnaire.

BACKGROUND

Monitoring and recording patients' pain, disability and quality of life is increasingly important in medicine. Patient reported outcome measures (PROMs) are widely used to accomplish this and are frequently used as primary outcomes of clinical trials ^{1,2}. PROMs are also incorporated in patient monitoring systems to evaluate the quality of care ³, to provide personalised medicine ^{4,5} and as part of value based healthcare analysis ^{3,6}.

A frequently-used PROM in hand surgery, hand therapy and rehabilitation medicine is the Patient Rated Wrist Evaluation (PRWE) ⁷. The PRWE was developed to create a valid and reliable tool to quantify pain and disability of the wrist ⁸ in disorders such as distal radius, scaphoid fractures, arthritis or other musculoskeletal disorders affecting the wrist and hand. The PRWE has a score between 0 to 100 with two subscale scores; pain and disability. A low score on the PRWE represents little pain or disability while a high PRWE score represents a high level of pain and disability. The PRWE correlates significantly with measures such as grip strength, range of motion and the SF-36 quality of life questionnaire ⁷. Good to excellent test-retest reliability was reported for both the original questionnaire as well as for several language versions, including the Dutch language version ⁹. The PRWE has been recommended as a core outcome measure for assessment of distal radius fractures ^{10,11}.

Since it has been reported that a longer questionnaire will have a lower response rate ¹²⁻¹⁴ there has been a focus on defining shorter versions accepted measures ¹⁵⁻¹⁸. Shorter measures can improve efficiency of assessment or allow time for additional constructs to be assessed. Especially in busy clinical settings shorter questionnaire may provide smoother delivery of care. For the PRWE, However, no attempts to reduce the length of the questionnaire have been reported. In other questionnaires for example, during development of the QuickDASH ¹⁷ three different methods were used; expert opinion, a correlation analysis and a Rasch model, with expert opinion ultimately selected as the most parsimonious solution to reduce the DASH from 30 items to 11. Another method is applied in PROMIS, an international collaboration to develop a generalized item bank for PROMs, which uses computerized adaptive testing based on item response theory ¹⁹. An alternative promising method to reduce item length of questionnaires is by generating decision trees using Chi-squared Automated Interaction Detection (CHAID).

CHAID is a non-parametric data mining technique used to automatically detect interactions between categorized variables in large data sets²⁰. It is often used as an analytical method for market segmentation, but has recently also been successfully applied for item reduction of the personality and life events questionnaire²¹. A potential advantage of CHAID over other item reduction methods is its efficiency in data reduction. For the personality and life events questionnaire CHAID-based modelling resulted in a reduction of questions from 26 to 4, instead of a reduction to 9 questions as achieved with computer adaptive testing based on item response theory²¹.

So far, CHAID has rarely been used as an item reduction technique for PROMs. In the present exploratory study, we aim to determine if we can develop a decision tree-based version of an often used PROM in hand surgery (PRWE) with a significant reduction in questions without compromising the psychometric performance.

METHODS

Patient selection

In this retrospective cohort study we used data from all patients treated between November 2011 and May 2016 in Xpert Clinics, a network of private practices for hand surgery and hand therapy, that were treated conservatively or surgically for a wrist-related problem (see Table 1 for a specification of the most common disorders). Data used in the present study were collected as part of routine outcome measurement of all patients in all 11 participating clinics. All patients gave consent for anonymized analysis of their data and institutional review board of the Erasmus MC approved the study.

Measurement

Patients were asked to fill in a web-based version of the Dutch patient reported wrist/hand evaluation⁹. This questionnaire consists of 17 questions, divided into a pain subscore of five items, a disability subscore of ten items and aesthetics subscore using two questions. The aesthetics subscore is not scored, pain and disability scores can vary between 0 and 50 and can be combined into a total sumscore²². From these patients, all PRWHEs completed on intake, six weeks,

three months, six months or twelve months were analysed. Only the PRWE part of the questionnaire was used for analysis excluding the questions concerning cosmetics of the hand, that only appear on the PRWHE version.

Decision tree development

The decision tree was generated using the Chi-squared Automated Interaction Detection (CHAID) ²⁰ algorithm. This algorithm classifies data based on the interaction between dependent factors and an independent factor. In this study the dependent factor was the sumscore of the pain or disability subscale of the PRWE. The independent factors were the individual questions. The algorithm works in several steps: First, the algorithm will identify the question which answers will provide the best discrimination of the sumscore. Secondly, it will try to split all questionnaires based on the answers of the identified question into subgroups. Splits were only performed when splits were significant, with a p-value < 0.05. Thirdly, within those subgroups the algorithm will identify the most discriminative question and split the subgroup again based on the answers of the most discriminative question in the subgroup, until stop conditions are met. Finally, when stop conditions are met, an end group (= terminal node) is created. For each terminal node a score will be predicted. The end result of the algorithm is a decision tree which classifies questionnaires based on their answers to specific questions and predicts the sumscore for each terminal node.

Optimization of split and stop parameters of the CHAID algorithm was performed to find the optimal decision trees for both the pain and disability sub scores separately. Parameters used for optimization were the minimal split, minimal bucket and the maximal depth ²⁰. Minimal split was defined as the minimal number of PRWE questionnaire needed for the algorithm to perform a split, minimal bucket was defined as the minimal amount of questionnaires in a subgroup after splitting and maximal depth was defined as the maximal amount of splits allowed to perform on each questionnaire.

The completed PRWE questionnaires were randomly split into a development and a validation group in a three-to-one ratio. The development group was used to optimize, develop and select a decision tree. The validation group was used to assess the agreement of the selected decision tree with the original PRWE in an independent dataset.

To select an optimal decision tree we calculated the difference between the original PRWE sub score and the predicted subscore for all questionnaires, for each decision tree developed with an unique set of parameters. The mean and standard deviation of these differences was calculated for each decision tree. We manually selected the optimal decision tree-based on a combination of a low standard deviation and a low depth (i.e., a small number of questions). The resulting final Decision Tree PRWE (DT-PRWE) was used for further comparisons with the original PRWE.

Reliability and agreement

To compare the DT-PRWE with the original PRWE in the independent validation group, we performed three analyses. The intraclass correlation between the original PRWE and the DT-PRWE was calculated to assess the inter-version reliability. In addition, Bland-Altman plots were made to analyse the agreement between the original PRWE and DT-PRWE scores. The mean difference and the range of agreement between the PRWE and the DT-PRWE was also calculated. Finally, we calculated spearman correlations between the original and DT-PRWE score. All analyses were performed using R, with the interface R studio. More specifically, the CHAID package ²³.

RESULTS

Patient selection

In total 10394 patient reported wrist evaluations (PRWE) were completed between November 2011 and May 2016, which were randomly split into a development group containing 7795 questionnaires and a validation group containing 2599 questionnaires. Characteristics of patients who completed the questionnaire can be found in Table 1. Within both groups there was heterogeneity in terms of, amongst others, duration of the symptoms and pathology. However, as also can be seen, patient characteristics were similar between both groups.

Table 1. Patient characteristics.

	Development Group (n=7795) %*	Validation Group (n=2599) %*
Operated hands		
Right	60	61
Left	38	37
Dominant hand		
Right	85	84
Left	10	11
Bimanual	3	3
Gender		
Female	61	61
Age		
< 20	8	8
20-30	17	17
30-40	15	16
40-50	17	19
50-60	20	18
60-70	8	8
70 >	2	2
Durations of disability		
Less than 3 months	16	16
3-6 months	20	21
6-12 months	24	23
12-24 months	17	17
24-48 months	11	10
More than 48 months	10	10
Workload		
No payed labor	21	20
Light physical labor	30	31
Medium physical labor	28	29
Heavy physical labor	19	18
Treatment type		
Surgically	71	71
Conservative	27	27

	Development Group (n=7795)	Validation Group (n=2599)
	%*	%*
Treatment		
First extensor lodge release	9	10
Wrist arthroscopy	8	8
Tendinitis or Tendovaginitis	8	8
Brunelli	7	6
GCD	6	6
TFCC reinsertion	5	5
MCI	4	4
Pisiformectomy	3	4
PRC	3	4
GCV	3	3
Radius osteotomy	3	3
Scaphoid osteosynthesis	2	2
Ulna shortening	2	2
Other	34	34
Answering time	2:54[2:03-4:24]**	2:55[2:03-4:23]**

All questionnaires were randomly assigned to either the development or validation group. The table displays the characteristics of patients that completed the PRWE questionnaire. Both groups were heterogeneous but comparable in terms of characteristics.

* Percentage of the corresponding group

** Shown are median and [Q1-Q3]

Decision tree development

The results of the optimization for the CHAID based decision trees for the pain sub score, using the development group data, are displayed in Figure 1. Maximal depth (that is, the maximum number of questions that is allowed) was varied between two and four and minimal bucket size between 10 and 100. The minimal split size was linked to the minimal bucket size and was always three times larger. The standard deviation of the difference between the original PRWE and the predicted PRWE pain score in the development group ranged between 2.5 and 3.4 points on the 0-50 PRWE pain score, depending on the maximal depth and minimal bucket size. More specifically, a larger minimal bucket size and a maximum depth of 2 resulted in higher standard deviations while a maximal depth of 3 and 4 resulted in an almost equal standard deviation. Therefore, we selected a decision tree for the pain sub score, highlighted with the arrow, with a maximal depth of three and a minimal bucket size of 10.

The results of the optimization for the CHAID-based decision trees for the disability sub score, using the development group data, are displayed in Figure 2. Maximal depth was varied between three and six and minimal bucket size between 10 and 100. The minimal split size was linked to the minimal bucket size and was always three times larger. The standard deviation of the difference between the original PRWE and the predicted PRWE pain score in the development group ranged between 2.5 and 3.4 points on the 0-50 PRWE disability score, depending on the maximal depth and minimal bucket size. More specifically, a larger minimal bucket size resulted in higher standard deviations while any maximal depth resulted in an almost equal standard deviation. Therefore, we selected a decision tree for the disability sub score, highlighted with the arrow, with a maximal depth of three and a minimal bucket size of 30. A total of 336 terminal nodes were created, thus there are 336 different ways of navigation through the DT-PRWE with a maximum of 3 questions per patients per subdomain. An online version of the DT-PRWE ²⁴ can be filled in and provides subscores and a total score. In addition, syntax for a LimeSurvey version of the DT-PRWE questionnaire is available as download.

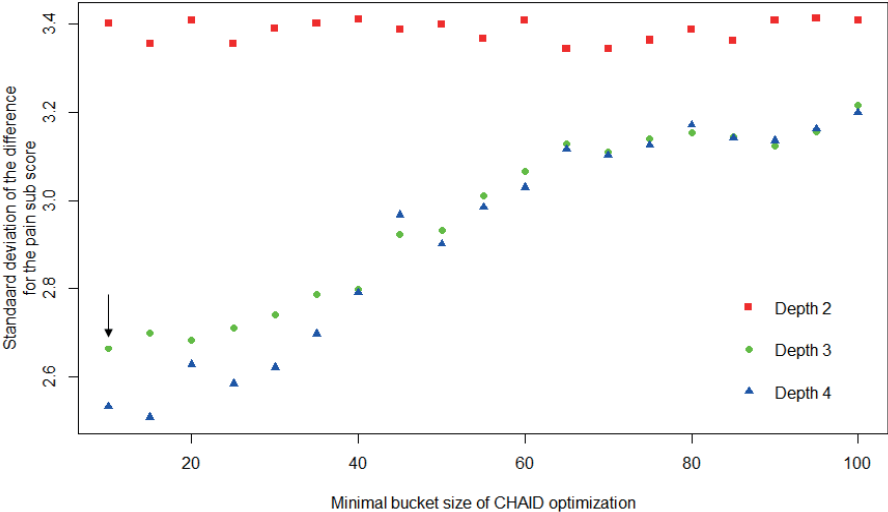


Figure 1. Standard deviation of the difference between the PRWE pain score and the DT-PRWE pain score. Optimization of the CHAID-algorithm displaying the standard deviation of the difference between the original Patient Reported Wrist Evaluation (PRWE) and the decision tree-based PRWE (DT-PRWE) in the development set as a function of minimal bucket size and maximal depth of the CHAID-algorithm. A lower standard deviation indicates more similarity between both scores and therefore a better decision tree. The arrow indicates the decision tree that was selected for the PRWE-DT.

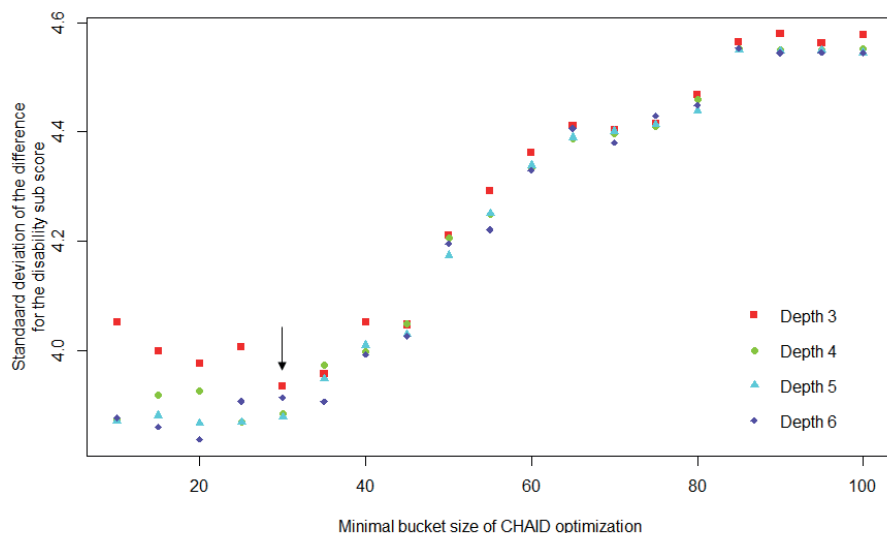


Figure 2. Standard deviation of the difference between the PRWE disability score and the DT-PRWE disability score. Optimization of the CHAID-algorithm displaying the standard deviation of the difference between the original Patient Reported Wrist Evaluation (PRWE) and the decision tree-based PRWE (DT-PRWE) in the development set as a function of minimal bucket size and maximal depth of the CHAID-algorithm. A lower standard deviation indicates more similarity between both scores and therefore a better decision tree. The arrow indicates the decision tree that was selected for the PRWE-DT.

Reliability and agreement

The differences in the validation dataset between the original PRWE and DT-PRWE for all individual questionnaires are displayed in Figure 3A-C. All figures display a normal distribution with a high peak around a zero difference and relatively low width. The Intra Class Correlation (ICC) calculated between the original PRWE sumscore and the DT-PRWE was 0.96 for the pain subscore, 0.92 for the disability subscore and 0.97 for the total PRWE sumscore. Spearman correlations between the PRWE and DT-PRWE were 0.98, 0.97 and 0.98 for, respectively, function, pain and total score. The agreement between the PRWE and the DT-PRWE are further shown in the Bland Altman plots for both subscores (Figure 4). From these plots, it can be seen that agreement is highest for high and low scores, while the middle range showed lower agreement. Furthermore, the Bland-Altman plots show the mean difference between PRWE versions as the middle red line and the 95% confidence interval of the mean difference as the upper and lower red lines. The agreement of the pain subscore has a mean difference of -0.18 with a 95%CI between -6.04 and 5.67. The agreement of

the disability subscore has a mean difference of 0.53 with a 95%CI between -7.67 and 8.74. The agreement of the total sumscore has a mean of 0.35 with a 95%CI between -9.92 and 10.62.

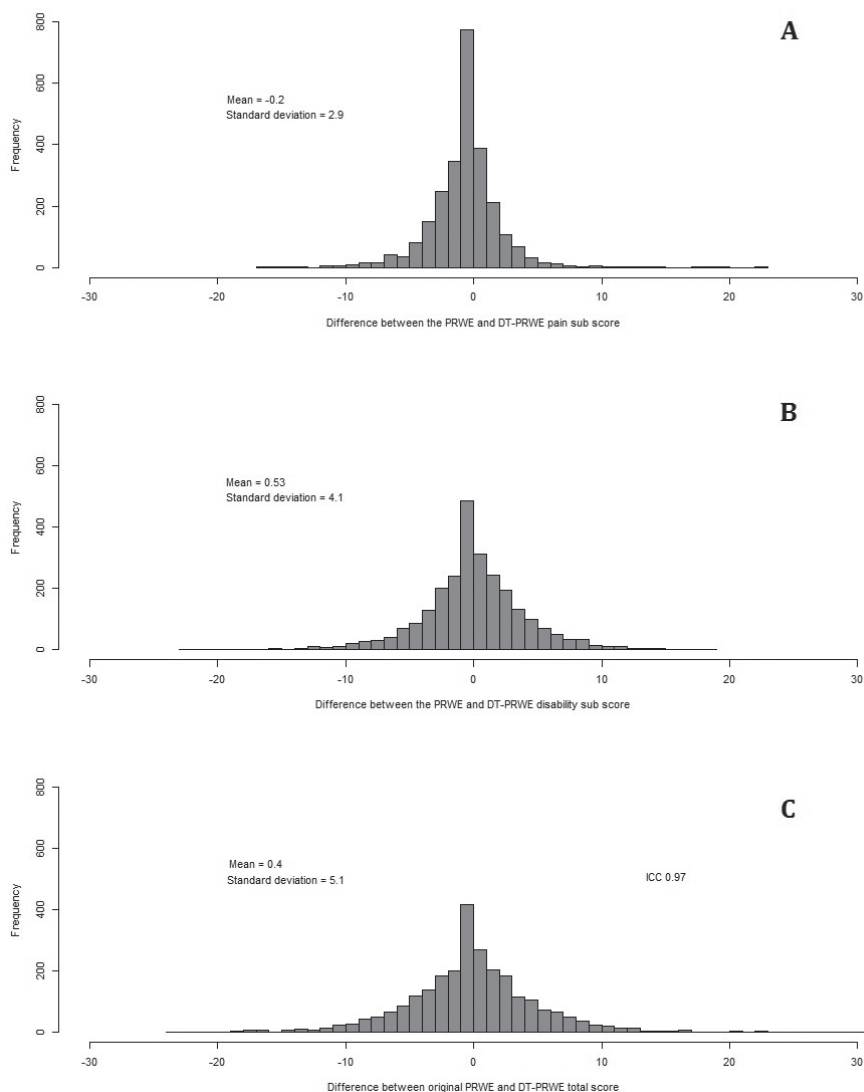


Figure 3A-C. Distribution of the differences between original PRWE score and DT-PRWE. Figure 3A shows this distribution for the pain sub score, 3B for the disability sub score and 3C for the total score of all questionnaires in the validation group. Furthermore, ICC of the total score is displayed for all questionnaires in the validation group.

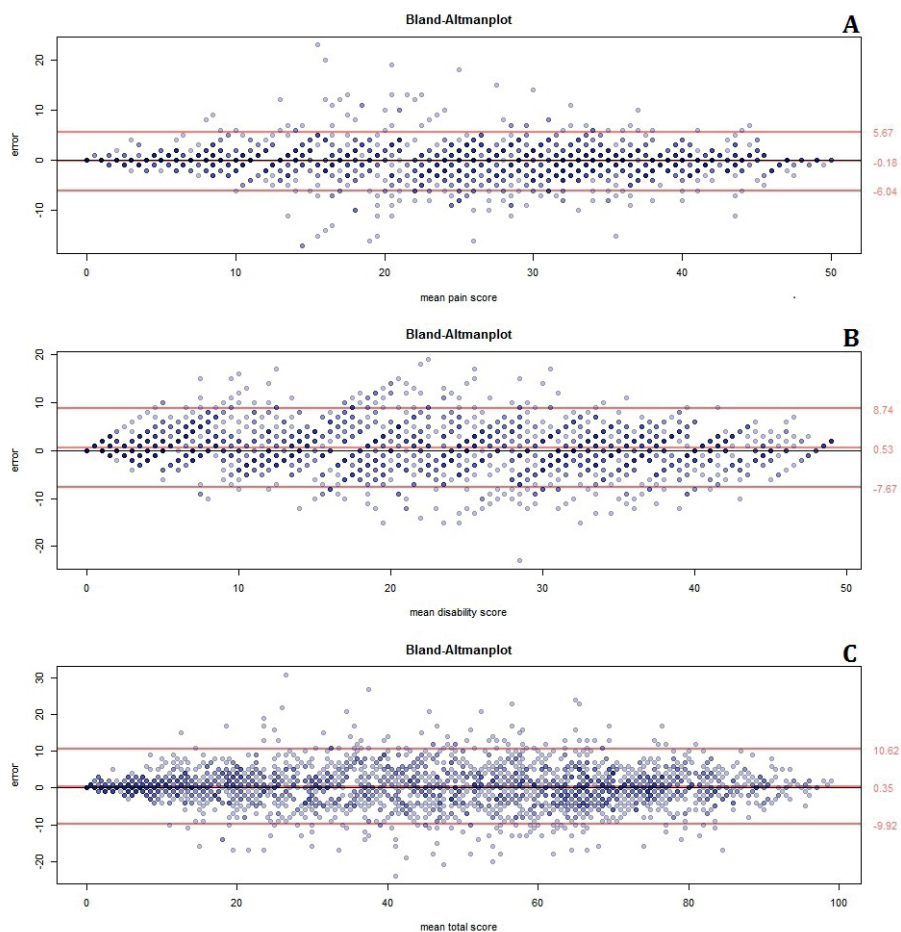


Figure 4ABC. Bland-Altman plots displaying the agreement between the original PRWE and the decision tree PRWE. Figure 4A shows this agreement for the pain subscore of the Patient Reported Wrist Evaluation (PRWE). Figure 4B shows this agreement for the disability subscore of the Patient Reported Wrist Evaluation (PRWE). Figure 4C shows this agreement for the total sumscore of the Patient Reported Wrist Evaluation. In all figures, the middle red line represents the mean error. The outer lines represent the 95% confidence interval. The darkness of the dots indicate the number of overlapping data points at the same location.

DISCUSSION

This study developed and evaluated a decision tree-based version of the PRWE using the CHAID algorithm resulting in a significant reduction in the number of questions while maintaining a high agreement with the original questionnaire. After parameter optimization, we developed a decision tree for the subscores of pain and disability separately, that can be combined into a total PRWE score. Using only a maximum of three questions per subscore, we found an ICC of 0.97 between the original PRWE sumscore and the DT-PRWE sumscore in our independent validation dataset. Bland-Altman plots indicated higher agreement between both versions in patients with relatively low and high scores, while a lower agreement was found in patients in the middle range of scores. The Bland-Altman plots do not show any systematic bias, although confidence intervals do indicate that scores could vary up to about 10% of the score maximum between versions

The present study cannot directly be compared with previously performed test-retest validation studies. However, the reliability reported in these studies can provide context to interpret the differences that we find in the present study between the full version and the decision tree version. The minimal detectable change of 12.2²² is larger than the limits of agreement in the Bland-Altman plot, indicating that the difference between the full version and the decision tree scores is smaller than the minimal detectable difference of the original PRWE. This is also supported by the high correlation between the original and DT-PRWE scores.

The finding in the present study that the number of items of PROMs such as the PRWE can be reduced using techniques such as a decision tree questionnaire while maintaining high agreement with the original questionnaire is in line with findings for other reductions of PROMs, using similar or different techniques. Techniques to reduce item number can be divided into techniques resulting in fixed reductions and in dynamic reductions. When using fixed reductions, the reduced questionnaire always consists of the same items in the same order, such as in the QuickDASH and Brief MHQ[13,14]. When using dynamic reductions, follow-up items are based on the response(s) of the previous item(s), such as in computerized adaptive testing²⁵ and in a decision tree questionnaire. The QuickDASH and Brief MHQ were developed by identifying the questions

that correlated best with the final score within each subscore. This resulted in a reduction of the DASH from thirty to eleven items, with an ICC of 0.94. The Brief-MHQ reduced the number of items from thirty-seven to twelve, with a correlation of 0.99 with the original score. This is comparable with the ICC of 0.97 we found in our study.

The decision tree approach used in the present study has a number of advantages. A first advantage is that we were able to maintain both subscores (pain and disability) and maintain the multidimensionality of the original PRWE. For example the QuickDash and Brief MHQ did not maintain subscores. In addition, maintaining this multidimensionality makes possible to combine and compare data from the DT-PRWE with data from the full questionnaire, since previously completed questionnaires of the full version can be converted to the DT-PRWE questionnaire score. Since a decision tree questionnaire can only be administered electronically, we made an electronic version of the questionnaire, available as download, in the open source LimeSurvey software to facilitate use of the DT-PRWE. This questionnaire can be administered using an internet connection or can be completed offline. In contrast, computerized adaptive testing (CAT) based on item response theory uses a continuous connection with a server to administer the questionnaire. Another advantage of CHAID over CAT is the potential efficiency in reducing items, as has been shown in previous research²¹.

The present study has a number of strengths and limitations. A strength is that we were able to develop and test the decision tree using over 10.000 completed questionnaires. This allowed the CHAID algorithm to develop a decision tree version of the PRWE with an agreement of 0.97. The large amount of questionnaires used for the development and validation allowed the algorithm to reliably predict a score on a scale between 0 and 50, similar to the original PRWE scale. A possible limitation of this study is that we simulated how patients would fill in the DT-PRWE based on their responses on the original PRWE. It is possible that responses to the proposed DT-PRWE differ from the responses to the original PRWE because the items are not asked in the same sequence.

A general limitation for any form of a short version of a questionnaire, whether it is using a fixed or dynamic reduction, is that it reduces the amount of information that is obtained from individual patients. When, for example,

a questionnaire is used to screen if patients show specific patterns in specific questions at an individual patient level, then a short version of the questionnaire may not be appropriate. However, in case the questionnaire is also used to determine how the scores of a patient on a specific items change over time, the DT version is not appropriate since the same questions may not be asked again. Additionally, future research should better determine the responsiveness, reproducibility and validity of the DT version. However, for example, for measuring outcome at group level, for comparative effectiveness, for quality of care evaluation and value-based healthcare, often several questionnaires are collected from the same patients and the outcome of interest is a total score. In that case, a shortened questionnaire may be a time-efficient way to increase patient compliance and reduce patient burden. A further application of our DT version to calculate a total score for the full PRWE when patients do not complete the entire questionnaire. Many outcome measure developers suggest substitution of the mean score, the impact of this strategy has not been evaluated and it can be problematic where multiple items are missing. Use of DT version would provide a validated approach to handling missingness.

Given the PRWE was already a relatively brief scale the benefits of reduction in items would have to be weighed against any potential changes in measurement properties beyond those evaluated in this study. Future research into questionnaire reduction using a decision tree should focus on multiple aspects of the reduced questionnaire. Primarily, the reliability of the DT-PRWE should be compared with the reliability of the original PRWE in a test-retest study, and where the score are not derived from the full version. Secondly, responsiveness of both the DT-PRWE and the original PRWE should be tested, preferably for multiple musculoskeletal diagnoses. Finally, clinical implementation of the DT-PRWE should be investigated. More specifically, patients experience with the electronic DT-PRWE can provide an interesting point of view.

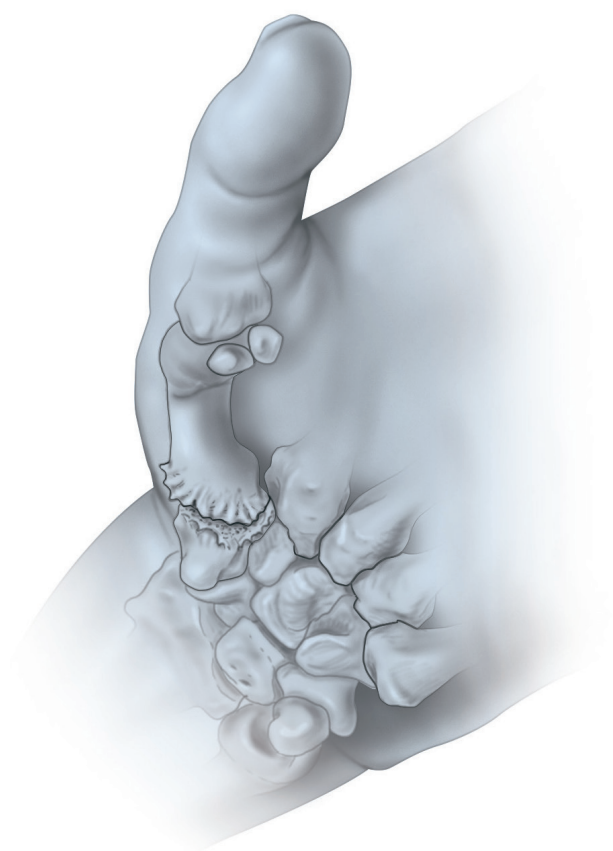
CONCLUSIONS

We found that the CHi-squared Automated Interaction Detection (CHAID) algorithm is able to reduce a patient reported outcomes measure, which is widely used in hand surgery and therapy, The developed decision tree patient reported wrist evaluation (DT-PRWE) uses maximal six instead of fifteen questions and has a high agreement with the original PRWE.

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CHAPTER 6

ITEM REDUCTION OF THE BOSTON CARPAL TUNNEL QUESTIONNAIRE USING DECISION TREE MODELLING

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ABSTRACT

Objective: The aim of this study is to produce an electronic decision tree (DT) version of the Boston Carpal Tunnel Questionnaire (DT-BCTQ) using the Chi-squared automatic interaction detection (CHAID) algorithm to reduce questionnaire length of the Boston carpal tunnel questionnaire (BCTQ) while minimizing the loss of measurement properties.

Design: Criterion standard study. All BCTQ's completed between January 2012 and September 2016 by patients who were treated for carpal tunnel syndrome (CTS) were randomly divided into a development and a validation dataset at a three-to-one ratio. Optimization of the CHAID-algorithm was performed in the development dataset to determine the most optimal DT-BCTQ.

Setting: Private hand clinic providing both surgical and non-surgical (orthosis and exercise therapy) treatment for hand and wrist disorders.

Participants: 4470 CTS patients completed a total of 10055 BCTQ's.

Interventions: Not applicable.

Main outcome measures: The intraclass correlation coefficient (ICC) was calculated between the original BCTQ-scores and the scores predicted by the DT-BCTQ in the validation dataset. Bland-Altman plots visualized the agreement between the BCTQ and the DT-BCTQ.

Results: The DT-BCTQ reduced the number of questions needed to ask a patient from 11 to a maximum of 3 for the symptom severity scale (SSS) domain and from 8 to maximally 3 for the functional status scale (FSS) domain. The ICC between the original BCTQ and DT-BCTQ was 0.94. The mean difference between the BCTQ and DT-BCTQ was 0.05 on the 0-5 scale (CI= -0.48, 0.57) for the SSS, 0.02 (CI= -0.45, 0.49) for the FSS and 0.04 (CI= -0.31, 0.39) for the total BCTQ-score.

Conclusion: By creating the DT-BCTQ, we diminished the number of questions needed to ask a patient from 18 to a maximum of six questions, three for each subscore, when administering the BCTQ while maintaining an ICC of 0.94 with the original BCTQ.

INTRODUCTION

In modern patient-centred healthcare, the patient experience of disease is increasingly important in both clinical practice and research¹. To assess patient experience of disease, patient-reported outcome measurements (PROMs) are frequently employed for monitoring disease², improving quality of care³ and as primary outcomes in clinical research⁴. Within the field of hand surgery, a widely used PROM to assess the severity of carpal tunnel syndrome (CTS) is the Boston Carpal Tunnel Questionnaire (BCTQ)⁵ also known as the Levine questionnaire. The BCTQ is often utilized as a primary outcome measure in clinical CTS research⁶⁻⁸ and is herein the most commonly-used standardized measure to assess symptom severity⁹. Although the BCTQ has been found to be a reliable, responsive and acceptable instrument¹⁰, it has also been shown that questionnaire length and a low patient-perceived content validity of the questionnaire might be burdensome for patients and that response burden is negatively correlated with a reduction in response rate¹¹. In addition, diminishing response burden of multiple PROMs can be beneficial, especially in clinics where patients are asked to fill in multiple questionnaires at frequent timepoints. In PROM research, reducing questionnaire length while maintaining robust psychometric properties is frequently proposed¹²⁻¹⁷. Regarding the BCTQ, a six-item version of the SSS-domain of the BCTQ was developed by applying exploratory factor analysis and item response theory (IRT) analysis of the original SSS¹⁷.

A method that is particularly suitable for reducing item length of electronic questionnaires is Chi-squared Automated Interaction Detection (CHAID). CHAID is a non-parametric method to automatically detect interactions between categorical variables in large datasets¹⁸ and is commonly applied in marketing research¹⁹. CHAID is able to construct a decision tree from the questionnaire items based on the discriminatory power of individual items and classifies data based on the interaction between dependent and independent factors. In this way, the CHAID-algorithm is able to recognize answer patterns within a questionnaire and their relation to the total score. It is called a decision tree as after a first question is presented, based on the score for this item, the most discriminative next question is presented, which can be different for each score for the first question. This pattern can be repeated until a sum score is

reliably calculated. The CHAID technique has already been successfully applied to reduce item length of multiple assessments within the medical field²⁰⁻²². For example, the CHAID algorithm was successfully used to shorten the Prodromal Questionnaire for routine screening for psychosis from 92 to only 16 items while maintaining similar sensitivity and specificity for identifying patients with psychosis²⁰.

The aim of this study was to determine answer patterns within the BCTQ in relation to the total score by applying the CHAID-algorithm. In doing so, an electronic decision-tree version of the BCTQ could be produced to diminish questionnaire length of the BCTQ with a minimum loss of measurement properties.

METHODS

Measurements

To assess the severity of CTS symptoms and functional status, patients filled out the BCTQ (Dutch Language Version²³) at baseline, six weeks, three months and six months of treatment. The BCTQ covers two domains - the symptom severity scale (SSS) and the functional status scale (FSS), including 11 and eight items respectively. Every item consists of five answer options, ranked in terms of severity of the complaint and translating to a score from 1 to 5. The domain subscores are then calculated by taking the average of the scored items. For this study, all completed questionnaires at all different timepoints (intake, six weeks, three months and six months) were used for the analysis. Furthermore, we collected baseline characteristics from all patients, such as gender, age and type of treatment, consisting of conservative or surgical treatment and primary or recurrent treatment. In addition, we recorded the duration of completion of the BCTQ

Patient selection

For this study, we utilized data from patients who were treated either surgically with a carpal tunnel release or conservatively with a splint between January 2012 and September 2016 at one of the clinics of Xpert Clinic. Xpert Clinic is a specialized clinic providing both hand therapy and surgery for wrist- and

hand complaints. Patients were diagnosed with CTS by a physician based on the combination of symptoms, physical examination findings and electrodiagnostic testing. In addition, patients were asked by email to complete the BCTQ for the treated hand in our web-based outcome registration system at intake, six weeks, three months and six months after treatment. In the case of patients who underwent multiple CTS treatments, only the first treated hand was included in this study. Patients were selected if they completed the BCTQ at least once. As all items of the BCTQ had to be completed by the patients to be submitted electronically, we had no missing items in each BCTQ. The data employed in this study was collected during routine outcome measurement and all patients supplied their consent for anonymized use of their data. This study was approved by the institutional review board of the Erasmus MC. Further, we adhered to the STROBE-guidelines

Decision-tree development

All completed BCTQ questionnaires were randomly divided into a development and validation dataset at a three-to-one ratio by computerized randomisation with the statistical program, R. The BCTQ questionnaires within the development dataset were employed to optimize and select a decision tree and the validation dataset was utilized to test the external validity of the selected decision trees.

In the development dataset, two decision trees were created, one for the SSS and one for the FSS subdomain score. As a first step, the CHAID-algorithm determined the item of the subdomain with the best discriminative power for that subdomain score, defined as the item for which the subdomain score differed most between the various answer options. Next, the CHAID-algorithm placed the most discriminative item at the start of the decision tree and then split all the completed questionnaires into subgroups based on the answer given for that item. Thereafter, within these subgroups, the CHAID-algorithm would again identify the most discriminative item and split that subgroup into smaller subgroups based on the answer options of that item. Splits were performed only when the subdomain scores of the grouped questionnaires for a specific answer option were significantly different ($p\text{-value} < 0.05$) from the subdomain scores of the subgroups for the other answer options of that specific item. This process continued until stop conditions were met, which depended on the settings of the

parameters minimal split, minimal bucket and maximal depth of the decision tree, of the CHAID-package in R²⁴. In our case, the minimal split referred to the minimal number of BCTQ questionnaires needed to be present in a subgroup for the algorithm to seek a subsequent split within that subgroup. The minimal bucket is defined as the minimal number of questionnaires necessary to end in a subgroup after splitting. Lastly, maximal depth is defined as the maximum amount of subsequent splits allowed to be performed and ranges from 2 to 4. When stop conditions are met, an end group ('terminal node') is created. Subsequently, a score will be predicted for each terminal node. Therefore, the end result of executing the CHAID-algorithm is a decision tree that classifies answer patterns within questionnaires and is able to predict the domain scores based on the terminal node where the subject ends.

In the development dataset, we determined the optimal decision tree for a domain of the BCTQ by calculating the difference between the original scores and scores predicted by the decision tree for each possible decision tree. From this, we computed the mean and standard deviation (SD) of these differences for each decision tree and manually selected the decision tree with the best trade-off between a low SD and low depth (number of subsequent splits). The chosen decision tree BCTQ (DT-BCTQ) was then validated within the independent validation dataset.

Decision-tree validation

Within the independent validation group, we compared the final DT-BCTQ with the original BCTQ by performing two analyses. First, we created Bland-Altman plots to evaluate the amount of agreement between the predicted scores by the DT-BCTQ and original BCTQ. Secondly, the mean difference and variability in the difference between the predicted and original scores were calculated. Lastly, we computed the ICC between the predicted domain scores from the DT-BCTQ with the original scores of the BCTQ. All analyses were performed using R version 1.0.143, with the R studio interface using the CHAID package²⁴.

RESULTS

Patient selection

A total of 10055 BCTQ questionnaires were completed between January 2012 and September 2016 by 4470 patients. Subsequently, 7541 and 2514 questionnaires were randomly selected for the development and validation datasets, respectively. The patient characteristics for these datasets can be observed in Table 1. The average age of all included patients was 53.5 ± 13.4 , 87% received surgical treatment and 90% received primary treatment. The average SSS, FSS and total BCTQ score was 2.26 ± 0.85 , 2.12 ± 0.84 and 2.19 ± 0.79 , respectively.

Decision-tree development

The SD of the difference between the predicted and original SSS-score ranged from 0.23 to 0.38 on a 1-5 scale for all decision trees, depending on maximal depth and minimal bucket size. For the FSS-score, this ranged from 0.21 to 0.34. A maximum depth of 2 resulted in higher SD's while a maximal depth of 3 resulted in similar SD's as a maximal depth of 4. In addition, a larger minimal bucket resulted in higher SD's for the difference between the predicted and original score. Therefore, we selected the final decision tree for the SSS domain with a maximal depth of 3 and the most optimal minimal bucket size setting of 10. This resulted in a decision tree for the SSS domain with a SD of the difference between the predicted and original SSS score of 0.25. Likewise, we chose a decision tree for the FSS domain with a maximal depth of 3 and the optimal setting of a minimal bucket size of 25. This resulted in a decision tree for the FSS domain with a SD of the difference between the predicted and original FSS score of 0.24.

Table 1. Characteristics of the patients who completed the BCTQ questionnaires, with the n for the amount of completed BCTQ questionnaires assigned to each dataset.

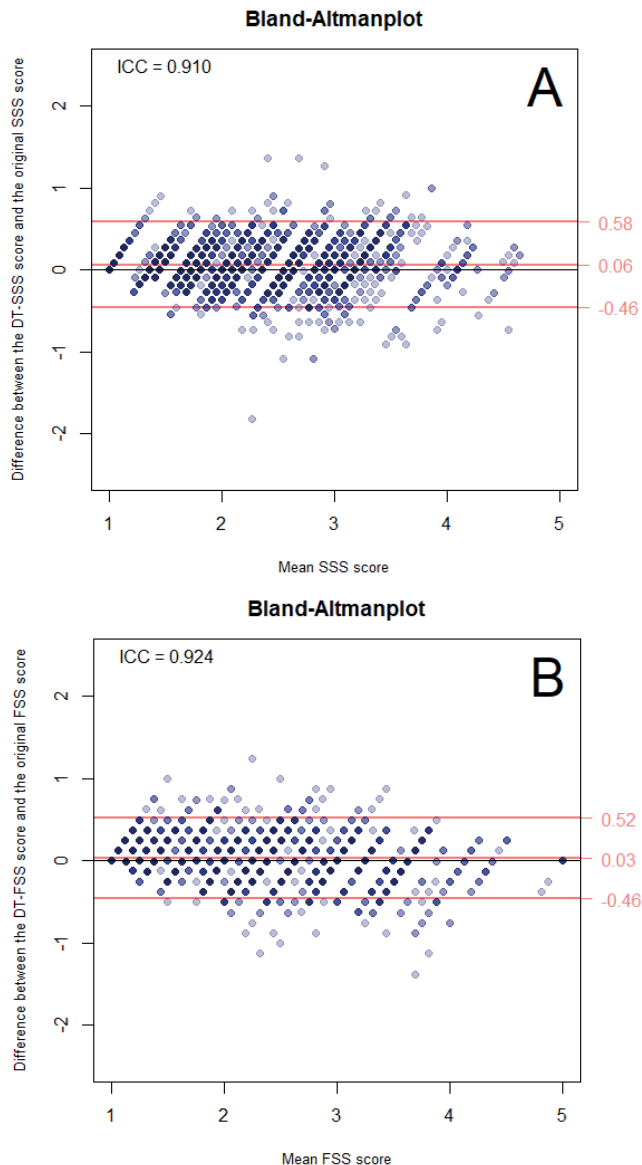
		Development Dataset (n=7541)	Validation Dataset (n=2514)
Categorical variables		%	%
Gender	Women	73	70
Treatment	Conservative	13	11
	Surgical	87	89
	Primary	90	89
	Recurrent	10	11
Age	<30	5	6
	30-40	11	10
	40-50	19	18
	50-60	34	34
	60-70	20	20
	>70	11	13
Continuous variables		Mean \pm SD	Mean \pm SD
BCTQ-score	Total	2.17 \pm 0.79	2.15 \pm 0.77
	FSS	2.11 \pm 0.84	2.09 \pm 0.83
	SSS	2.24 \pm 0.84	2.21 \pm 0.82
		Median (Q1-Q3)	Median (Q1-Q3)
Duration of completion of the BCTQ		167 (121-243)	167 (122-243)

The final decision trees for the SSS and FSS domains are presented in Supplementary Figures 1 and 2. Viewing these figures, all possible paths through which a patient is able to answer the decision trees are visualized, which results in 67 and 59 different paths within the DT-SSS and DT-FSS domains, respectively, with a maximum of three questions posited per domain. In addition, we published an online version of the DT-BCTQ that is openly available (<https://personeel.equipezorgbedrijven.nl/ls/index.php?r=survey/index&sid=824633&lang=nl>)²⁵.

Decision-tree validation

Figure 1A-C depicts the Bland-Altman plots for the difference between the predicted scores by the selected decision trees and original score for the SSS, FSS and total score within the validation dataset. The mean difference between the DT-SSS and original SSS was 0.06 (CI= -0.64 to 0.63) on a 1-5 scale (Figure 1A). The mean difference for the FSS-domain was 0.03 (CI= -0.46 to 0.52) (Figure 1B). Lastly, the agreement of the total BCTQ score had a mean of 0.05 (CI= -0.32 to 0.41) (Figure 1C). In addition, the distributions of the differences

between the original and predicted scores by the selected decision trees for the SSS, FSS and total BCTQ score are visualized in Figure 2A-C. Furthermore, the predicted scores for the SSS, FSS and total BCTQ had an ICC with the original scores of 0.91 (CI= 0.87-0.94), 0.92 (CI= 0.89-0.96) and 0.95 (CI= 0.94-0.96), respectively.



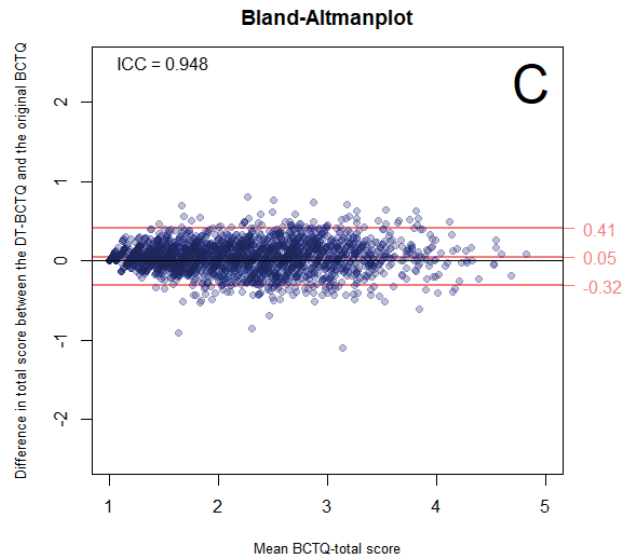
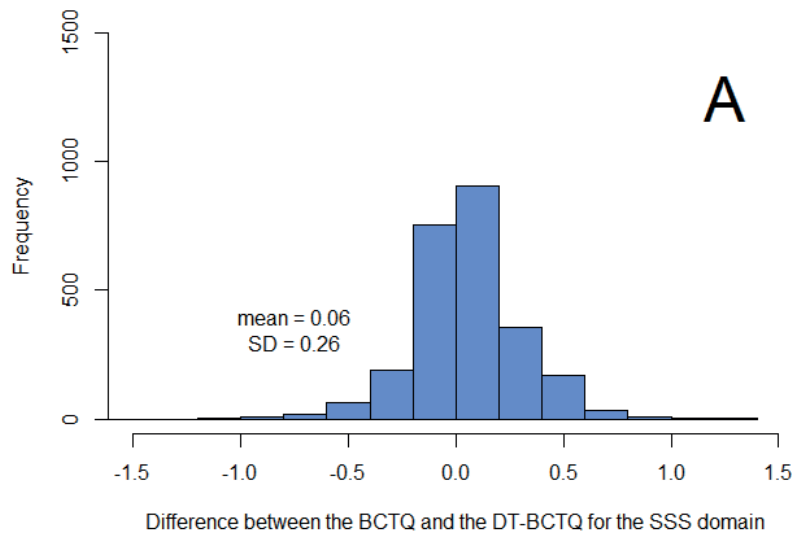


Figure 1A-C. Bland-Altman plots displaying the agreement between the original BCTQ and the DT-BCTQ for the SSS (figure 1A), the FSS (figure 1B), and the total BCTQ-score (figure 1C). In addition, the ICC between the original BCTQ and the DT-BCTQ is given for the total BCTQ-score and the two separate domains. Darker points represent a higher frequency of data for that point.



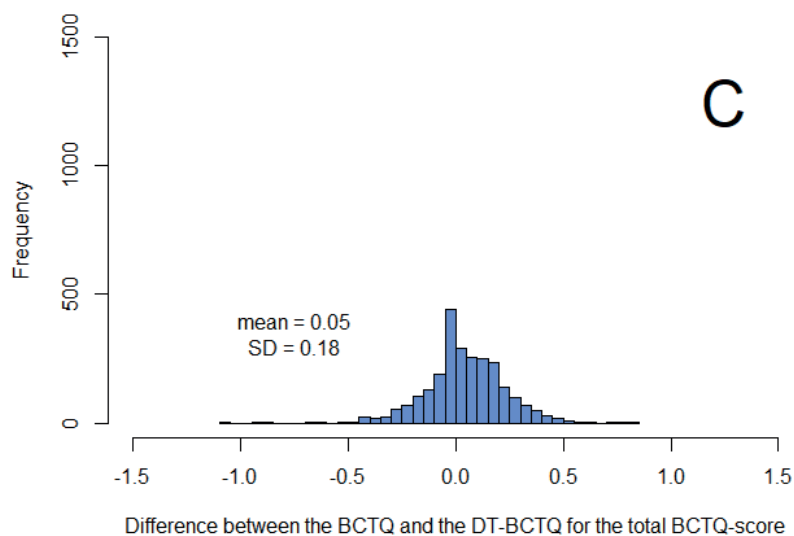
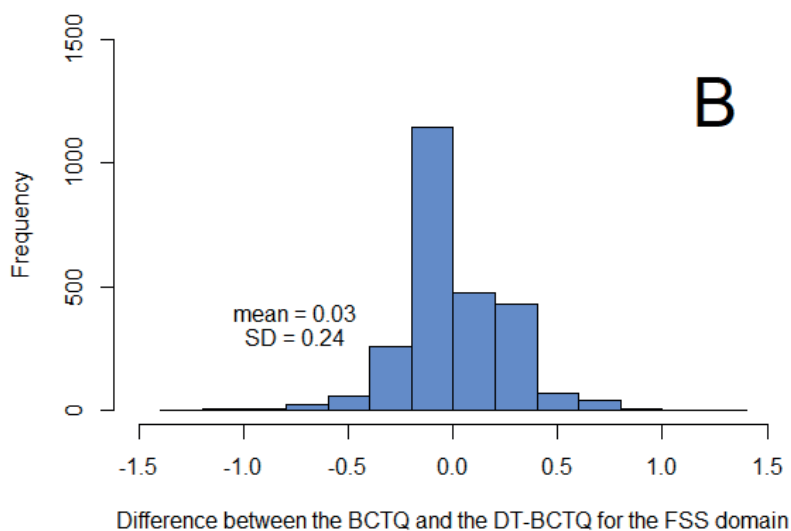


Figure 2A-C. Distributions of the differences between the original BCTQ and the DT-BCTQ for the SSS (figure 2A), the FSS (figure 2B) and the total BCTQ-score (figure 2C).

DISCUSSION

By analyzing the patterns through which the BCTQ was completed, applying the CHAID algorithm, we were able to reduce the total amount of questions of the BCTQ needed to pose to a patient to assess the severity of CTS from 18 to maximally six questions, three for each subscore, while maintaining a high amount of agreement (ICC of 0.94) with the original BCTQ in our independent validation dataset.

Although the BCTQ is a widely used questionnaire to assess symptom severity in daily clinical practice and clinical research, no study has previously attempted to reduce item length for both domains of the BCTQ. Atroshi et al.¹⁷ developed a six-item version of the SSS domain of the BCTQ by using exploratory factor analysis and item response theory (IRT) analysis, which resulted in an ICC of 0.80 with the original 11-item SSS. Furthermore, no previous studies have reported item diminution for the FSS and total score of the BCTQ yet.

By employing approximately 10.000 completed BCTQ questionnaires in the construction of the decision-tree version of the BCTQ, we were able to construct decision trees for the two domains of the BCTQ with an ICC of 0.91-0.92. We included multiple questionnaire from patients when available because in this specific analysis we were interested in recognizing patterns in item response. The purpose of this evaluation was to investigate the internal correlations between the questions of the BCTQ and total score. The algorithm carries this out by analyzing the distribution of answers for the different questions in relation to the total score¹⁸. While some patients completed multiple questionnaires, this was at different timepoints (baseline, early and later after treatment), which may result in differences in item response and therefore permits the algorithm to better detect these patterns. Moreover, because this study had access to a large amount of completed BCTQ questionnaires, large development and validation datasets could be built that allowed the CHAID-algorithm to reliably predict BCTQ scores while greatly reducing the amount of questionnaire items necessary. Furthermore, because of the large datasets that were utilized to develop the decision trees, our results are likely to be generalizable to other CTS populations as well.

Study Limitations

An important limitation of this study is that we simulated how patients would fill in the DT-BCTQ based on their response to the original BCTQ. It is possible that the responses to the DT-BCTQ might be different from those of the original BCTQ because the items are not posed in the same sequence. While computerized administration of health status assessments in the form of, for example, decision-tree modelling or computer adaptive testing (CAT) can be beneficial, these methods also have disadvantages. For example, patients must be willing to accept the electronic version of the questionnaire and a higher degree of technological facilities are needed²⁶. Seeing the DT-BCTQ is a fully electronic questionnaire, it will be difficult to implement it in practices with limited access to online technology. An advantage of a CHAID-based decision tree is that the tree is fixed and therefore technically easier to apply compared to CAT which continuously needs to calculate the next-best question based on the previously administered questions, requiring specific CAT software and often slowing down the processes of presenting a next question to the patient. Furthermore, additional studies are required to evaluate the psychometric properties of the DT-BCTQ, such as the test re-test reliability and validity. As well, although the agreement between the DT-BCTQ and original BCTQ scores is high, results from the DT-BCTQ to measure severity of CTS complaints might not be entirely comparable to the findings of previous studies employing the original BCTQ.

Although the item reduction of the BCTQ might save patients only a limited amount of time, in clinical practice, often several additional questionnaires are presented to a patient, such as a quality of life questionnaire and patient-reported experience measure. Therefore, decreasing the length of each specific questionnaire can still be clinically relevant to diminish the total burden for the patient and increase response rates. Additionally, because each individual patient will receive the most relevant questions from the BCTQ based on their responses, the DT-BCTQ might improve patient-perceived content validity and could therefore also bolster response rate.

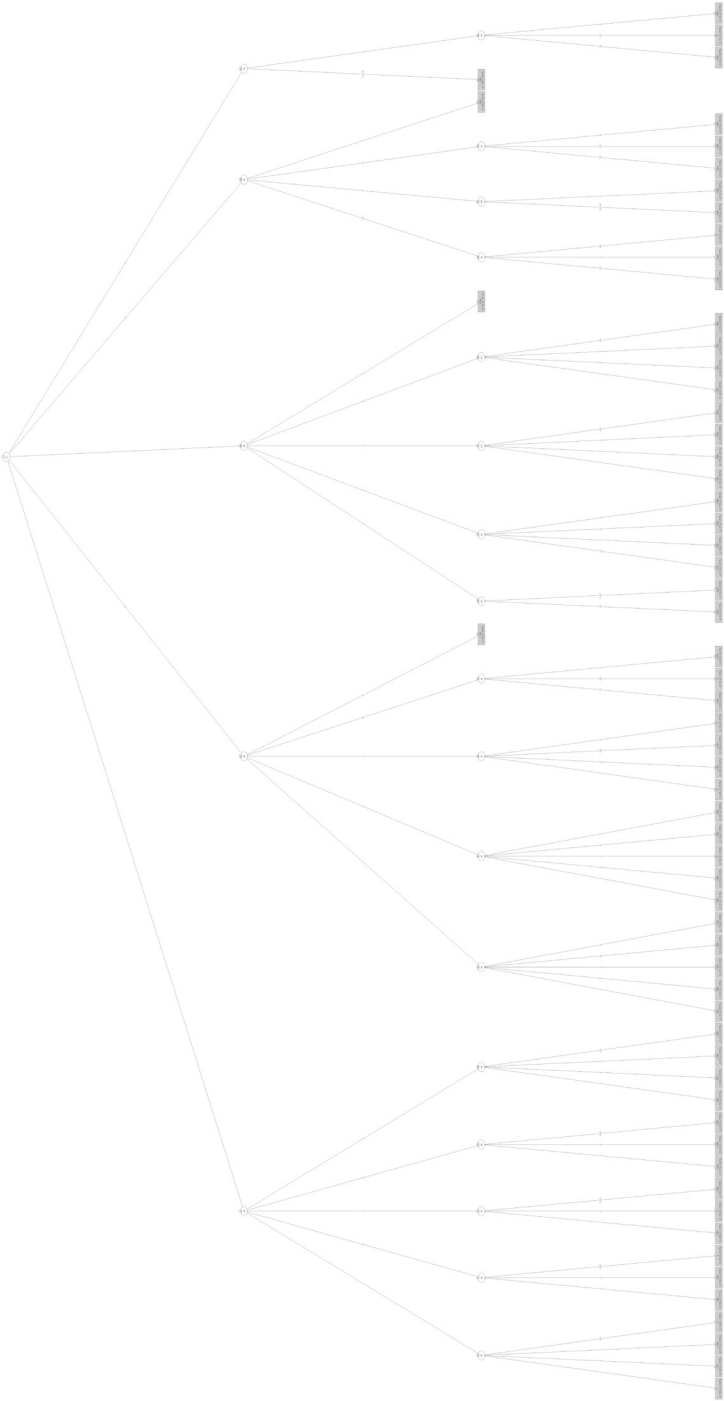
CONCLUSIONS

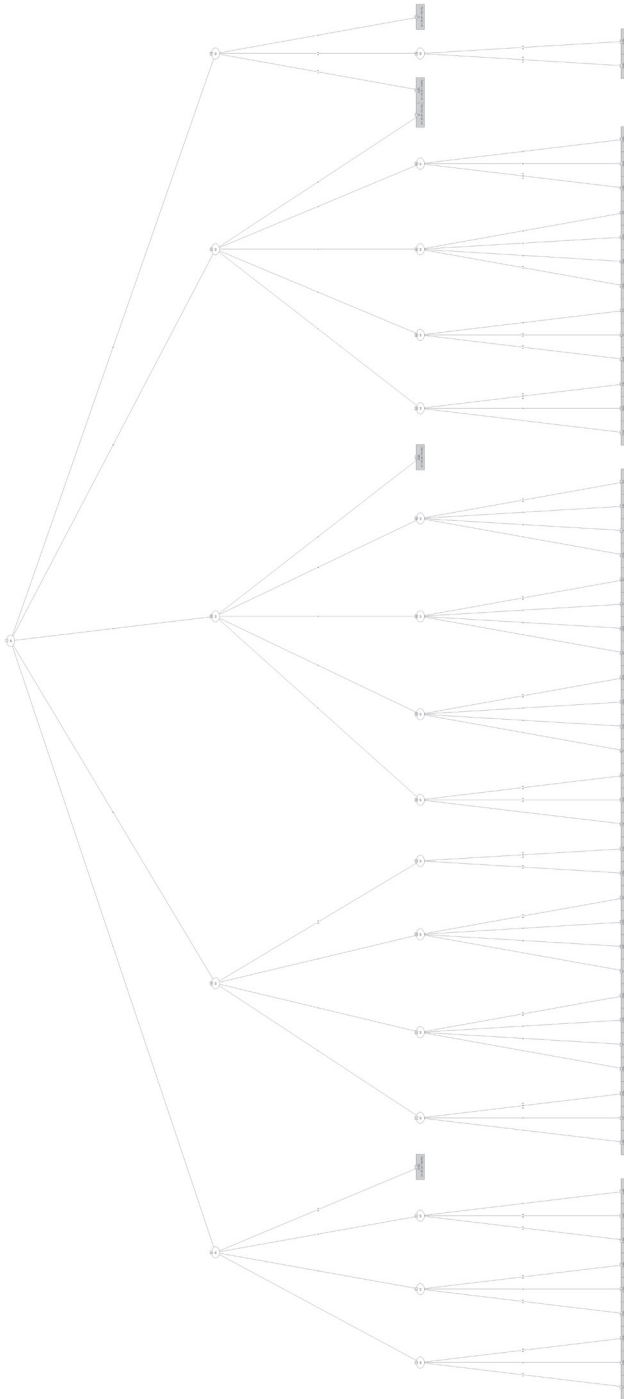
By creating the DT-BCTQ, we reduced the amount of questions needed to pose to a patient from 18 to a maximum of six questions, three for each subscore, when administering the BCTQ while maintaining an ICC of 0.94 with the original BCTQ. This DT-BCTQ might reduce patient burden by shortening answer time and may improve patient-perceived content validity. As such, the DT-BCTQ could increase response rate when used for routine outcome measurement. This might especially be beneficial in clinics where patients are asked to fill in multiple questionnaires at frequent timepoints. Future research into the DT-BCTQ could focus on multiple aspects, such as the reliability and responsiveness of the DT-BCTQ in comparison with the original BCTQ, clinical implementation of the DT-BCTQ and the experiences of patients with the electronic DT-BCTQ. In this way, the collection of data in clinical practice and CTS research through the BCTQ can be optimized to improve response rates and reduce response burden for patients in the future.

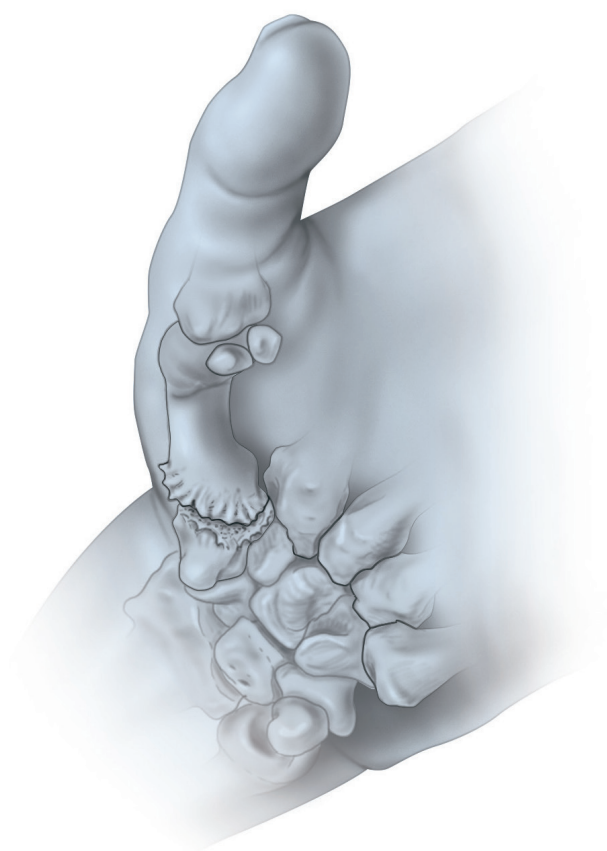
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CHAPTER 7

ILLNESS PERCEPTIONS OF PATIENTS WITH FIRST CARPOMETACARPAL OSTEOARTHRITIS, CARPAL TUNNEL SYNDROME, DUPUYTREN'S CONTRACTURE OR TRIGGER FINGER.

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ABSTRACT

Purpose: Previous studies indicate that patients with a more negative perception of their illness tend to respond less favorably to treatment, but little is known about whether illness perceptions differ based on the type of hand or wrist conditions. Therefore, we compared illness perceptions between patients scheduled to undergo surgery for four major illnesses in hand surgery: carpometacarpal osteoarthritis, Dupuytren's disease, carpal tunnel syndrome, and trigger finger syndrome. We hypothesized there would be differences in illness perception between these patient groups.

Methods: Pre operatively, patients were asked to complete the Brief Illness Perception Questionnaire (Brief-IPQ) as part of routine outcome measurement in a specialized hand and wrist surgery clinic. The Brief-IPQ is a validated questionnaire to rapidly assess the cognitive and emotional representation of illness. Differences in illness perception between the four diagnostic groups, corrected for age and sex, hand dominance and work type, were examined. Cohen's D effect sizes were calculated for the between group differences.

Results: We included 514 patients in the analyses: 87 with carpometacarpal osteoarthritis, 146 with Dupuytren's disease, 129 with carpal tunnel syndrome and 152 with a trigger finger. On a scale ranging from zero (most positive perception) to 80 (most negative perception) the Brief-IPQ sum scores for these subgroups were 42.0, 28.2, 38.8 and 33.3, respectively. Corrected for age, sex, hand dominance and work type, patients with Dupuytren's disease had a more positive perception of their illness than patients with carpometacarpal osteoarthritis and carpal tunnel syndrome. Compared to carpometacarpal osteoarthritis patients the effect size for Dupuytren, carpal tunnel syndrome, and trigger finger syndrome patients was respectively 1.28, 0.32 and 0.81.

Conclusions: In these patients with various hand/wrist disorders, small to very large differences were found in their preoperative perceptions of illness. These differences need to be considered during preoperative medical consultations and/or when investigating surgical outcomes. Interventions that directly target negative illness perceptions might improve treatment outcomes for carpometacarpal osteoarthritis and carpal tunnel syndrome.

INTRODUCTION

Understanding how patients perceive their illness is important to improve treatment outcomes. A negative illness perceptions is associated with decreased hand function in patients suffering from chronic osteoarthritis of the hand ¹. Psychosocial interventions can improve illness perceptions and are associated with both better treatment outcomes ^{2,3} and increased self-efficacy ⁴. Illness perceptions before treatment have shown to be important independent predictors of treatment outcome in other medical areas. It is important to investigate potential differences in illness perceptions before treatment of patients with various hand pathologies. There is only one study that investigated illness perception in chronic osteoarthritis patients, but a comparison across different hand or wrist conditions has not been made. Increasing knowledge about differences in illness perceptions between hand surgery patients is important to understand which illness perceptions need to be addressed in which patient group to ultimately improve outcomes in hand surgery. Interventions to modify patients' illness perceptions may be particularly relevant for those patient groups presenting with more negative illness perceptions.

The common sense model of self-regulation describes how patients perceive their illness and how it relates to patients' experience of symptoms ^{5,6}. This model describes a feedback loop in which patients respond to their condition and symptoms by the formation of illness perceptions, which influence coping mechanisms and health behaviors (e.g., treatment initiation, treatment adherence). These coping mechanisms and health behaviors will then again influence symptom severity. Based on the common sense model, the Illness Perceptions Questionnaire (IPQ) was developed to measure patients' perception of their illness⁷. This questionnaire captures eight domains of illness perception: 1) 'consequences' describes the expected outcome/effects of the illness, 2) 'timeline' describes how long the patient believes the illness will last, 3) 'personal control' evaluates beliefs as to how much the patient can control the illness, 4) 'treatment control' how much the treatment can control the illness, 5) the domain 'identity' describes the extent to which patients view experienced symptoms as part of their illness, 6) the 'concern' domain describes how concerned patients are about their illness, 7) 'illness comprehensibility' describes how well the patient understands their disease, and 8) the 'emotional representation' domain is the extent of emotional complaints the patient experiences due to the illness.

The aim of this study was to determine whether patients scheduled for surgery for one of four common hand illnesses (First Carpometacarpal Osteoarthritis (CMC-1), Carpal Tunnel Syndrome (CTS), Trigger Finger Syndrome (TFS) and Dupuytren's contracture) differ in their overall and domain specific illness perceptions. We hypothesized there would be differences in illness perceptions between these groups, even when taking into account possible demographic differences between the diagnostic groups.

MATERIALS AND METHODS

Study design

Between September 2017 and November 2017 patients were included for this study at our clinic. Our clinic is a specialized center for treatment of hand and wrist problems and has 18 different locations, 18 European Board certified (FESSH) hand surgeons, and over 150 hand therapists. We included all patients who were scheduled to undergo surgery for either: 1) carpometacarpal osteoarthritis (CMC-1 OA), 2) carpal tunnel syndrome (CTS), 3) a trigger finger, or 4) Dupuytren's disease, who gave written informed consent and who completed the illness perception questionnaire, as part of routine outcome measurements. A clinical diagnosis was made by a certified hand surgeon; when considered necessary, a radiograph was taken or electrodiagnostic studies were performed to confirm the diagnosis.

The study was approved by the local institutional review board.

Measurement

Participants completed the Dutch version of the Brief-IPQ^{8,9} as part of their clinical care between the first consultation and one day before surgery. A brief demographic questionnaire was completed with a hand therapist after the first consultation. Patients received an invitation to complete the IPQ in an email. Up to three reminders were sent. The Brief-IPQ is a reliable and validated measuring tool based on the original and the revised IPQ^{7,10}.

The Brief-IPQ consists of eight questions to quantify how patients perceive their illness across eight different illness perception domains. Patients are asked on 10-point scales "how much does your illness affect your life?" (0 = no affect

at all, 10 = severely affects my life; Consequences domain), “How long do you think your illness will continue?” (0= a very short time, 10 = forever; Timeline domain), “How much control do you feel you have over your illness?” (0= absolutely no control, 10 = extreme amount of control; Personal control domain), “how do you think your treatment can help your illness?” (0= not at all, 10 = extremely helpful; Treatment control domain), “how much do you experience symptoms from your illness?” (0=no symptoms at all, 10 = many severe symptoms; Identity domain), “how concerned are you about your illness?” (0= not at all concerned, 10 = extremely concerned; Concern domain), “how well do you feel you understand your illness? (0= don’t understand at all, 10 = understand very clearly; Illness comprehensibility domain)” and “how much does your illness affect you emotionally?” (0= not at all affected, 10 = extremely affected; Emotional consequences domain). The authors of the Brief-IPQ advise to replace the term ‘illness’ in these questions with the illness being studied in a particular setting⁹. We changed the term ‘illness’ to ‘hand or wrist illness’ to cover the large variety of patients that are treated for different hand or wrist conditions in our clinic. As an indication of patient’s overall illness perception, we calculated a sum score after reverse scoring the treatment control, personal control and illness comprehensibility items, as proposed by the questionnaire developers. The Cronbach’s Alpha in our sample was 0.7 indicating an acceptable internal consistency¹¹. Higher scores reflect a more negative perception of illness.

Baseline demographics

To correct for potential confounding, demographic characteristics of all patients (including age, sex, work type and hand dominance) were collected before initiating treatment.

Statistical analysis

An ANOVA was performed to assess differences between the four diagnostic groups. If the data was not normally distributed, a Kruskal-Wallis test was performed. ANCOVA was performed to investigate confounding of potential differences in the ANOVA analysis by patient characteristics. A post-hoc analysis of the ANCOVA using Tukey’s test was performed to compare the illness perceptions of the four groups. We performed a post-hoc sensitivity analysis to

determine the effect size we could detect with our sample. Given a numerator degree of freedom of 18, a power of 0.8 and an alpha of 0.05, we would be able to detect an effect size of 0.15 or larger in the ANOVA and an effect size of 0.2 or larger in the ANCOVA. For all tests, a p -value ≤ 0.05 was considered statistically significant. Cohen's D effect sizes were calculated as the differences between the two groups divided by the pooled standard deviation. An effect size between 0.2 and 0.5 was deemed small, between 0.5 and 0.8 medium, between 0.8 and 1.2 large and bigger than 1.2 as very large.¹²

RESULTS

Of 1059 eligible patients, 514 (48%) completed the Brief-IPQ as part of routine outcome measurements. There were no significant differences in baseline characteristics age, sex, hand dominance and work type between patients that did complete the questionnaire and those who did not. Of the 514 patients who completed the questionnaire, 87 had CMC-1 OA, 146 Dupuytren's disease, 152 CTS, and 129 had a trigger finger. Table 1 presents the patients demographics of the entire group and each diagnostic group separately. The CTS group had a significantly lower age and more patients with CTS were employed in jobs with average physical intensity of work. There were no significant between-group differences on other clinical and demographic variables.

There was a significant difference between groups in overall IPQ scores ($p < 0.05$). After adjusting for age, sex, workload and whether the dominant hand was operated, ANCOVA still showed a significant difference between the overall IPQ scores of the four groups ($F(3.351) = 20.48$, $p < 0.05$). CMC-1 patients had the most negative illness perception followed by Dupuytren, CTS, and TFS patients (see Table 1). Compared to carpometacarpal osteoarthritis patients the effect size for Dupuytren, CTS, and TFS patients was respectively 1.28, 0.32 and 0.81.

Table 1. Baseline patient characteristics and IPQ scores. The table shows all baseline patient characteristics, for all patients and separate for each diagnostic group.

	Patient characteristics and psychological characteristics					
	all patients n = 514		CMC-1 n = 87	Du- puytren n = 146	CTS n = 152	Trigger finger n = 129
Age, mean (sd)	58,6 (12,4)	*	60,0 (8,5)	62,5 (9,1)	54,24 (14,8)	58,5 (12,9)
Sex, % female	53	†	76	23	73	62
dominant hand	57	†	46	49	64	64
treated, % yes						
Work type, %						
No work	42	†	49	49	32	40
Light work	23	†	13	22	35	24
Average work	26	†	23	15	38	27
Heavy work	9		15	7	9	9
Consequences,						
mean(sd)	5,8 (2,8)	*	7,5 (1,6)	3,5 (2,7)	6,8 (2,3)	6,1 (2,6)
(range: 0-10)						
Timeline, mean(sd)	5,6 (2,9)	*	6,7 (2,3)	6,1 (3,4)	5,5 (2,6)	4,2 (2,6)
(range: 0-10)						
Personal control,						
mean(sd)	4,0 (2,8)		4,2 (2,5)	3,8 (3,2)	4,1 (2,6)	4,2 (2,7)
(range: 0-10)						
Treatment control,						
mean(sd)	8,4 (1,4)		8,3 (1,2)	8,3 (1,4)	8,5 (1,4)	8,6 (1,5)
(range: 0-10)						
Identity, mean(sd)	5,6 (2,8)	*	6,9 (2,2)	3,7 (2,7)	6,6 (2,4)	5,6 (2,7)
(range: 0-10)						
Concern, mean(sd)	5,1 (2,9)	*	6,5 (2,5)	3,5 (2,6)	5,8 (2,8)	4,8 (2,9)
(range: 0-10)						
Illness comprehensi-						
bility, mean(sd)	8,3 (2,0)	*	8,4 (1,9)	8,6 (1,6)	8,0 (2,0)	8,2 (2,3)
(range: 0-10)						
Emotions, mean(sd)	3,7 (3,0)	*	5,2 (2,8)	2,1 (2,5)	4,5 (3,0)	3,4 (2,8)
(range: 0-10)						
Sum score,						
mean(sd)	34,9 (12,1)	*	42,0 (9,6)	28,2 (11,8)	38,8 (10,1)	33,3 (11,7)
(range: 0-80)						

CTS, carpal tunnel syndrome; CMC-1 OA, carpometacarpal osteoarthritis

* indicates $p < 0.05$ using an ANOVA† indicates $p < 0.05$ using a chi-squared test

All patients had a similar strong positive belief in the treatment, as well as low personal control (see Figure 1). On the consequences, timeline, identity, concern, illness comprehensibility and emotional representation scales there were significant differences between the groups (Table 1). These differences remained significant after adjusting for age, gender, workload and whether the

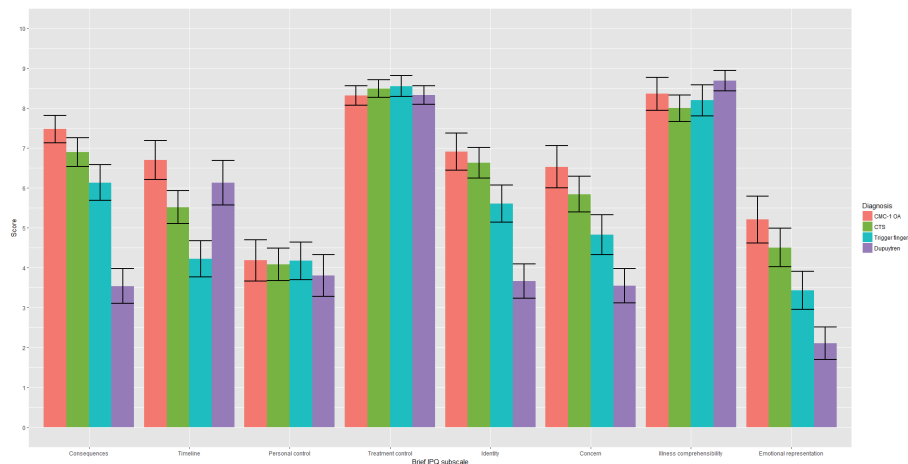


Figure 1. Mean IPQ subscale scores for each diagnostic group. The error bars represent the 95% confidence intervals for the mean score in a specific diagnostic group. CTS, carpal tunnel syndrome; CMC-1 OA, carpometacarpal osteoarthritis

Table 2 presents the post-hoc analysis of the ANOVA of the differences in IPQ subscale scores between the groups. The largest significant differences were found between CMC-1 OA and Dupuytren's disease on the consequences and identity scales, i.e. patients with CMC-1 OA scored 3.9 and 3.2 points higher (i.e. less favorable perception), respectively, compared to patients with Dupuytren's disease. Moreover, the only significant difference between the CMC-1 OA and CTS groups was on the timeline scale and the sum score, i.e. patients with CMC-1 OA scored 1.2 and 3.7 points higher, respectively, than patients with CTS.

Furthermore, post-hoc analysis of the ANCOVA (Table 3) showed that only patients with Dupuytren's disease had a significantly more positive illness perception than the other three groups. The only other significant differences were between CMC-1 OA and CTS on the emotional representation and timeline scale, i.e. patients with CMC-1 OA scored 1.1 and 1.1 points higher, respectively, than patients with CTS.

Table 2. Post-hoc analysis of the ANOVA. The table shows the differences between all individual subgroups.

Consequences	Timeline	Personal control	Treatment control	Identity	Concern	Illness comprehension	Emotional representation	IPQ sumscore
ANCOVA								
CTS - CMC	-0,58	-1,19 *	-0,10	0,18	-0,28	-0,69	-0,36	-3,72 *
Trigger finger - CMC	-1,34 *	-2,48 *	-0,01	0,24	-1,30 *	-1,70 *	-0,16	-8,50 *
Dupuytren - CMC	-3,93 *	-0,57	-0,38	0,02	-3,24 *	-3,00 *	0,33	-13,87 *
Trigger finger - CTS	-0,76 *	-1,29 *	0,09	0,06	-1,02 *	-1,01 *	0,20	-4,81 *
Dupuytren - CTS	-3,35 *	0,62	-0,28	-0,16	-2,96 *	-2,30 *	0,69 *	-10,14 *
Trigger finger	-2,59 *	1,90 *	-0,37	-0,22	-1,94 *	-1,28 *	0,49	-5,33 *

CTS, carpal tunnel syndrome; CMC, carpometacarpal osteoarthritis
* indicates a p value < 0,05

Table 3. Post-hoc analysis of the ANCOVA. The table shows the differences between all individual subgroups, after correcting for age, gender, work load and hand dominance.

	Consequences	Timeline	Personal control	Treatment control	Identity	Concern	Illness con- prehensibility	Emotional representation	IPQ sumscore
ANCOVA									
CTS - CMC	-0,53	-1,14	* -0,06	-0,19	-0,36	-0,72	0,63	-1,10	* -3,40
Trigger finger - CMC	0,34	-1,54	-0,13	-0,41	0,52	-0,70	-0,72	-2,07	-4,71
Dupuytren - CMC	-3,42	* -0,40	0,15	0,00	-2,85	* -2,81	* -0,22	-3,17	* -12,7
Trigger finger - CTS	0,86	-0,40	-0,07	-0,21	0,88	0,02	-1,35	-0,97	-1,24
Dupuytren - CTS	-2,89	* 0,74	0,20	0,20	-2,48	* -2,10	* -0,84	* -2,07	* -9,25
Dupuytren - Trigger finger	-3,76	* 1,14	0,28	0,41	-3,36	* -2,12	0,50	-1,10	-8,00

CTS, carpal tunnel syndrome; CMC, carpometacarpal osteoarthritis
* indicates a p value < 0.05

DISCUSSION

This study compared preoperative illness perceptions in patients scheduled for surgery for CMC-1 OA, Dupuytren's disease, CTS or TFS. Patients with CMC-1 OA have a more negative perception of their illness, whereas patients with Dupuytren's disease have a more positive perception of their illness. This difference was mainly driven by: i) consequences patients experienced from the disease, ii) to what extent patient viewed the experienced symptoms as part of their illness, iii) their concern about the illness, and iv) emotional consequence of the illness.

These findings suggest that preoperative interventions focused on changing illness perceptions may not be necessary for patients with Dupuytren's, but may be helpful for patients with CMC-1 and CTS. A meta-analysis of illness perception¹³ has shown that individuals with various medical illnesses and similar illness perceptions to patients with CMC-1 and CTS have impaired physical functioning, psychological wellbeing and social functioning¹⁴⁻¹⁷. Research also shows that psychosocial interventions can change illness perception and thus improve treatment outcomes across a variety of medical conditions^{18, 19}. Such psychosocial interventions focus on patients' perceptions of the consequences of their disease and the manner in which they label and interpret their symptoms and disease. For example, in patients with coronary heart disease, interventions that i) educated patients about their illness, ii) changed nonadaptive or incorrect perceptions, or iii) taught patients how to cope with their illness, were effective to change patients illness perceptions²⁰. This is in line with the current opinion about the added value of psychosocial interventions on outcomes in hand surgery²¹.

We also found between group similarities regarding the amount of perceived control over the illness. Although patients in these four groups may have different underlying pathologies, they all had similarly low levels of personal and high levels of treatment control, as well as similarly high levels of perceived understanding of their illness. This pattern is similar to what has been reported for patients undergoing total hip or knee replacement surgery²². Such patterns of low perceived personal control on the one hand, and high treatment control and understanding of the disease on the other hand, might be typical for patients scheduled for elective surgery.

Especially low personal control could have a negative influence on the outcome and might therefore be a viable target for intervention. Low personal control has been shown to be associated with worse adherence to treatment^{23, 24} and worse outcomes^{25, 26}. For example, Hsiao et al showed that patients with positive illness perceptions adhered better to anti-hypertension medication than patients with negative illness perceptions. If this association of adherence also extends to post-operative rehabilitation, this represents an opportunity for educational or psychosocial interventions. This could be achieved by helping patients understand that, after surgery, the outcome of their recovery is co-dependent on their motivation and adherence to post-operative rehabilitation protocols²⁷. By helping patients to reconsider their perceived lack of personal control, we may improve treatment outcome.

A limitation of our study is the non-responder rate. Of all patients who were scheduled for surgery during the study period, 52% did not complete the Brief-IPQ. However, non-response was not dependent on any of the baseline characteristic (age, sex, hand dominance and work type; data not shown). Thus, we believe that these factors did not influence the conclusions of this study.

Several factors may have influenced the results acquired via the Brief-IPQ. First, all questionnaires were collected *after* patients had received their diagnosis during initial consultation and were scheduled for surgery; this may have had an impact on how they perceived their illness. Consulting with a surgeon can influence the perception of the illness. Any misconception the patient had before the consultation might be addressed by the surgeon during the consultation. Second, for most patients this was the first time that their illness was labeled as ‘something to be treated’ and the need for surgery itself might make the illness seem more threatening; both these aspects may have influenced the patient’s perception of illness. Third, differences between treatment locations may result in different illness perception. However, post hoc analyses revealed that there was little variance in illness perceptions that could be explained by location (ICC = 0.03; not further reported). Fourth, we know that patients with Dupuytren’s disease have no pre-operative pain^{28, 29} and that CMC-1 OA is characterized by pain³⁰. While we could not test this in the present study, it is possible that pain influences illness perceptions of hand surgery patients, and this should be assessed in future studies. Fifth, differences in other psychosocial factors such as

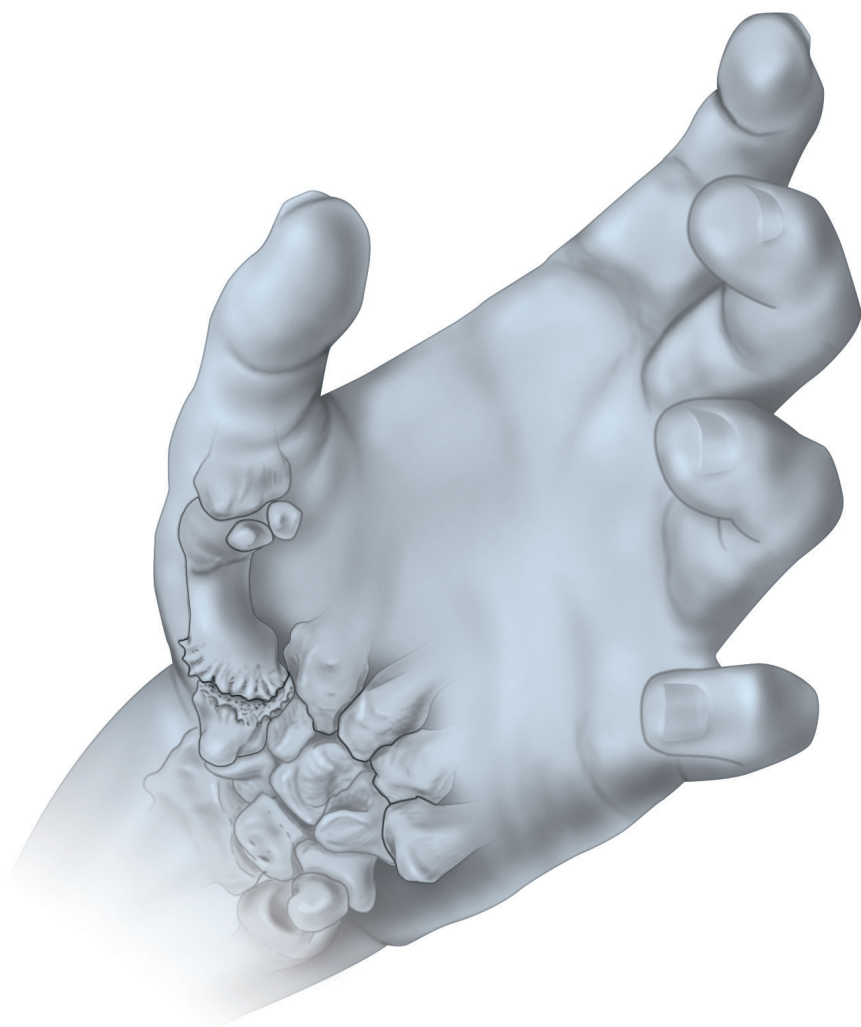
anxiety and depression, as described by Beleckas et al. could influence patients perception of illness³¹. Finally, patients referred to a highly specialized hand clinic, such as our clinic, might perceive their illness as being more severe as compared to patients referred to a less specialized clinic. All these factors exist in daily practice and will likely influence, to some extent, illness perception in daily practice. Therefore, our findings can only be generalized to situations where illness perceptions are evaluated under similar circumstances. The results of this study have important clinical implications by drawing attention to the differences in illness perception among individuals who undergo four common hand and wrist conditions. By being aware of an individual's illness perception along with the type of surgery they will receive, surgeons can directly target the particular aspects of illness perception through educational information and the language they use (i.e. avoiding language that may amplify negative illness perceptions). In some cases, in which illness perception is negative, psychosocial interventions focused on increasing resiliency may be helpful. Given that the four surgical procedures are elective, undergoing skills training to improve illness perception may be feasible, particularly when recommended by surgeons, along with educational information about optimized recovery and outcome of surgery.

Future studies should focus on how illness perceptions of patients scheduled for hand surgery relate to treatment outcomes, how illness perceptions relate to specific types of coping, and how interventions on illness perceptions affect outcomes. For example, in patients suffering from CMC-1 OA, evaluating the association between illness perception and outcome might provide more preoperative information on the expected outcome and enable surgeons to better inform patients about their expected outcome. Furthermore, evaluating how these patients cope with pain may provide more insight into the role of illness perceptions in coping with the outcomes of disease, which can provide a framework to guide patients during treatment and optimize their outcome.

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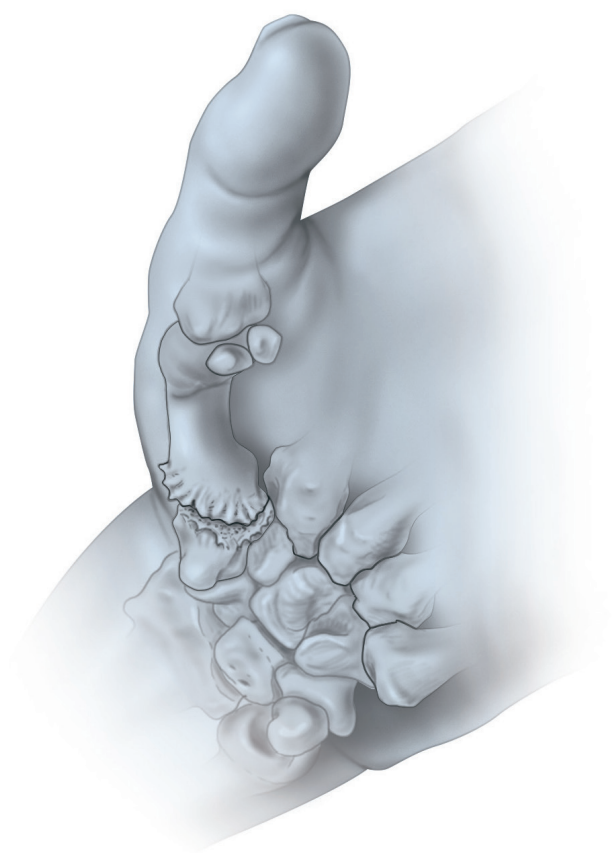
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PART 2

PSYCHOSOCIAL EFFECTS IN PATIENTS WHO RECEIVE NONSURGICAL TREATMENT FOR THUMB BASE OSTEOARTHRITIS



CHAPTER 8

PSYCHOLOGICAL FACTORS ARE MORE STRONGLY ASSOCIATED WITH PAIN THAN RADIOGRAPHIC SEVERITY IN NON-INVASIVELY TREATED FIRST CARPOMETACARPAL OSTEOARTHRITIS

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ABSTRACT

Background: The aim of this study was to investigate to what extent psychological factors are related to pain levels prior to non-invasive treatment in patients with osteoarthritis of the first carpometacarpal joint.

Methods: We included patients (n=255) at the start of non-invasive treatment for osteoarthritis of the first carpometacarpal joint who completed the Michigan Hand Outcome Questionnaire. Psychological distress, pain catastrophizing behavior and illness perception was measured. X-rays were scored on presence of scaphotrapeziotrapezoid osteoarthritis. We used hierarchical linear regression analysis to determine to what extent pain levels could be explained by patient characteristics, X-ray scores and psychological factors.

Results: Patient characteristics and X-ray scores accounted for only 6% of the variation in pre-treatment pain levels. After adding the psychological factors to our model, 47% of the variance could be explained.

Conclusions: Our results show that psychological factors are more strongly related to pain levels prior to non-invasive treatment in patients with osteoarthritis of the first carpometacarpal joint than patient characteristics and X-ray scores, which implies the important role of these factors in the reporting of symptoms. More research is needed to determine whether psychological factors will also affect treatment outcomes for patients treated non-invasively for osteoarthritis of the first carpometacarpal joint.

INTRODUCTION

Osteoarthritis of the first carpometacarpal joint (CMC-1 OA) is a degenerative disease that causes pain and loss of function ¹. Patients are initially treated non-invasively ² with hand therapy, occupational therapy, an orthosis, or a combination of treatment modalities ³. Non-invasive treatment is an effective treatment that may prevent the need for surgical treatment ⁴ and reduces pain in a selection of patients ⁵.

At the start of the treatment, considerable variation in pain levels between patients is seen ⁵. However, traditional patient and disease attributes, e.g. age, grip strength and X-ray scores, only explain a small amount of the variation in reported pain and disability, which suggests other factors are at play ^{6,7}. It is currently unclear which factors are associated with pain for CMC-1 OA patients.

Several studies on surgical treatment of OA, including total knee or hip replacement ⁸⁻¹¹ and surgery for CMC-1 OA ^{12,13} found that psychological factors (e.g. depression, pain catastrophizing behavior and illness perception) are associated with worse patient reported outcomes, both before and after treatment. Moreover, recent studies suggested that interventions improving catastrophizing behavior ¹⁴ and negative illness perception ¹⁵ have a beneficial effect on OA symptoms.

Although there is evidence for the association between psychological factors and symptom severity in knee and hip OA, little is known regarding this association for patients treated non-invasively for CMC-1 OA ^{16,17}. In particular, the association between psychological factors and pain, which is the primary complaint of CMC-1 OA patients ¹⁸, is currently unknown. Moreover, while illness perceptions have been shown to be important factors in other conditions, like knee OA, no studies have investigated to what extent illness perceptions are associated with pain in this patient population ¹¹. Therefore, the aim of this study is to investigate to what extent psychological distress, pain catastrophizing behavior and illness perceptions are associated with pain levels prior to non-invasive treatment in CMC-1 OA patients.

METHODS

Setting and study population

This cross-sectional study was performed at Xpert Clinic in The Netherlands. Xpert Clinic is a specialized private treatment center for hand and wrist conditions. Xpert Clinic has 20 different locations, with 20 European Board certified (Federation of European Societies for Surgery of the Hand) hand surgeons and over 150 hand therapists.

All patients who received non-invasive treatment, consisting of orthosis and/or hand therapy, for CMC-1 OA at Xpert Clinic between September 2017 and July 2018 were invited to complete several questionnaires as part of routine clinical care to measure symptom severity, psychological status, understanding of disease and quality of life prior to treatment. These questionnaires were e-mailed after the first consultation and before non-invasive treatment started. Three reminders were e-mailed to non-responders. Furthermore, baseline demographics, including age, sex, hand dominance and occupational intensity were collected. Occupational intensity was classified by the hand therapist in one of the following categories: not employed, light occupational intensity (e.g. working in an office), moderate occupational intensity (e.g. working in a shop) or severe occupational intensity (e.g. construction work). All patients provided written informed consent.

Michigan Hand Outcomes Questionnaire

The Michigan Hand Outcomes Questionnaire (MHQ) ¹⁹ is a patient reported outcome measure with six domains (pain, aesthetics, hand function, performance of activities of daily living, work performance and satisfaction) with good validity, reliability and responsiveness in CMC-1 OA patients ²⁰. Scores range from 0-100 (0 = poorest function, 100 = ideal function). In the present study the pain scores were reversed (0 = no pain, 100 = extreme pain).

The MHQ pain subscale was used as primary outcome measure, because pain is the primary complaint and the main reason to seek treatment for CMC-1 OA patients ¹⁸. To also see if there is an association between psychological effects and patient reported hand performance, we used the total MHQ score as secondary outcome measure.

Patient Health Questionnaire-4

The Patient Health Questionnaire-4 (PHQ) ²¹ is a generic depression- and anxiety-screening tool and was used to measure psychological distress. This questionnaire is a combination of two brief screening tools (Patient Health Questionnaire-2 and Generalized Anxiety Disorder-2). The PHQ contains two domains (anxiety and depression) with two questions each. The total score ranges from 0-12 (0 = no indication for psychological distress; 12 = strong indication for psychological distress). It has a good reliability and validity in the general population ²².

Pain Catastrophizing Scale

The Pain Catastrophizing Scale (PCS) ²³ was used to assess catastrophizing behavior in response to pain. This questionnaire consists of 13 questions and 3 domains (helplessness, magnification and rumination). It has been demonstrated to have good validity, reliability and responsiveness in patients with pain related problems ^{24, 25}. The total score ranges from 0-52 (0 = no catastrophizing behavior; 52 = severe catastrophizing behavior).

Brief Illness Perception Questionnaire

The Brief Illness Perception Questionnaires (B-IPQ) ²⁶ was used to assess the patients' perceptions of illness. This questionnaire is a short version of the Revised Illness perception Questionnaire ²⁷. In the B-IPQ each subscale of the Revised Illness perception Questionnaire is summarized by one question. Five questions assess cognitive illness representation, two questions assess emotional representations, one question assesses understanding of disease and in the final question patients are asked to list the factors they believe to have caused their illness. This last question was not part of our questionnaire. Reliability and validity has been demonstrated for multiple conditions, including low back pain, cardiovascular disease and chronic obstructive pulmonary disease ²⁸⁻³¹.

CMC-1 joint X-rays

The patients' records were searched for X-rays of the first carpometacarpal joint. If multiple X-rays were present, we selected the X-ray in which both the CMC-1 joint and the scaphotrapeziotrapezoid joint (STT) were most clearly

visible. The Eaton-Glickel classification³² ranges from stage I to stage IV. Stage III is defined as excessive CMC-1 degeneration and subluxation. Stage IV is defined as stage III with additional presence of STT OA. According to this classification, presence of STT OA indicates the most advanced stage of structural damage. Therefore, we used this feature as indication of radiographic severity of disease. The first 100 X-rays were independently scored by both a European Board-certified hand surgeon (G.V.) and a junior scientist (L.H.). The Intraclass Correlation Coefficient was 0.58 (95% CI 0.49-0.65). This is in agreement with the study by Dela Rosa et al.³³, who reported fair to moderate inter-observer agreement for the Eaton-Glickel classification, with similar agreement rates for stage I, III and IV. The scores of the junior scientist were used for all patients. Patients without an X-ray of the CMC-1 joint were excluded.

Statistical analyses

A complete case analysis was performed with patients who completed all previously mentioned questionnaires. To see whether patients with missing data differed from patients with complete data, two non-responder analyses were performed; both for patients who completed the MHQ, but did not complete the psychological questionnaires and for patients who completed all questionnaires, but without X-ray of the CMC-1 joint. For these analyses, T-tests were used for normally distributed continuous data and Mann-Whitney-Wilcoxon tests were used for continuous data that was not normally distributed. Chi square statistics were used for categorical data. We calculated Pearson correlation coefficients to determine to what extent the psychological variables were correlated.

Data were analyzed using hierarchical linear regression analyses with baseline MHQ-pain levels as a dependent variable. In the first step of the analysis, age, sex and occupational intensity were entered into the model. Presence of STT OA was added in the second step of analysis. In the third step, we entered the total PHQ score, as well as the total PCS score. In the fourth step, all B-IPQ subscales were added in order to determine the effect of illness perceptions on pain, after correcting for psychological distress and pain catastrophizing behavior.

For all variables, the regression coefficients (B) are reported, which represents the increase in the dependent variable for one unit increase in the independent variable, when all other variables remain constant. In order to compare the

relative contribution of each explanatory variable on the outcome, the standardized regression coefficients (β) are also reported. Standardized regression coefficients allow for comparison of the strength of associations when the independent variables were measured on different scales. For all models both the multiple explained variance (R^2) and the explained variance adjusted for number of variables in the model (adjusted R^2) is calculated.

All analyses were performed using R statistical computing, version 3.4.1. For all tests a p-value smaller than 0.05 was considered statistically significant.

RESULTS

Non-responder analysis

We identified 475 patients at the start of non-invasive treatment for CMC-1 OA who had completed the MHQ. 5.2% of these patients did not complete all psychological questionnaires. Of the patients who completed all questionnaires, 40.4% did not have an X-ray of the CMC-1 joint. Supplemental tables 1-2 show demographic characteristics and MHQ scores for responders and non-responders, indicating no significant differences in any patient characteristic or MHQ-pain scores between responders and non-responders.

Patient characteristics

255 patients were included in the analysis (figure 1). Their mean age was 60 ± 8 years (mean \pm SD) and 75% of the patients were female. The mean MHQ-pain score was 52.9 ± 17.3 and the mean total MHQ score was 59.7 ± 15.2 . Table 1 shows baseline characteristics for all included patients. Correlations between the psychological factors ranged from -0.24 to 0.60 (supplemental table 3), which can be interpreted as weak to moderate correlations³⁴.

Table 1. Baseline characteristics of the patients included for analysis

Baseline characteristics	Total (n = 255)
Age in years	59.8 (7.8)
Sex (%)	
Female	74.9%
Hand dominance (%)	
Right	91.4%
Left	6.3%
Both	2.4%
Laterality of the affected hand (%)	
Right	47.8%
Left	50.2%
Both	2.0%
Dominant hand affected (%)	51.8%
Duration of symptoms in months (median, interquartile range)	12 (6-24)
Occupational intensity (%)	
Not employed	40.0%
Light	21.6%
Moderate	27.5%
Severe	11.0%
STT OA present (%)	13.3%
PHQ score	1.6 (2.6)
PCS score	12.2 (10.0)
B-IPQ Consequences	6.4 (2.3)
B-IPQ Timeline	7.8 (2.3)
B-IPQ Personal control	5.3 (2.3)
B-IPQ Treatment control	6.8 (1.8)
B-IPQ Identity	6.1 (2.5)
B-IPQ Concern	6.1 (2.7)
B-IPQ Understanding	8.4 (2.0)
B-IPQ Emotional response	4.3 (2.8)
MHQ-pain	52.9 (17.3)

* Values reported as mean (SD) unless otherwise stated.

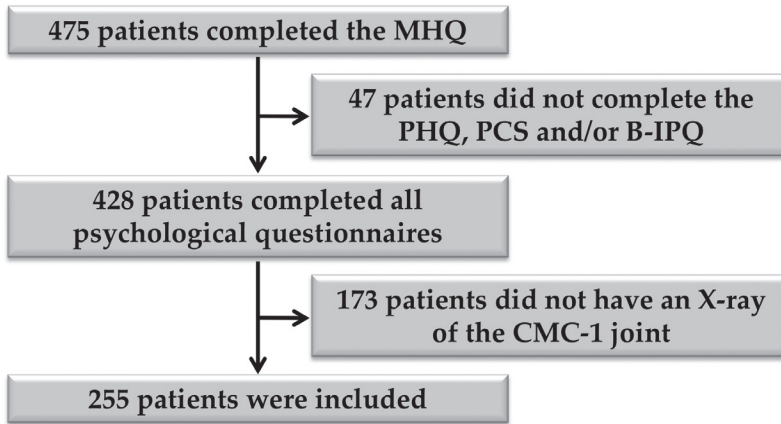


Figure 1. Flowchart.

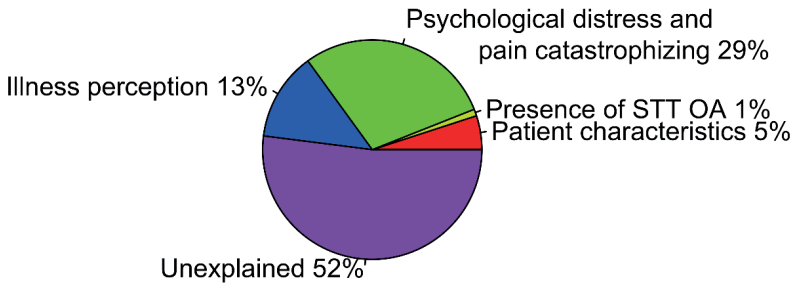


Figure 2. Increase in explained variance (increase in multiple R^2) of pre-treatment MHQ-pain per step in the hierarchical linear regression model

Hierarchical linear regression

Table 2 shows the outcomes of the hierarchical regression analysis. In model 1 and 2, female sex was statistically significantly associated with higher MHQ-pain scores. However, after adding psychological distress and catastrophizing behavior to the model, sex was no longer statistically significantly related to pain, while higher PHQ and PCS scores were statistically significantly associated with higher MHQ-pain scores. After adding the B-IPQ subscales to the model, B-IPQ subscales ‘consequences’ and ‘identity’ were, in addition to PHQ score and PCS score, also statistically significantly associated with pain. Figure 2 shows the increase in explained variance per model. Model 1 and 2 had an

explained variance of 5% and 6% respectively. After adding psychological distress and catastrophizing behavior, the explained variance increased to 35%, and after adding illness perceptions, the explained variance increased to 47%. In this model, more psychological distress (PHQ score, $B = 0.79$), more pain catastrophizing behavior (PCS score, $B = 0.46$), experiencing more consequences (B-IPQ ‘consequences’, $B = 1.36$) and more symptoms (B-IPQ ‘identity’, $B = 1.11$) were statistically significantly associated with higher MHQ-pain scores. Of all significant variables in the final model, total PCS score had the largest standardized regression coefficient ($\beta = 0.27$) in this model, indicating that pain catastrophizing behavior has the largest independent effect on pre-treatment pain of all variables investigated in this study.

We found similar associations in the hierarchical linear regression analysis on total MHQ score. Further details are reported in supplemental table 4.

Table 2. Beta coefficients and explained variance (R^2) for hierarchical linear regression models explaining pre-treatment pain levels. In each additional model, more variables potentially explaining pre-treatment pain levels are included. Both the unstandardized (B) and standardized (β) regression coefficients are reported.

	Model 1 (Patient characteristics)		Model 2 (Model 1 + Presence of STT OA)		Model 3 (Model 2 + Psychological distress and pain catastrophizing)		Model 4 (Model 3 + Illness perception)		Univariable models	
	B	β	B	β	B	β	B	β	B	β
Explanatory variables										
Age	-0.09	-0.04	-0.08	-0.03	-0.003	-0.001	-0.01	-0.005	-0.15	-0.07
Sex, male	-8.48***	-0.49***	-8.36**	-0.48**	-5.13*	-0.30*	-3.25	-0.19	-8.18	-0.47
<i>Physical activity at work</i>										
(<i>ref = no work</i>)										
Light	-1.85	-0.11	-1.94	-0.11	0.38	0.02	1.68	0.10	0.08	0.005
Moderate	-2.09	-0.12	-2.14	-0.12	-1.54	-0.09	-1.95	-0.11	-0.29	-0.02
Severe	3.05	0.18	4.03	0.23	2.52	0.15	1.29	0.07	3.07	0.18
STT OA, present			-4.87	-0.28	-3.62	-0.21	-2.55	-0.15	-4.56	-0.26
PHQ score					1.10*	0.16*	0.79*	0.12*	2.91	0.43
PCS score					0.75***	0.44***	0.46***	0.27***	0.94	0.55
B-IPQ Consequences							1.36**	0.19**	3.84	0.52
B-IPQ Timeline							-0.76	-0.10	0.69	0.09
B-IPQ Personal control							-0.56	-0.08	-1.29	-0.17



	Model 1 (Patient characteristics)	Model 2 (Model 1 + Presence of STT OA)	Model 3 (Model 2 + Psychological distress and pain catastrophizing)	Model 4 (Model 3 + Illness perception)	Univariable models
B-IPQ Treatment control				0.30	-0.52
B-IPQ Identity				1.11**	2.88
B-IPQ Concern				0.40	3.03
B-IPQ Understanding				0.25	0.33
B-IPQ Emotional response				0.72	3.12
Multiple R ²	0.051	0.060	0.346	0.474	0.47
Adjusted R ²	0.032	0.037	0.325	0.439	0.41

* p ≤ 0.05
** p ≤ 0.01
*** p ≤ 0.001

DISCUSSION

The aim of this study was to investigate to what extent psychological factors are related to pre-treatment pain levels in patients receiving non-invasive treatment for CMC-1 OA. After controlling for patient characteristics and radiographic severity of OA, we found that higher psychological distress, more pain catastrophizing behavior and experiencing more consequences and symptoms from the illness were independently associated with higher pre-treatment pain levels. Pain catastrophizing behavior has the strongest association with pre-treatment pain. Patient characteristics and radiographic severity of the disease had no additive predictive value for pre-treatment pain.

Several previous studies focused on the association between X-ray scores and pain in patients with CMC-1 OA. However, different methods are available to score X-rays³⁵ and the available literature is conflicting^{6, 7, 36-39}. Several radiographic OA features including erosions and sclerosis have been linked to pain levels^{36, 39}, while Dahaghin et al.⁷ in a large population study (n=3906) reported that radiographic OA was poorly correlated with pain. In our study, we found that presence of STT OA could only explain a limited amount of variance in pain scores. Possibly, other radiographic OA features have a stronger association with pain and would therefore be more informative. However, as presence of STT OA is a clear indication of advanced CMC-1 OA in the Eaton-Glickel classification³², we expected a stronger association between presence of STT OA and pain in CMC-1 OA patients. While X-rays may still have an important role in clinical practice, our study indicates that their value for understanding pain scores is limited.

To our knowledge this is the first study that assessed pre-treatment pain in CMC-1 OA patients that included both radiographic severity and psychological factors in the analysis. Murphy et al.⁴⁰ performed a similar study for women with knee OA. They found that fatigue, sleep quality and depression explained additional variance in pain severity after correcting for age and X-ray scores. This is in line with our findings that psychological factors explained additional variance in pre-treatment pain. However, in our study we found that psychological factors explained an additional variance of 40% compared to 10% in Murphy et al., which may be explained by use of different definitions of psychological variables in both studies.

Becker et al.¹⁷ reported that symptom severity could largely be explained by whether or not the patients sought treatment for his symptoms and by pain catastrophizing behavior. This is in agreement with our finding that pain catastrophizing behavior has the strongest association with pre-treatment pain of all variables included in our study.

While no studies reported the association between pain and illness perceptions for patients with CMC-1 OA, Hill et al.⁴¹ found that higher pain levels were associated with reporting more frustration, experiencing more consequences and expecting a chronic timeline in people with musculoskeletal hand problems.

The strength of this study is the large population where we combined psychological distress, pain catastrophizing as well as illness perceptions in explaining pre-treatment pain in non-invasively treated CMC-1 OA. Moreover, we included presence of STT OA in our analyses as measure for structural damage to the CMC-1 joint. To our knowledge this is the first study that combined psychological factors and radiographic severity of disease to explain pre-treatment pain levels of CMC-1 OA patients.

Study limitations

A limitation of our study is the quality of the X-rays that we used to score presence of STT OA. These X-rays were taken as part of daily clinical practice and therefore not taken in a standardized way, making it difficult to score all radiographic OA features. For that reason we only scored presence of STT OA, because presence of STT OA is an indication that radiologically the disease has reached an advanced stage³². Still our study clearly demonstrates that presence of STT OA, on X-rays taken as part of routine care, is not related to pre-treatment pain, whereas psychological factors show a strong association with pre-treatment pain.

In addition, it is not possible to draw any causal implications from our research findings due to the cross-sectional design of our study. While our study demonstrates a strong association between pre-treatment pain levels and psychological factors, more research is needed to determine the direction of this association.

Future research

Based on the strong association between pre-treatment pain and treatment outcomes in our study and in previous studies [17, 23, 31], the question arises whether psychological factors will affect treatment outcomes and consequently, whether treatment results will improve when patients receive psychological support in addition to usual care. A large prospective study may provide valuable knowledge of the longitudinal association between psychological factors and pain and can be used to answer the research questions of interest.

Moreover, future studies have to demonstrate what type of psychological intervention would improve pain levels most in non-invasively treated CMC-1 OA patients, while also being feasible to offer in addition to usual care. This study suggests that pain catastrophizing behavior is the most important factor to target with a psychological intervention, but psychological distress and/or negative illness perceptions may be relevant targets for intervention as well.

In conclusion, the present study demonstrates that patient characteristics and X-rays have limited value for understanding pain in patients with CMC-1 OA. In contrast, we found a strong association between psychological factors and pain levels prior to non-invasive treatment. Clinicians should be aware of the strong relation between pain and psychological factors and should look beyond X-ray scores to judge pain intensity in patients with CMC-1 OA.

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SUPPLEMENTARY TABLES

Supplemental table 1. Non-responder analysis for patients who completed the MHQ, but did not complete the psychological questionnaires

Variables	Responder (n=428)	Non-responder (n=47)	P-value
Age in years	59.9 (7.7)	61.5 (8.9)	0.23
Female (%)	76.9	76.6	1
Hand dominance (%)			0.29
Right	90.7	89.4	
Left	6.8	4.3	
Both	2.6	6.4	
Dominant hand affected (%)	52.6	42.6	0.25
Duration of symptoms in months (median, interquartile range)	12 (6-24)	12 (6-33)	0.38
MHQ-pain (reversed)	53.7 (17.6)	53.5 (17.0)	0.95
MHQ-aesthetics	82.0 (19.8)	78.3 (21.0)	0.24
MHQ-hand function	58.3 (18.4)	57.3 (16.9)	0.70
MHQ-activities of daily life	66.0 (21.9)	65.2 (15.7)	0.38
MHQ-work performance	61.0 (26.0)	66.3 (25.4)	0.18
MHQ-satisfaction	42.8 (21.7)	44.2 (20.3)	0.67
MHQ-total score	59.4 (14.9)	59.8 (14.4)	0.63

* Values reported as mean (SD) unless otherwise stated.

Supplemental table 2. Non-responder analysis for patients with complete questionnaires, but without CMC-1 joint X-ray

	Responder (n=255)	Non-responder (n=173)	P-value
Age in years	59.8 (7.8)	60.1 (7.6)	0.74
Female (%)	74.9	79.8	0.29
Hand dominance (%)			0.82
Right	91.4	89.6	
Left	6.3	7.5	
Both	2.4	2.9	
Dominant hand affected (%)	51.2	54.4	0.76
Duration of symptoms in months (median, interquartile range)	12 (6-24)	12 (5-24)	0.58
MHQ-pain	52.9 (17.3)	54.8 (18.0)	0.27
MHQ-aesthetics	83.0 (19.5)	80.4 (20.4)	0.12
MHQ-hand function	57.9 (18.0)	59.0 (18.9)	0.54
MHQ-activities of daily life	66.2 (22.2)	65.8 (21.3)	0.79
MHQ-work performance	61.3 (26.4)	60.3 (25.5)	0.81
MHQ-satisfaction	43.2 (22.2)	42.2 (20.8)	0.66
MHQ-total score	59.7 (15.2)	59.1 (14.4)	0.68

* Values reported as mean (SD) unless otherwise stated.

Supplemental table 3. Correlation matrix of the psychological variables

	1	2	3	4	5	6	7	8	9
1. PHQ total score	—	—	—	—	—	—	—	—	—
2. PCS total score	0.55	—	—	—	—	—	—	—	—
3. B-IPQ Consequences	0.33	0.45	—	—	—	—	—	—	—
4. B-IPQ Timeline	0.09	0.17	0.27	—	—	—	—	—	—
5. B-IPQ Personal control	-0.08	-0.23	-0.06	0.05	—	—	—	—	—
6. B-IPQ Treatment control	-0.12	-0.24	0.02	-0.10	0.31	—	—	—	—
7. B-IPQ Identity	0.17	0.26	0.52	0.24	-0.05	0.02	—	—	—
8. B-IPQ Concern	0.34	0.48	0.60	0.35	-0.11	-0.10	0.50	—	—
9. B-IPQ Understanding	-0.11	-0.22	0.03	0.11	0.13	0.18	0.06	0.003	—
10. B-IPQ Emotional response	0.41	0.53	0.57	0.18	-0.12	-0.08	0.36	0.59	-0.02

Interpretation of correlation coefficients [34]:

0.00 – 0.30 Negligible correlation

0.30 – 0.50 Weak correlation

0.50 – 0.70 Moderate correlation

0.70 – 0.90 High correlation

0.90 – 1.00 Very high correlation

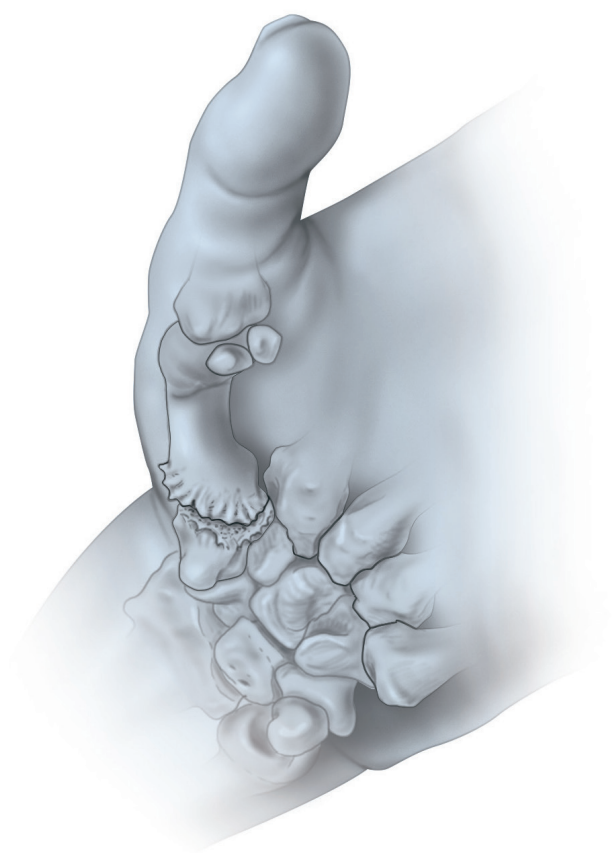
Supplemental table 4. Beta coefficients and explained variance (R^2) for hierarchical linear regression models explaining pre-treatment disease severity (total MHQ score). In each additional model, more variables potentially explaining pre-treatment disease severity are included. Both the unstandardized (B) and standardized (β) regression coefficients are reported.

	Model 1 (Patient characteristics)		Model 2 (Model 1 + Presence of STT OA)		Model 3 (Model 2 + Psychological distress and pain catastrophizing)		Model 4 (Model 3 + Illness perception)		Univariable models	
	B	β	B	β	B	β	B	β	B	β
Explanatory variables										
Age	0.04	0.02	0.04	0.02	-0.04	-0.02	-0.02	-0.01	-0.01	-0.01
Sex, male	8.82***	0.58***	8.77***	0.58***	6.03**	0.40**	4.28*	0.28*	7.92	0.52
<i>Physical activity at work</i>										
<i>(ref = no work)</i>										
Light	7.62**	0.50**	7.69**	0.51**	5.75*	0.38*	4.32*	0.28*	6.03	0.40
Moderate	3.82	0.25	3.86	0.25	3.30	0.22	3.98	0.26	2.40	0.16
Severe	0.83	0.05	0.36	0.02	1.74	0.11	2.32	0.15	1.36	0.09
STT OA, present			2.72	0.18	1.76	0.12	0.86	0.06	2.57	0.17
PHQ score					-1.22**	-0.21**	-0.86*	-0.15*	-2.60	-0.44
PCS score					-0.58***	-0.39***	-0.28**	-0.19**	-0.80	-0.53
B-IPQ							-1.83***	-0.28***	-3.78	-0.58
Consequences										
B-IPQ Timeline							0.90**	0.14**	-0.50	-0.08
B-IPQ							0.38	0.06	1.11	0.17
Personal control										
B-IPQ							-0.09	-0.01	0.39	0.05
Treatment control										



	Model 1 (Patient characteristics)	Model 2 (Model 1 + Presence of STT OA)	Model 3 (Model 2 + Psychological distress and pain catastrophizing)	Model 4 (Model 3 + illness perception)	Univariable models
B-IPQ				-0.84*	-2.53 -0.41
Identity					
B-IPQ				-0.54	-2.83 -0.50
Concern					
B-IPQ				-0.07	0.42 0.05
Understanding					
B-IPQ				-0.53	-2.86 -0.53
Emotional response					
Multiple R ²	0.086	0.090	0.358	0.522	—
Adjusted R ²	0.067	0.067	0.336	0.489	—

* p ≤ 0.05
** p ≤ 0.01
*** p ≤ 0.001



CHAPTER 9

ASSOCIATIONS BETWEEN POSITIVE TREATMENT OUTCOME EXPECTATIONS, ILLNESS UNDERSTANDING AND OUTCOMES: A COHORT STUDY ON NON-OPERATIVE TREATMENT OF FIRST CARPOMETACARPAL OSTEOARTHRITIS

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ABSTRACT

Purpose: More positive outcome expectations and illness perceptions are associated with better outcomes for patients with several osteoarthritic orthopedic conditions. However, it is unknown whether these factors also influence outcomes of non-operative treatment for first carpometacarpal osteoarthritis (CMC-1 OA). Therefore, we assess the role of pre-treatment outcome expectations and illness perceptions in reports of pain and hand function three months after non-operative treatment for CMC-1 OA.

Materials and methods: We conducted a cohort study with 219 patients treated non-operatively for CMC-1 OA between September 2017 and October 2018. Patients were included in the study if they completed measures of pain and hand function, illness perceptions (scale: 0-10) and expectations (scale: 3-27) as part of routine outcome measurements. Pain and hand function were measured before treatment and three months after starting treatment using the Dutch version of the Michigan Hand Outcome Questionnaire. Multivariable linear regression analysis was used to assess the influence of outcome expectations and illness perceptions on pain and hand function.

Results: Both positive outcome expectations ($B = 0.64$; 95%CI[0.1-1.2]) and a better illness understanding (an illness perception subdomain; $B = 1.53$; 95%CI[0.2-2.9]) at baseline were associated with less pain at three months. For hand function, similar estimated were found.

Conclusions: We found that positive outcome expectations and a better illness understanding, were associated with a better outcome of non-operative treatment for CMC-1 OA.

INTRODUCTION

Carpometacarpal osteoarthritis of the thumb (CMC-1 OA) is a disabling illness where non-operative treatment can often be successful¹. The incidence of CMC-1 OA is estimated at 7.5%, of which 20 % seeks treatment². Usually, treatment is started non-operatively with orthosis, injections, or hand therapy. As a recent study indicated, a good outcome of non-operative treatment for CMC-1 OA may delay and often prevent surgical treatment³. Given the considerable variation in treatment outcome for CMC-1 OA and modest patient satisfaction⁴, it is important to understand which pre-treatment factors are associated with a better outcome of non-operative treatment for CMC-1 OA.

To date, it is mostly unknown which factors are associated with a better outcome of non-operative treatment for CMC-1 OA. One study found no predictive factors for treatment outcome over and above baseline pain and function¹. However, in this study, the psychological mindset of patients at the start of the treatment was not assessed.

Several aspects of the influence of patient mindset on the outcome of treatment have been assessed before. For example, studies have found that patients who experience more psychological distress and who have a stronger tendency to catastrophize pain may benefit less from CMC-1 OA treatments⁵⁻⁸. However, these studies are limited as they did not adjust for baseline disease severity.

Two additional and potentially-important aspects of the patient mindset are the extent to which a patient has positive expectations about the efficacy of the treatment, and the illness perceptions of the patients. Several studies in other conditions have demonstrated a positive association between outcome expectations and better patient-reported treatment outcomes across a variety of medical conditions including osteoarthritis⁹⁻¹⁴. However, no prior studies have prospectively examined the role of expectations and illness perception on outcomes of non-operative treatment in CMC-1 OA.

Therefore, we investigated the association between treatment outcome expectations and illness perceptions and patient-reported pain and hand function three months after starting non-operative treatment of CMC-1 OA patients, while adjusting for baseline pain, function, psychological distress and catastrophic thinking about pain.

METHOD

Context

The study was performed at Xpert Clinic and Handtherapie Nederland, comprising of 22 outpatient clinics for hand surgery and therapy in the Netherlands, and took place between September 2017 and October 2018, after approval by the local Medical Ethical Committee (Rotterdam, NL/sl/MEC-2018-1088). Patients were treated by hand therapists who received the same internal training on how to treat CMC-1 OA with hand therapy. Participants received treatment under the supervision of (generally) the same therapist, using a standardized protocol. All therapist are certified physical therapist with extensive experience as a hand therapist.

Patients

All patients receiving non-operative treatment for CMC-1 OA who completed psychological screening questionnaires before treatment and the Michigan Hand Outcome Questionnaire (MHQ) before treatment and three months after treatment were included in the cohort. Details of the data collection have been published earlier¹⁵. Patients and therapists were not blinded to the treatment.

Intervention

All patients were clinically diagnosed with CMC-1 OA based on presenting complaints and clinical signs. As defined in the Dutch guideline¹⁶ for primary CMC-1 OA, all patients were offered non-operative treatment first, including an orthosis and/or hand therapy. In general, treatment consisted of prescribing a custom-made or prefabricated thumb orthosis (usually including CMC-1 palmar and radial abduction and slight metacarpophalangeal flexion) and one to two 25-minute sessions of hand therapy per week for a total of 12 weeks. The first six weeks of treatment aimed at correcting the position of the CMC-1 into a more stable position of palmar and radial abduction and prevention of flexion and adduction. This included coordination and mobility exercises⁴ (4-6 times/day, 10-15 repetitions). The last six weeks of treatment were mainly focused on improving active stability and pinch strength and also included functional exercises⁴ (2-3 times/day up until 50-100 repetitions). Additional or fewer sessions could be planned based on the therapist's judgment and the

availability of the participant. A more detailed description of the treatment has been reported in a previous paper^{1,4}.

Outcome measures

The primary endpoint for this study was three months after starting non-operative treatment. As the primary outcome, we used the pain subscale of the Dutch version of the MHQ¹⁷, measured as part of routine outcome measurements. The MHQ is a validated patient-reported outcome measure to assess patients' pain and hand functioning^{17,18}. The secondary outcome was the hand function subscale of the MHQ. The questions of these subscales result in a 0 (severe pain or dysfunction) – 100 (no pain or dysfunction) score. All data was collected as part of routine outcome measurement using GemsTracker electronic data capture tools¹⁹. After the initial diagnosis, a hand therapist assigns prespecified routine outcome measures to all patients in the clinic. Patients receive emails to complete online questionnaires at preset time points. This system has been described in more detail in an earlier publication¹⁵. Completing questionnaires is encouraged and facilitates evaluation of progress throughout the treatment, but completing questionnaires is not required for any part of the treatment.

Baseline demographics

Baseline characteristics of all patients (including age, sex, workload, duration of complaints, hand dominance, smoking status, and body mass index) were collected by the therapist during the first consultation.

Patient mindset

To assess patients' baseline mindset, patients completed four questionnaires: i) the Patient Health Questionnaire (PHQ-4)²⁰, a screening tool for depression and anxiety that results in a score from 0 (no psychological distress) – 12 (high psychological distress), ii) the Pain Catastrophizing Scale (PCS)²¹, a questionnaire to assess a patient's tendency to catastrophize pain. The PCS ranges from 0 (no pain catastrophizing) – 52 (high pain catastrophizing), iii) the Credibility/ Expectancy Questionnaire (CEQ)²², a questionnaire that measures patients' outcome expectations and credibility of the treatment and results in a score from 3 (low expectations and credibility) – 27 (high expectations and credibility). The CEQ specifically asks patients how much they "feel" or

“think” the treatment will reduce symptoms and the physical limitation due to symptoms of their CMC-1 OA. In this study, we only evaluated the 3-item expectancy subscale of the CEQ. iv) The Brief Illness Perceptions Questionnaire (B-IPQ)²³, a questionnaire that measures how patients perceive their illness on eight separate domains, using a single 0-10 question for each domain. The fourth question of the IPQ asks patients how they think the treatment will affect their illness. Since this construct is evaluated using the expectancy domain of the CEQ as well, this item of the B-IPQ was not used in our analyses. We used the validated Dutch versions of all questionnaires²⁴⁻²⁶.

Data analysis

First, we assessed the univariable associations of all baseline characteristics with pain and hand function at three months. However, in this analysis we adjusted for baseline MHQ, because we previously found that baseline pain and function were strongly related to the outcome³. Then, to assess which patient characteristics and mindset variables were independently associated with outcome, we performed two multivariable linear regressions with pain and hand function as outcomes. In addition to an overall multivariable model, we developed a stepwise multivariable model to assess the contribution of the different sets of variables to the explained variance (R^2). First, we added patient and disease characteristics to the model, second, we added psychological distress and pain catastrophizing, and finally, we added outcome expectations and illness perceptions. We added psychological distress and pain catastrophizing first, because previous literature has shown associations between these variables and pain and hand function. The relationship between outcome expectations, illness perceptions and outcomes is unknown. Therefore, we added these variables last.

All analyses were conducted using R statistical computing, version 3.3.4. For all tests, a p -value ≤ 0.05 was considered statistically significant. We assumed that all relationships were linear and the model residuals were normally distributed. We confirmed these assumptions. A power calculation using G Power (version 3.1), based on a multivariable model, indicated that a sample of 159 patients was needed to detect a small to medium effect ($f = 0.1$) of the patient mindset on outcomes given a power of 0.8 and alpha of 0.05.

The funder played no role in the design, conduct, or reporting of this study.

RESULTS

Between September 2017 and October 2018, we included 219 patients. Figure 1 shows the flow of patients throughout the study and reasons for exclusion. 87% of all patients who completed the MHQ also completed all mindset questionnaires while at three months, 60% of these patients also completed the MHQ. There were no significant differences patients who did and did not complete all necessary questionnaires.

Table 1 presents the baseline demographic characteristics and mindset variables of all patients that are included in the analysis. Patients had a mean age (SD) of 60 (7) years old and the majority were female (76%). On average, the MHQ pain subscale at three months improved by 10 points ($p < 0.001$, 95%CI [8 – 12]) and the MHQ hand function subscale increased by 5 points ($p < 0.001$, 95%CI [3 – 7]) compared to baseline.

In the univariable analyses, where we only adjusted for baseline MHQ values, being a smoker was associated with more pain at three months. Additionally, having more positive outcome expectations was associated with less pain and increased hand function at three months (see Table 2).

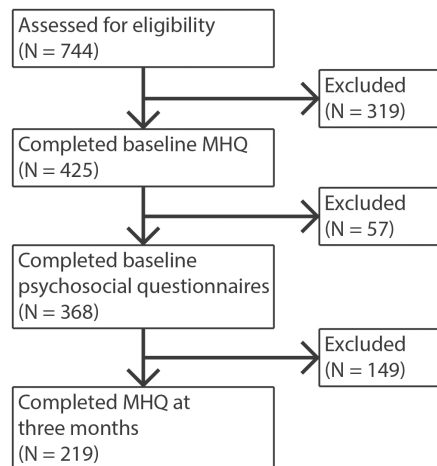


Figure 1. Flow diagram of the study. Michigan Hand outcome Questionnaire (MHQ)

Table 1. Baseline patient and psychosocial characteristics of the study population (n = 219 patients receiving non-operative treatment for first carpometacarpal osteoarthritis)

	Value	Questionnaire Range
Age, year (SD)	60 (7)	
Sex, Male, (%)	52 (24)	
Duration of complaints, months, median (IQR)	10 (5-24)	
BMI, mean (SD)	27 (5)	
Current non-smoker, (%)	195 (89)	
Workload, (%)		
No paid labor	84 (38)	
light physical labor	45 (21)	
medium physical labor	64 (29)	
heavy physical labor	26 (12)	
Baseline MHQ pain, mean (SD)	46 (16)	0 (worst) – 100 (best)
Baseline MHQ hand function, mean (SD)	56 (17)	0 (worst) – 100 (best)
PHQ Psychological Distress, median (IQR)	0 (0-2)	0 (best) – 12 (worst)
Pain Catastrophizing Score, median (IQR)	10 (5-18)	0 (best) – 52 (worst)
CEQ Expectations Score, median (IQR))	18 (15-20)	3 (worst) – 27 (best)
IPQ consequences, median (IQR)	7 (5-8)	0 (best) – 10 (worst)
IPQ timeline, median (IQR)	8 (6-10)	0 (best) – 10 (worst)
IPQ personal control, median (IQR)	5 (4-7)	0 (worst) – 10 (best)
IPQ identity, median (IQR)	7 (5-8)	0 (best) – 10 (worst)
IPQ concern, median (IQR)	7 (5-8)	0 (best) – 10 (worst)
IPQ illness comprehensibility, median (IQR)	9 (8-10)	0 (worst) – 10 (best)
IPQ emotional consequences, median (IQR)	4 (1.5-7)	0 (best) – 10 (worst)

Michigan Hand outcome Questionnaire (MHQ), Body Mass Index (BMI), Patient Health Questionnaire(PHQ), Credibility and Expectations Questionnaire (CEQ), Illness Perceptions Questionnaire (IPQ)

In the multivariable analyses a more positive outcome expectation and a better illness understanding (an illness perception subdomain) of patients' illness were associated with less pain (see Table 3). For hand function, a more positive outcome expectation was associated with better hand function at three months. Figures 2 and 3 illustrate the magnitude of the effect of pre-treatment expectations and illness perceptions on pain and hand function at three months, illustrating both the systematic effects and the relatively large variation between subjects.

Stepwise linear regression analysis revealed that 32% of the variance in pain at three months could be explained by patient characteristics and baseline pain. No additional variance could be explained by psychological distress and pain

catastrophizing, but outcome expectations and illness perceptions explained an additional 5% of the variance over and above all other variables (Supplementary Table 1). For hand function, 28% of the variance at three months could be explained by patient characteristics and baseline hand function. An additional 1% could be explained by psychological distress and pain catastrophizing and outcome expectations and illness perceptions explained an additional 4% over and above all other variables (Supplementary Table 2).

Table 2. Multivariable associations between MHQ at three months and individual predictors, adjusted for baseline MHQ, indicating the association of the different variables with the MHQ outcome

	MHQ Pain - three months			MHQ Hand function - three months		
	B	95%CI	β	B	95%CI	β
Age	0.26	[0-0.6]	0.10	0.00	[-0.2-0.2]	0.00
Sex. Male	-0.45	[-5.8-4.9]	-0.02	2.91	[-1-6.8]	0.20
Duration of complaints (months)	0.02	[-0.1-0.1]	0.03	-0.03	[-0.1-0]	-0.05
BMI	0.09	[-0.3-0.5]	0.02	-0.03	[-0.4-0.3]	-0.01
Current non-smoker	9.53	[2.4-16.7]	0.49	4.03	[-1.3-9.4]	0.28
Workload						
ref (no paid labor)	-	-		-		
Light physical labor	3.99	[-2-10]	0.21	3.50	[-1.1-8.1]	0.24
Medium physical labor	-2.21	[-7.6-3.2]	-0.11	0.04	[-4.1-4.2]	0.00
Heavy physical labor	-6.46	[-13.8-0.9]	-0.33	-1.80	[-7.4-3.8]	-0.12
PHQ Psychological Distress (0-12)	-0.56	[-1.6-0.4]	-0.07	-0.78	[-1.5-0]	-0.12
Pain catastrophizing scale (0-52)	-0.06	[-0.3-0.2]	-0.03	-0.18	[-0.4-0]	-0.11
CEQ Expectancy scale (3-27)	0.66	[0.2-1.1]	0.16	0.53	[0.2-0.9]	0.17
IPQ Consequences (0-10)	-0.28	[-1.4-0.8]	-0.03	-0.36	[-1.1-0.4]	-0.06
IPQ Timeline (0-10)	-0.86	[-1.9-0.1]	-0.10	-0.56	[-1.3-0.2]	-0.09
IPQ Personal control(0-10)	0.30	[-0.7-1.3]	0.03	0.96	[0.2-1.7]	0.14
IPQ Identity (0-10)	-0.46	[-1.4-0.5]	-0.06	-0.29	[-1-0.4]	-0.05
IPQ Concern (0-10)	-0.67	[-1.7-0.3]	-0.09	-0.50	[-1.2-0.2]	-0.09
IPQ Illness comprehensibility (0-10)	1.18	[-0.2-2.5]	0.10	0.40	[-0.6-1.4]	0.04
IPQ Emotional consequences (0-10)	0.14	[-0.7-1]	0.02	-0.55	[-1.2-0.1]	-0.11

Bold indicates statistically significant covariates

Michigan Hand outcome Questionnaire (MHQ). Body Mass Index (BMI). Patient Health Questionnaire(PHQ). Credibility and Expectations Questionnaire (CEQ). Illness Perceptions Questionnaire (IPQ)

Table 3. Multivariable linear regression model for pain and hand function at three months, adjusted for all covariates, indicating the adjusted contributions of all variables in a multivariable model. The bold numbers indicate the variables that are significantly associated with the outcome.

	MHQ Pain – at three months			MHQ Hand function – at three months		
	B	95%CI	β	B	95%CI	β
Age	0.21	[-0.2-0.6]	0.08	-0.10	[-0.4-0.2]	-0.05
Sex. Male	-1.64	[-7.4-4.1]	-0.08	3.20	[-1.2-7.6]	0.22
Duration of complaints (months)	0.03	[-0.1-0.1]	0.04	-0.01	[-0.1-0.1]	-0.01
BMI	0.12	[-0.3-0.6]	0.03	-0.03	[-0.4-0.3]	-0.01
Current non-smoker	8.94	[1.6-16.3]	0.46	3.44	[-2.3-9.2]	0.24
Workload						
ref (no payed labor)	1	-	0	1	-	0
Light physical labor	6.41	[0.1-12.8]	0.33	2.86	[-2.1-7.8]	0.20
Medium physical labor	0.43	[-5.8-6.7]	0.02	0.10	[-4.8-5]	0.01
Heavy physical labor	-3.65	[-11.7-4.4]	-0.19	-2.11	[-8.3-4.1]	-0.14
Baseline MHQ score (0-100)	0.56	[0.4-0.7]	0.47	0.40	[0.3-0.5]	0.47
PHQ Psychological Distress (0-12)	-0.39	[-1.5-0.8]	-0.05	-0.37	[-1.3-0.5]	-0.06
Pain catastrophizing scale (0-52)	0.11	[-0.2-0.5]	0.05	-0.01	[-0.3-0.2]	0.00
CEQ Expectancy scale (3-27)	0.64	[0.1-1.2]	0.15	0.44	[0-0.8]	0.14
IPQ Consequences (0-10)	0.13	[-1.2-1.5]	0.02	0.14	[-0.9-1.2]	0.02
IPQ Timeline (0-10)	-0.53	[-1.6-0.5]	-0.06	-0.12	[-0.9-0.7]	-0.02
IPQ Personal control(0-10)	-0.12	[-1.2-0.9]	-0.01	0.72	[-0.1-1.5]	0.11
IPQ Identity (0-10)	-0.13	[-1.2-1]	-0.02	-0.11	[-0.9-0.7]	-0.02
IPQ Concern (0-10)	-0.66	[-1.9-0.6]	-0.09	0.09	[-0.9-1.1]	0.02
IPQ Illness comprehensibility (0-10)	1.53	[0.2-2.9]	0.13	0.22	[-0.8-1.3]	0.02
IPQ Emotional consequences (0-10)	0.76	[-0.3-1.8]	0.11	-0.19	[-1-0.6]	-0.04

Bold indicates statistically significant covariates

Michigan Hand outcome Questionnaire (MHQ), Body Mass Index (BMI), Patient Health Questionnaire(PHQ), Credibility and Expectations Questionnaire (CEQ), Illness Perceptions Questionnaire (IPQ)

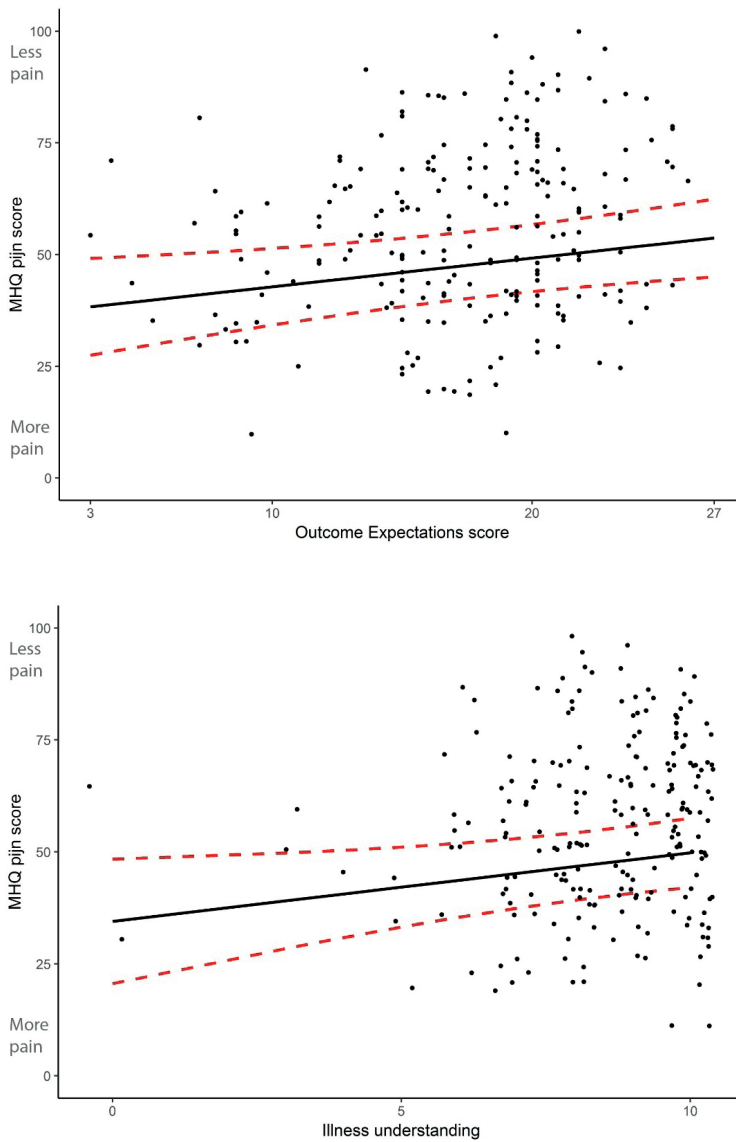


Figure 2AB. Effect plots of association between outcome expectations (A) and illness understanding (B) and pain at three months. All points represent individual patients. Jitter, minimal random variance, has been added to display overlapping points. Higher Michigan Hand outcome Questionnaire (MHQ) pain score on the y-axis represents less pain. Higher scores on the x-axes represent more positive outcome expectations or better understanding.

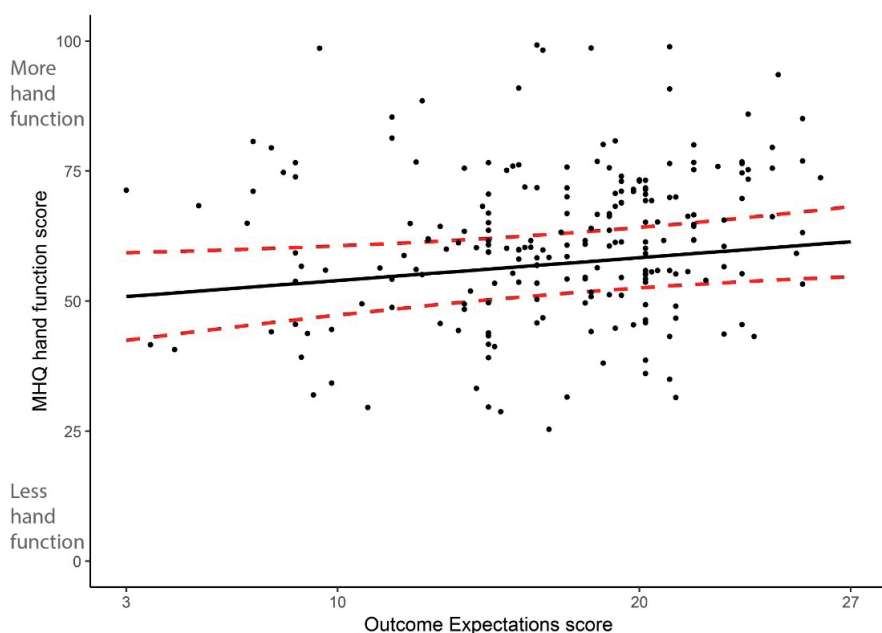


Figure 3. Effect plots of association between expectations and hand function at three months. All points represent the scores of individual patients. Jitter has been added to display overlapping points. Higher Michigan Hand outcome Questionnaire (MHQ) hand function score on the y-axis represents more hand function. Higher scores on the x-axis represent more positive outcome expectations

DISCUSSION

We investigated the relation between the psychological mindset of CMC-1 OA patients at the start of a non-operative treatment and patient-reported pain and hand function at three months after treatment. We found that two aspects of the patient mindset, positive outcome expectations and a better illness understanding, were independently associated with a better outcome of non-operative treatment for CMC-1 OA. After adjusting for patient characteristics, pain catastrophizing and psychological distress, we found that two aspects of the patient mindset, positive outcome expectations and a better illness understanding, were independently associated with a better outcome of non-operative treatment for CMC-1 OA.

Our finding that more positive outcome expectations are associated with better outcomes is in line with several other studies^{27,28}. For example, Blanchard et al.²⁷ found that women with higher self-efficacy and outcome expectations were

more likely to be active during cardiac rehabilitation and Lurie et al.²⁸ found that lumbar disc herniation patients with more positive outcome expectations had better outcomes and were more physically active during cardiac rehabilitation.

Several mechanisms may explain the relationship between outcome expectation and patient-reported outcomes. For example, studies indicate that having more positive treatment outcome expectations may trigger psychobiological mechanisms, such as anxiety reduction, positive affectivity, cognitive reinterpretation, treatment adherence, and conditioning²⁹⁻³¹. This is confirmed in studies showing that interventions aimed to optimize patients' outcome expectations have improved outcomes³²⁻³⁵. Future studies could investigate how different expectation management strategies affect patients with CMC-1 OA and evaluate their effects on outcomes in daily clinical practice.

In addition to outcome expectations, our results show that patients that report a better illness understanding have less pain at three months. This is in line with findings from Hanusch et al.¹¹, who found that better illness understanding was associated with better early recovery after total knee arthroplasty. Moreover, Mosleh et al.³⁶ found that patients with coronary heart disease who reported better illness understanding were more likely to adhere to exercise therapy.

While we studied associations, several studies have investigated strategies to change patients' illness perception. For instance, Lee et al.³⁷ educated trauma patients on the theory of illness perceptions and asked them to identify inadequate perceptions. In this study, they found that these patients obtained more positive illness perceptions, however the influence on outcome was unfortunately not studied. Future studies may investigate if incorporating these strategies in the treatment of CMC-1 OA also leads to a more positive illness perception and, most importantly, in better outcomes.

In contrast with previous literature, we did not find an association between outcomes of non-operative treatment for CMC-1 OA and pain catastrophizing and psychological distress. For example, the papers by Das De et al.⁶ and Lozano-Calderon et al.⁷ showed that these factors play an important role in patients with CMC-1 OA. However, in these studies post-treatment PROMs were not adjusted for pre-treatment PROMs, which might explain the difference with our own findings. As CMC-1 OA complaints are known to be associated with

pain catastrophizing and psychological distress before treatment³⁸, it may be worthwhile to further investigate potential indirect pathways through which these mindset variables affect treatment outcomes in CMC-1 OA.

The strengths of our study are its longitudinal design and the fact that this is the first to study the influence of expectations alongside other psychosocial factors on outcome of non-operative treatment of CMC-1 OA. More specifically, most upper extremity studies do not take pre-treatment symptoms into account when investigating the role of the patients' mindset, even though pre-treatment symptoms play an important role in predicting outcomes in upper extremity conditions^{3, 39}.

Study limitations

A limitation of our study is the non-response rate during our study; 87% of all patients who completed the MHQ also completed all mindset questionnaires while at three months, 60% of these patients also completed the MHQ. However, there were no significant differences in baseline characteristics between the non-responders and the patients included in the analysis, suggesting no selection bias on the reported analyses. Furthermore, this percentage of missing data is representative of routine longitudinal data collection. For example, Crijns et al.⁴⁰ found similar rates of missing data in hand surgery patients.

CONCLUSION

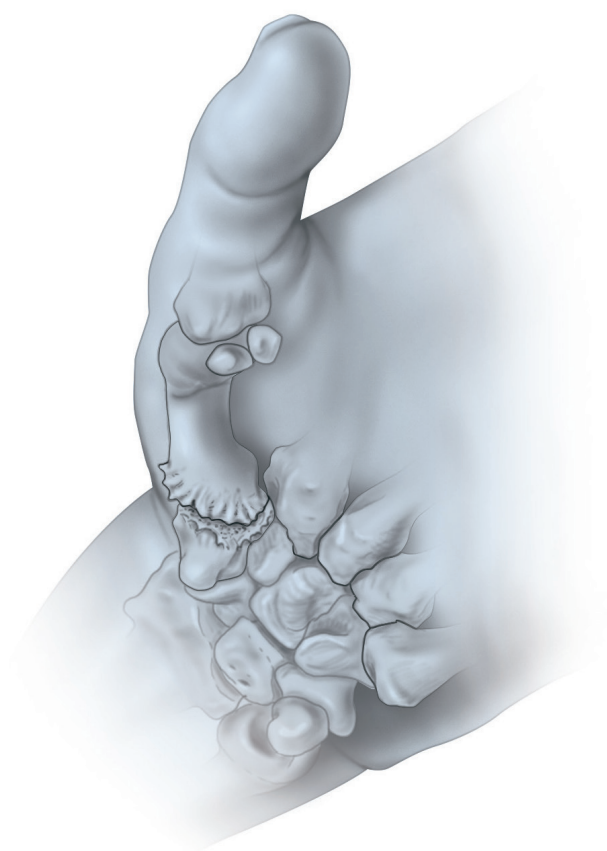
Our finding that higher outcome expectation leads to better outcomes may challenge the common belief in orthopedic surgery, hand surgery and hand therapy that a patient should not have too high expectations⁴¹. Discussing outcome expectations at the start of the non-operative treatment, in particular with patients who appear skeptic about the potential treatment benefits, might contribute to better outcomes. Our results also indicate that explaining the illness to a patient may also improve the outcome of treatment. Therefore, it might be worthwhile for clinicians to ensure that the patient understands the etiology and prognosis of their illness.

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CHAPTER 10

PATIENTS WITH HIGHER TREATMENT OUTCOME EXPECTATIONS ARE MORE SATISFIED WITH THE RESULTS OF NON- OPERATIVE TREATMENT FOR THUMB BASE OSTEOARTHRITIS: A COHORT STUDY

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ABSTRACT

Objective: To investigate how satisfaction with treatment outcome is associated with patient mindset and Michigan Hand Outcome Questionnaire (MHQ) scores at baseline and 3 months in patients receiving non-operative treatment for thumb base osteoarthritis (CMC-1 OA).

Setting: 20 outpatient locations of a clinic for hand surgery and hand therapy in The Netherlands.

Participants: Patients (n=308) receiving non-operative treatment for CMC-1 OA, including exercise therapy, an orthosis, or both, between September 2017 and February 2019.

Interventions: Non-operative treatment (i.e. exercise therapy, an orthosis, or both)

Main outcome measure: Satisfaction with treatment outcomes was measured after three months of treatment. We measured total MHQ score at baseline and at three months. As baseline mindset factors, patients completed questionnaires on treatment outcome expectations, illness perceptions, pain catastrophizing, and psychological distress. We used multivariable logistic regression analysis and mediation analysis to identify factors associated with satisfaction with treatment outcomes.

Results: More positive pre-treatment outcome expectations were associated with a higher probability of being satisfied with treatment outcomes at three months (odds ratio = 1.15, 95% CI 1.07-1.25). Only a relatively small part (33%) of this association was due to a higher total MHQ score at three months. None of the other mindset and hand function variables at baseline were associated with satisfaction with treatment outcomes.

Conclusions: This study demonstrates that patients with higher pre-treatment outcome expectations are more likely to be satisfied with treatment outcomes after three months of non-operative treatment for CMC-1 OA. This association could only partially be explained by a better functional outcome at three months for patients who were satisfied. Health care providers treating patients non-operatively for CMC-1 OA should be aware of the importance of expectations and may take this into account in pre-treatment counseling.

INTRODUCTION

Osteoarthritis of the first carpometacarpal joint (CMC-1 OA) is a common disease, especially in postmenopausal women ¹. Symptoms include pain, limitations in activities, and loss of hand function ². Several non-operative and operative treatment options are available ³. Current practice is to treat patients non-operatively first. This often consists of exercise therapy, an orthosis, or both ⁴⁻⁶. Surgery can be considered if symptoms are not sufficiently relieved by non-operative treatment ⁴. Non-operative treatment is a successful treatment strategy for CMC-1 OA, which, on average, reduces pain and improves hand function ^{7,8}. Moreover, in a large cohort with a mean follow-up of 2.2 years, only 15% of the patients underwent further surgery ⁹.

Treatment outcomes such as pain relief and functional improvement have been frequently studied, however, in recent days there is increasing attention for the patients' interpretation of their treatment outcomes ¹⁰. Previous studies demonstrated that after hand therapy and an orthosis for CMC-1 OA, there is considerable variation in patients' satisfaction with treatment outcomes. However, it is still unknown which factors explain this variation in satisfaction with treatment outcomes for these patients ^{5,9}.

It has previously been reported that pain and hand function after treatment are associated with satisfaction with treatment outcomes for patients with hand and wrist disorders receiving surgical treatment or steroid injections ^{11, 12}. Additionally, patient mindset has been shown to be associated with satisfaction with treatment outcomes, again following either surgical treatment or steroid injections ^{12, 13}.

Patient mindset can be seen as particular associations and expectations that a patient has, which could affect a patients' attitude towards his treatment ¹⁴. Because patients generally have a particular mindset towards a treatment before starting treatment, communication between a clinician and patients could be an opportunity to modify this mindset, for example by changing expectations ¹⁵.

There have already been studies on the association between expectations and satisfaction in daily practice, but there is no consensus on this. Several authors suggested that patients with high expectations would be less satisfied, because

these patients are less likely to have their expectations fulfilled^{11, 13, 16}. Many surgeons apply this principle in practice¹⁷. However, other studies have suggested that patients should have positive expectations to improve treatment outcomes¹⁸⁻²². Possibly, this suggests that there is an optimum for expectations. Because of the conflicting suggestions in literature, there currently is no consensus or best practice on how clinicians should deal with patients' expectations in order to optimize treatment outcomes and satisfaction.

While it has been reported that pain, hand function, and patient mindset are associated with satisfaction with treatment outcomes for patients receiving surgical treatment or steroid injections for hand and wrist conditions, it remains unknown if these factors also explain satisfaction with treatment outcomes in patients receiving non-operative treatment for CMC-1 OA. In particular, the role of expectations is unclear. Therefore, the purpose of this study was to investigate which baseline characteristics, including total Michigan Hand Outcome Questionnaire (MHQ) score and patient mindset, are associated with the likelihood of being satisfied with treatment outcomes after three months of non-operative treatment for CMC-1 OA when accounting for total MHQ score at three months.

METHODS

Setting and study population

Between September 2017 and February 2019, this cohort study was performed with routine outcome measurement data from Xpert Clinic and Handtherapie Nederland, comprising 20 outpatient locations for hand surgery and hand therapy in The Netherlands. Over 150 hand therapists and 23 European Board certified (FESSH) hand surgeons are employed in our clinic. The cohort and data collection procedures have previously been described in more detail²³. All patients provided written informed consent and this study was approved by the Erasmus MC Medical Ethical Committee.

Patients were included when treated non-operatively for CMC-1 OA after being diagnosed with CMC-1 OA by a Federation of European Societies for Surgery of the Hand (FESSH) certified hand surgeon. The diagnosis was made based on clinical presentation and X-rays when required. Non-operative treatment

consisted of immobilizing the CMC-1 joint using an orthosis and performing exercises to improve the active stability of the CMC-1 joint and strength of the thenar muscles. This treatment protocol has previously been described in more detail ⁵. Non-operative treatment was offered for at least three months before surgery was considered. All hand therapists received the same training on how to treat CMC-1 OA patients. However, treatment was not fully standardized as in randomized controlled trials and therapists could deviate from this protocol based on patient preferences and clinical considerations.

All patients were invited to complete the questionnaires as part of routine clinical care before and after treatment. The questionnaires were sent after the first consultation with the hand surgeon. In addition, baseline characteristics including age, gender, occupational intensity, duration of symptoms, hand dominance, and affected hand, were collected. Occupational intensity was categorized as: not employed, light occupational intensity (e.g., working in an office), moderate occupational intensity (e.g., working in a shop), or severe occupational intensity (e.g., construction work). Patients who did not complete all questionnaires of interest at baseline and three months were excluded from the study.

Outcome measurements

Satisfaction with treatment outcomes was the primary outcome measure. This was measured using a self-designed questionnaire administered three months after the start of non-operative treatment. In this questionnaire, we asked patients “To what extent are you satisfied with the treatment outcomes obtained so far?”, which could be rated as poor, moderate, fair, good or excellent. We have dichotomized this, classifying patients rating their satisfaction with treatment outcomes as poor, moderate or fair as less satisfied, while classifying patients rating their satisfaction as good or excellent as satisfied. We dichotomized satisfaction, since the number of patients in some groups was not enough for analysis, and, from a clinical point of view, because we aimed to identify factors that predicted whether patients would be satisfied or dissatisfied with treatment outcomes.

At baseline and three months, patients were invited to complete the Michigan Hand Outcome Questionnaire (MHQ) ²⁴. The MHQ is a patient-reported

outcome measure with good reliability, validity, and responsiveness for CMC-1 OA patients²⁵. The MHQ consists of six domains (pain, hand function, aesthetics, work, activities of daily life, and satisfaction with hand function), each with a score ranging from 0-100 (0 = poorest function, 100 = ideal function). From these subscales, a total MHQ score is calculated for the affected hand, which is used in our analysis. We chose to use the total MHQ score at three months as functional improvement measure since it comprises a broad spectrum of domains relevant to patients with CMC-1 OA.

We used the Credibility and Expectancy Questionnaire (CEQ)²⁶ to measure outcome expectations regarding the treatment and the credibility of the treatment. This questionnaire has two domains (expectations and credibility) with three questions each. Scores per domain range from 3-27 (higher scores indicate higher expectations/credibility of the treatment).

In addition, we measured pain catastrophizing behavior, psychological distress, and illness perceptions. We measured this using the Pain Catastrophizing Scale (PCS)²⁷, the Patient Health Questionnaire-4 (PHQ-4)²⁸ and the Brief Illness Perception Questionnaire (B-IPQ)²⁹ respectively. We calculated a total score for each questionnaire. All questionnaires have been validated and good reliability has been reported^{26, 30-35}.

Statistical methods

We compared baseline characteristics for patients that were satisfied and less satisfied with treatment outcomes using T-tests for normally-distributed continuous data and Mann-Whitney-Wilcoxon tests for continuous data that were not normally distributed. Chi-square statistics were used for categorical data. Effect sizes (Cohen's d) were calculated for any statistically significant differences between continuous data. We performed a non-responder analysis to compare baseline characteristics of patients completing all questionnaires of interest (responders) and patients who only completed the MHQ at baseline and three months.

After dichotomizing satisfaction with treatment outcomes, we used multivariable logistic regression analysis to determine which baseline variables were associated with the probability of being satisfied with treatment outcomes when adjusting for patient characteristics, patient-reported hand function at

baseline, and patients' mindset. For the logistic regression model, odds ratios (OR) with 95% confidence intervals (95% CI) were calculated.

In the multivariable regression model, we included the aforementioned baseline characteristics, patient-reported hand function (total MHQ score), psychological factors (total PCS score, total PHQ-4 and total B-IPQ score), CEQ Expectancy Score, and CEQ Credibility Score. Using the rule of thumb of one variable per ten cases having the lowest-frequency outcome ('number of events') to fit a multivariable logistic regression model and with 13 variables of interest, we needed to include at least 130 patients with an event. Assuming that 50% of all patients would be classified as satisfied⁵, a minimum of 260 patients is needed. Since the number of patients treated in our clinic during the study period exceeded 260, we included all patients treated in our clinic during the study period.

Because both patients with overly high and very low expectations have been suggested to be less satisfied, we hypothesized that there might be an optimum for CEQ Expectancy Score^{12, 13, 16, 18-22}. We therefore tested whether our multivariable regression model would better fit the data when a non-linear effect of the CEQ Expectancy Score was included, using splines. We performed a likelihood ratio test to determine whether this model had a better fit than the model with CEQ Expectancy Score as a linear term.

We checked for multicollinearity in our multivariable logistic regression model using the variance inflation factor. We considered a variance inflation factor greater than 10 an indication for multicollinearity³⁶.

As a secondary analysis (in addition to our multivariable logistic regression), we performed a mediation analysis^{37, 38}. As previous studies in hand surgery and orthopaedics reported an association between treatment outcomes and satisfaction, the aim of the mediation analysis was to quantify how much of the association between a predictor and the dependent variable of interest (in this case: satisfaction with treatment outcomes) is the result of treatment outcomes (indirect effect) and how much is independent of that (direct effect)^{12, 39}. For this mediation model, our predictor and mediator variables were continuous, and our outcome was binary⁴⁰⁻⁴³. For the mediation model, we used the linear terms of all variables.

We assessed whether mediation was present by bootstrapping the indirect effect, as proposed by Preacher and Hayes ⁴⁴. We corrected for total MHQ score at intake in the analysis. The outcome of the mediation analysis is the proportion mediated, which is the percentage of the effect of the significant independent variable(s) due to the total MHQ score at three months. This is calculated by multiplying the regression coefficient of the predictor on the mediator with the regression coefficient of the mediator on the outcome.

Mediation analysis was performed in Mplus version 8.1, using Mplus code based on Feingold et al. ⁴⁵ for mediation with a continuous predictor and a non-rare binary outcome. All other analyses were performed using R statistical computing, version 3.5.2. For all tests, a p-value smaller than 0.05 was considered statistically significant.

RESULTS

In the study period, 656 patients were treated non-operatively for CMC-1 OA at our clinic and completed all relevant questionnaires at baseline. Of those patients, 308 patients also completed all questionnaires of interest three months after the start of treatment and were included in the analysis (Figure 1).

Of the included patients, 76% were female, the mean age was 61 years (SD 8), and the mean total MHQ score at baseline was 60 (SD 15). Table 1 shows all baseline characteristics of the included patients. We compared the baseline characteristics of the included patients (responders) to the patients who did not complete all questionnaires (non-responders) and only found that the included patients had a shorter duration of symptoms (responders: median 9, IQR (5-24), non-responders: median 12, IQR (6-24))(Supplemental table 1). Figure 2 shows the distribution of satisfaction on the 5-point Likert scale and the division into the two categories; of the 308 patients, 46% were satisfied with treatment outcomes, while 54% were less satisfied with treatment outcomes.

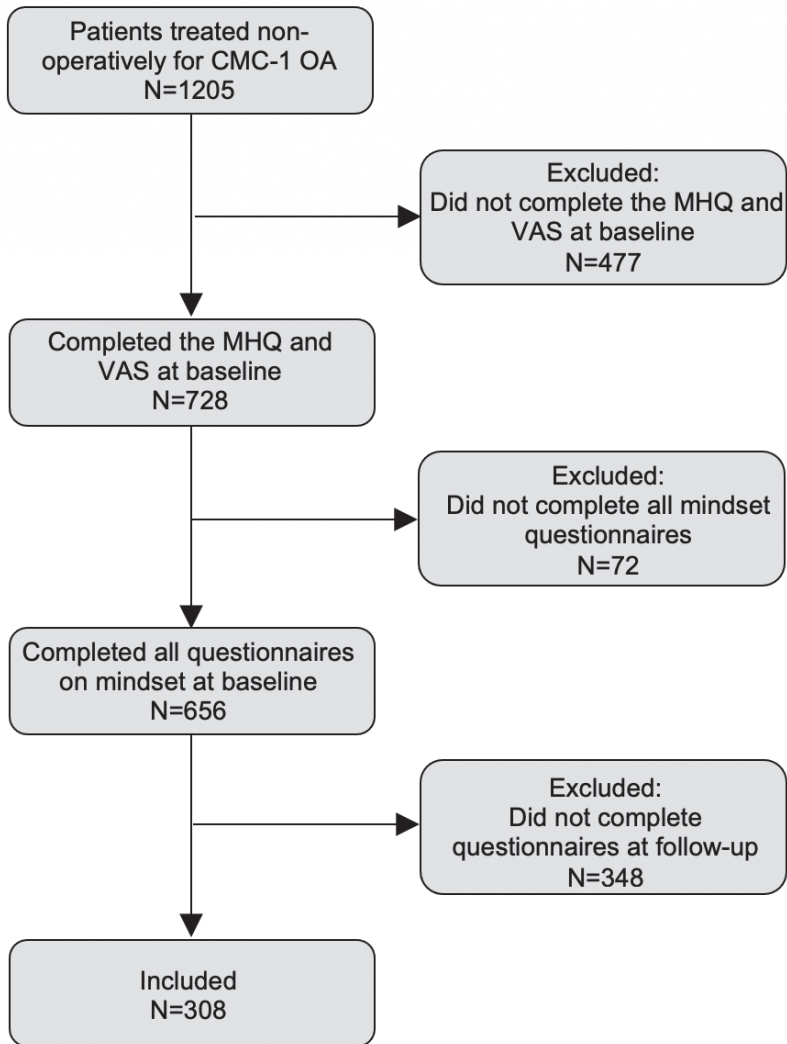


Figure 1. Flow chart of patient inclusion

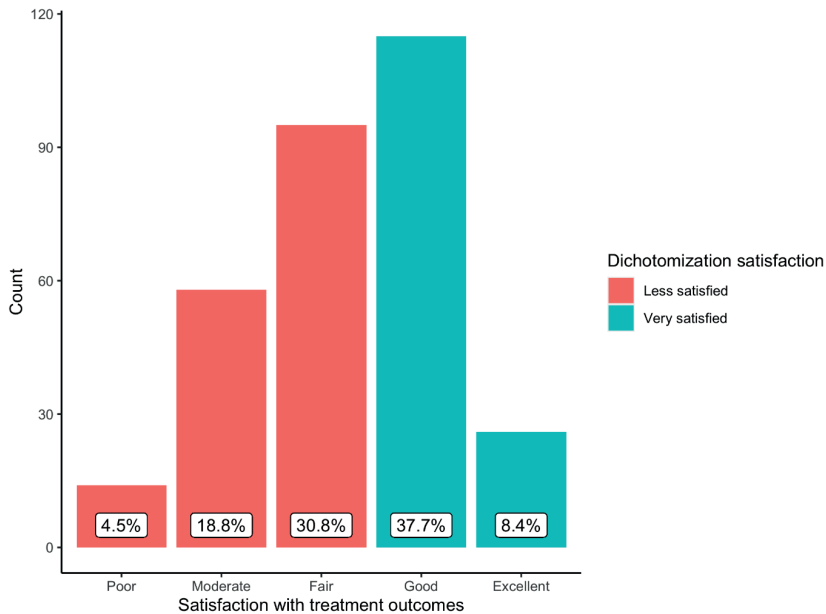
Table 1. Patient characteristics at baseline

Baseline characteristics	Questionnaire range (if applicable)	All included patients (n=308)	Satisfied with outcomes (n=141)	Less satisfied with outcomes (n=167)	Effect size	P-value
Age in years		61 (8)	61 (7)	61 (8)		0.781
Sex (%)						0.712
Female		76%	77%	75%		
Hand dominance (%)						0.683
Right		89%	88%	90%		
Left		6%	8%	5%		
Both		5%	4%	5%		
Affected hand (%)						0.525
Right		42%	42%	43%		
Left		46%	48%	44%		
Both		12%	10%	14%		
Dominant hand affected (%)		41%	42%	40%		0.849
Duration of symptoms in months, median (interquartile range)		9 (5-24)	8 (4-24)	12 (6-24)		0.454
Workload (%)						0.628
Not employed		39%	38%	40%		
Light		20%	22%	19%		
Moderate		30%	31%	29%		
Severe		11%	9%	13%		
MHQ score	0 – 100	60 (15)	63 (15)	57 (15)	0.37	0.001
PHQ score	0 – 12	1.2 (2.2)	0.9 (2.0)	1.4 (2.3)	-0.23	0.045
PCS score	0 – 52	11 (9)	10 (8)	13 (10)	-0.35	0.002
B-IPQ score	0 – 80	51 (9)	50 (10)	52 (8)	-0.23	0.044
CEQ Expectancy Score	3 – 27	18 (5)	20 (4)	17(5)	0.67	<0.001
CEQ Credibility Score	3 - 27	21 (4)	22 (4)	20 (4)	0.47	<0.001

* Values reported as mean (SD) unless otherwise stated. MHQ = Michigan Hand outcomes Questionnaire, PHQ = Patient Health Questionnaire-4, PCS = Pain Catastrophizing Scale, B-IPQ = Brief Illness Perception Questionnaire, CEQ = Credibility and Expectancy Questionnaire

Table 2. Multivariable logistic regression analysis on satisfaction with treatment outcomes

Multivariable logistic regression	OR (95% CI)
Age	1.01 (0.97-1.05)
Sex, male	0.77 (0.41-1.44)
Dominant hand affected	1.15 (0.70-1.89)
Duration of symptoms	1.01 (1.00-1.02)
Workload	
Light	1.21 (0.59-2.48)
Moderate	1.15 (0.57-2.30)
Severe	1.02 (0.39-2.60)
MHQ score	1.02 (1.00-1.04)
PHQ score	1.00 (0.86-1.14)
PCS score	0.99 (0.95-1.02)
B-IPQ score	1.02 (1.00-1.04)
CEQ Expectancy Score	1.15 (1.07-1.25)*
CEQ Credibility Score	1.03 (0.95-1.12)

* $p < 0.001$ **Figure 2.** The distribution of satisfaction with treatment outcomes using the original 5-point scale and the distribution of dichotomized satisfaction with treatment outcomes.

Patients that were less satisfied with treatment outcomes reported worse MHQ score, lower expectations of the treatment, and less treatment credibility at baseline compared to patients that were satisfied with treatment outcomes (Table 1). Also, patients that were less satisfied scored worse on psychological distress, pain catastrophizing, and illness perceptions.

While several baseline variables were associated with satisfaction with outcome in the univariable analysis (Table 1), higher CEQ Expectancy Score was the only significant variable associated with higher probability of being satisfied with treatment outcomes in the multivariable analysis (OR = 1.15, 95% CI 1.07-1.25)(Table 2). This odds ratio indicates that patients with one point more on the CEQ Expectancy Score have a 15% increase in odds of being satisfied with treatment outcomes.

We visualized the effect of the CEQ Expectancy Score on satisfaction with treatment outcomes on the original scale in Figure 3, showing a linear trend. Additionally, the likelihood ratio test showed that the model with non-linear effects of the CEQ Expectancy Score did not have significantly better fit ($p=0.23$) than the model with the CEQ Expectancy Score as a linear term. Therefore, we used the linear term of CEQ Expectancy Score in all analyses. We therefore were not able to find an optimum.

Based on the variance inflation factor, we did not find an indication for multicollinearity in the multivariable logistic regression model.

Mediation analysis

Based on the results from the multivariable logistic regression analysis, we hypothesized that patients with a higher CEQ Expectancy Score would also have a higher total MHQ score at three months and would, therefore, be more satisfied. To test this hypothesis, we performed a post-hoc mediation analysis. We found that only 33% of the effect of CEQ Expectancy Score on satisfaction with treatment outcomes was due to total MHQ score at three months (Figure 4). The remaining 67% of the effect of expectations can either be explained by a direct effect on satisfaction or by an indirect effect through another factor that was not measured. This indicates that a better MHQ score at three months can only partially explain the association between CEQ Expectancy Score and satisfaction with treatment outcomes.

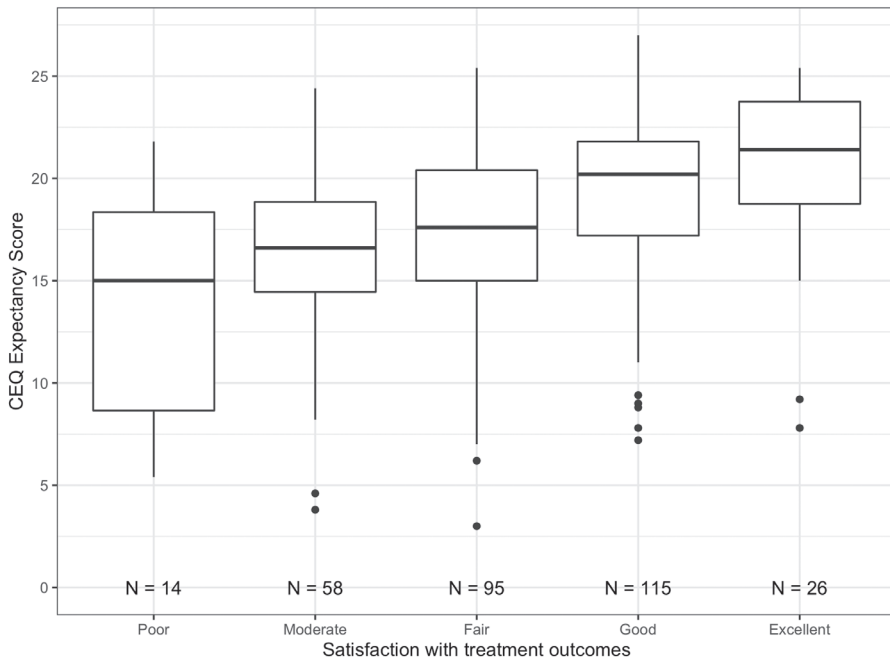


Figure 3. Box-and-whisker plot of CEQ Expectancy Score (range 3-27) per satisfaction category. The horizontal line represents the median and boxes represent the first and third quartile. The whiskers represent 1.5 times the interquartile range from the first and respectively third quartile.

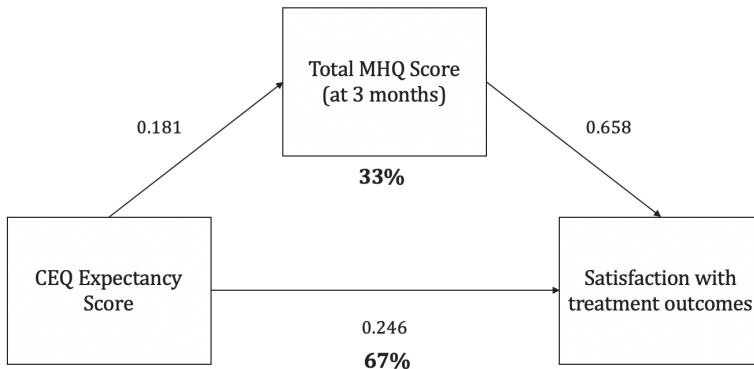


Figure 4. Mediation model. The relation between CEQ Expectancy Score and satisfaction with treatment outcomes was mediated by the total MHQ score at three months. The standardized regression coefficients are reported from the regression of CEQ Expectancy Score on total MHQ Score at three months and the regression of CEQ Expectancy Score and total MHQ Score at three months on satisfaction with treatment outcomes. All regression analyses were corrected for total MHQ score at baseline. The indirect effect (0.119) was divided by the total effect (0.365) of CEQ Score on satisfaction with treatment outcomes to obtain the proportion mediated (33%).

DISCUSSION

In this study, we found that patients with more positive expectations of the treatment outcome are more likely to be satisfied with treatment outcomes after three months of non-operative treatment for CMC-1 OA. Additionally, we found that only one-third of this effect was due to better treatment outcomes at three months.

Previous studies on other types of osteoarthritis reported that patients with higher expectations have better treatment outcomes such as pain and function⁴⁶⁻⁵². This is in agreement with our finding that higher expectations are associated with a higher total MHQ score at three months. In addition, we found a positive association between higher expectations and satisfaction with treatment outcomes, which is not completely in line with previous studies. For example, Jain et al.⁴⁸, Mahomed et al.⁵² and Neuprez et al.⁵³ also reported an association between higher expectations and satisfaction with treatment outcomes after orthopaedic surgery, while several authors reported a negative association between expectations and satisfaction⁵⁴ or suggested that it would be better to lower expectations^{11, 16, 49}. Possibly, these different findings may be explained by different treatments, different diseases (e.g., hip or knee OA), different questionnaires to assess expectations or different pre-treatment counselling. However, our results suggest that it would be better to optimize expectations to improve satisfaction and, to a lesser extent, improve treatment outcomes. A trial evaluating effects of different expectation management strategies of clinicians might provide valuable insights on how to address patients' expectations of their treatment.

Perhaps, the time point where patients completed the CEQ may explain why we found a positive association between treatment outcome expectations and satisfaction with outcomes. Patients in our study completed the CEQ after the first consultation with the hand surgeon. It could be that surgeons know from experience which patients will respond well to non-operative treatment and will, therefore, provide individualized information on the expected results of the treatment to patients. This could, in turn, influence the CEQ Expectancy Score in individual patients. However, in our analysis, we controlled for patient characteristics, patient-rated hand function and patients' mindset and still found no other predictive baseline factors for satisfaction with treatment outcomes than CEQ Expectancy Score.

Strengths and limitations

A strength of this study is the large sample size in a population-based cohort. Second, to our knowledge, this is the first study investigating satisfaction with treatment outcomes after exercise therapy, an orthosis, or both for CMC-1 OA. Third, by performing a mediation analysis, we were able to provide more insight into the mechanism of the association we found.

However, our study also has several limitations. Satisfaction with treatment outcomes is a complex construct that is difficult to measure and difficult to fully comprehend, as, for example, pointed out in an editorial by Ring and Leopold⁵⁵. Ring and Leopold describe that there are many reasons why one patient can be satisfied with the treatment outcome while another patient may be dissatisfied, while having the same treatment outcome. However, while satisfaction with treatment result is a difficult construct and influenced by many factors, it is also a very important and relevant outcome measure in striving for patient-centered care. Therefore, future studies investigating the underlying mechanisms that determine a patient's satisfaction with treatment outcome are needed to provide patient-centered care that is tailored to the patient's needs.

Another limitation is that, in this study, we used a self-designed questionnaire to assess satisfaction with treatment outcomes, which has not been validated yet. However, to our knowledge, there are no validated patient-reported outcome measures available to measure satisfaction with treatment outcomes for patients with hand and wrist disorders. The questionnaire we used and the dichotomization of our outcome measure is very similar to questionnaires and analyses used in previous studies, which facilitates us to compare our results with other studies^{11, 16}. However, to avoid dichotomization and the loss of information as a result, a validated patient-reported outcome measure for satisfaction with treatment outcomes with a continuous scale is needed to further optimize personalized care for individual patients.

Previous studies have reported that the context of treatment (e.g., communication style of the health care provider) also affects satisfaction with treatment outcomes^{19, 20, 56, 57}, hence a limitation is that we did not include a measure for treatment context in our study. Future studies should therefore include such measures in their analysis when studying satisfaction with outcomes, as well as study how to incorporate this into clinical practice.

In our study we found that more positive expectations are associated with higher satisfaction with treatment outcomes after three months of non-operative treatment for CMC-1 OA, which can only partially be explained by better treatment outcomes. This suggests that optimizing expectations might improve satisfaction and, to a lesser extent, improve treatment outcomes. However, future experimental studies are needed to determine whether modifying expectations of patients receiving non-operative treatment for CMC-1 OA, for example by framing pre-treatment information in a positive manner, will positively affect satisfaction and treatment outcomes.

CONCLUSION

This study demonstrates that patients with higher treatment outcome expectations are more likely to be satisfied with treatment outcomes after three months of non-operative therapy for CMC-1 OA. Health care providers treating patients non-operatively for CMC-1 OA should be aware of the importance of expectations and should take this into account in pre-treatment counseling.

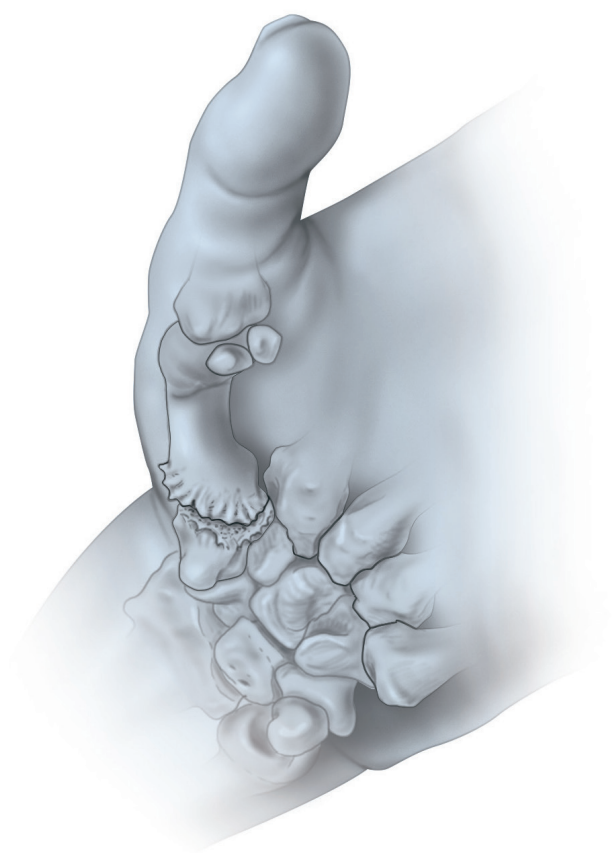
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CHAPTER 11

CHANGES IN MINDSET DURING TREATMENT INFLUENCES THE OUTCOMES OF NON- SURGICAL TREATMENT FOR THUMB OA; A COHORT STUDY

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ABSTRACT

Objectives: Several studies have found that a more negative mindset of patients (e.g., low expectations or distorted illness perception) is associated with worse treatment outcomes for osteoarthritis (OA) of the hand. However, none has tested if this mindset changes throughout the treatment or investigated its relation to treatment outcomes. The aims of this study was to examine the effect of change in patients' mindset on the change in pain.

Methods: We included patients that were treated nonsurgically for thumb base OA between June 2018 and June 2020. We assessed change in pain during three months of treatment on the pain subscale of the Michigan Hand outcomes Questionnaire (MHQ). We measured patients' mindset using three questionnaires: the Patient Health Questionnaire, Brief-Illness Perceptions Questionnaire, and Credibility/ Expectancy Questionnaire. The change in patients' mindset was defined as the difference in these questionnaires at three months post treatment compared to baseline. Multivariable linear regression analysis was used to assess the association between change in patients' mindset and change in pain.

Results: We included a total of 376 patients. Decreased psychological distress ($B = 1.11$, $p = 0.006$), more optimistic outcome expectations ($B = 0.73$, $p < 0.001$), decreased experienced consequences ($B = 0.9$, $p = 0.003$), decreased amount of symptoms that are contributed to the illness ($B = 1.16$, $p < 0.001$), decreased concern ($B = 0.80$, $p = 0.01$), and decreased emotional consequences ($B = 0.96$, $p < 0.001$) were associated with a decrease in MHQ pain during the first three months of treatment.

Conclusions: An increasing positive mindset during the first three months of nonsurgical treatment for thumb base OA is associated with greater decrease in pain. Our findings emphasize the need for randomized intervention studies to assess if actively changing the patients' mindset can cause an additional decrease in pain.

INTRODUCTION

Many studies have found that having a more negative mindset (e.g., low expectations or contributing complaints to the illness) is associated with a more negative outcome of treatments for osteoarthritis (OA) of the hand. For example, a large observational study found that kinesiophobia and pain catastrophizing were predictors for disability of the hand ¹. Another study found that patients with a tendency towards depression and high levels of pain catastrophizing reported more pain from atraumatic hand conditions ². Finally, we found in our cohort that patients with a more negative mindset at baseline report more pain and less hand function after non-operative treatment for thumb base OA ³. While all these studies suggest that improving the patients' mindset might improve outcomes, no study in treatments for hand OA has examined if the patients' mindset changes during the course of treatment and currently, to our knowledge, in patients with thumb base OA, no study has intervened in the patients' mindset.

In other fields, the change in patients' mindset has been examined and a small number of intervention studies have even been conducted. For example, in cardiac surgery bypass surgery, patients were randomized to treatment as usual or treatment combined with additional consultations to discuss and optimize expectations, some of which included a psychologist ⁴. The group with optimized expectations experienced a 50% reduction in patient-reported disability, compared to only 10% in the treatment-as-usual group. If these effects are similar in OA of the hand, interventions in the patients' mindset could improve the outcomes of hand OA.

We have previously examined the relationship between the baseline patients' mindset and outcomes in non-surgically treated patients with thumb base osteoarthritis (OA). First, we found that the patients' mindset explains 32% of the variance in baseline pain in patients that are starting nonsurgical treatment ⁵. Second, we found that patients with higher expectations of their outcome and a more positive perception of their illness at baseline report less pain three months after starting nonsurgical treatment ³.

Based on these studies, we hypothesized that 1) the mindset changes during the first three months of regular nonsurgical treatment for thumb base OA and

that 2) this a change in patients' mindset is associated with the change in pain. Hence, the aims of this study are 1) to observe the average patients' mindset over time and 2) to examine the association between change in patients' mindset on the change in pain. We defined the patients' mindset as a composition of four domains; pain catastrophizing, psychological distress, illness perceptions, and treatment credibility and expectations.

METHOD

Study design

We conducted a cohort study. Patients were treated with nonsurgical therapy, as defined in the Dutch guideline for primary CMC-1 OA ⁶. In general, this treatment consisted of a custom-made or prefabricated orthosis and 25-minute sessions of hand therapy per week for a total of 12 weeks. For most patients, the first six weeks of treatment aimed at correcting the position of the thumb. This comprised home exercises aimed to improve range of motion, coordination, and active stability. The last six weeks of treatment aimed to reduce orthosis usage and increasing pinch strength and active stability. Additional or fewer sessions could be planned based on the therapist's judgment and the participant's availability. A more detailed description of the treatment has been reported in a previous paper⁷. The inclusion started after approval of the local Medical Ethical Committee (MEC-2018-1088).

Setting

All patients were treated at Xpert Clinic and Handtherapie Nederland between May 2018 and June 2020. Xpert Clinic and Handtherapie Nederland are specialized clinics for hand and wrist disorders and comprises 22 outpatient clinics for hand surgery and therapy in The Netherlands. Patients are only treated if referred by their general practitioner. A FESSH certified surgeon or FESSH fellowship-trained surgeon diagnoses all patients. Hand therapists received extensive training and followed standardized treatment protocols for CMC-1 OA. Participants received treatment under the supervision of (generally) the same therapist, using a standardized protocol. All therapists are certified physical therapists with experience as a hand therapist. Treatment included the use of an orthosis, exercise therapy, or both. We have provided more details on the content of this treatment in our previous studies ^{7,8}.

Participants

We included patients scheduled for nonsurgical treatment for CMC-1 OA that completed psychological screening questionnaires before treatment and the Michigan Hand Outcome Questionnaire (MHQ) before treatment. All patients were clinically diagnosed with CMC-1 OA based on presenting complaints and clinical signs. Radiographs could be made to support the diagnosis. We excluded patients who did not complete the patient reported outcome measures on pain or psychosocial factors three months after nonsurgical treatment for CMC-1 OA.

Measures

The primary outcome for this study is the change in pain during three months of nonsurgical treatment for CMC-1 OA. Pain was measured with the pain subscale of the Dutch version of the MHQ^{9,10}. The MHQ is a validated patient-reported outcome measure to assess patients' pain. The subscales scores range from 0 (severe pain) – 100 (no pain) score. We calculated a change score of the MHQ pain scale between baseline and three months.

Patient characteristics (e.g., for medical history, age, sex, and body mass index (BMI)) are collected online by email before treatment and at the first consultation with the hand therapist (e.g., for physical intensity of the occupation, dominance).

We defined the patients' mindset as a composition of four domains; pain catastrophizing, psychological distress, illness perceptions, and treatment credibility and expectations. The individual aspects of the psychosocial profile are explained in further detail below.

- 1) the Patient Health Questionnaire (PHQ-4)¹¹, which is a screening tool for depression and anxiety that results in a score from 0 (no psychological distress) – 12 (high psychological distress);
- 2) the Pain Catastrophizing Scale (PCS)¹², which is a questionnaire to assess a patient's tendency to catastrophize pain. The PCS ranges from 0 (no pain catastrophizing) – 52 (high pain catastrophizing);
- 3) the Credibility/ Expectancy Questionnaire (CEQ)¹³, which is a questionnaire

that measures patients' outcome expectations and credibility of the treatment and results in a score from 3 (low expectations and credibility) – 27 (high expectations and credibility) for the two domains. The CEQ specifically asks patients how much they “feel” or “think” the treatment will reduce symptoms and the physical limitation due to symptoms of their CMC-1 OA.

4) The Brief Illness Perceptions Questionnaire (B-IPQ)¹⁴, a questionnaire that measures how patients perceive their illness on eight separate domains, using a single 0-10 question for each domain. As the B-IPQ treatment control item concerns the patients' view on the treatment effect and this construct is already evaluated using the CEQ, we did not use this B-IPQ item. We used the validated Dutch versions of all questionnaires¹⁵⁻¹⁷.

To measure the change in patients' mindset, we repeated the questionnaires at three months. We calculated the change between the baseline and the follow-up moment. However, we did not measure the PCS a second time because the PCS measures a trait and is thus not expected to change over time without a specific intervention¹⁸. Furthermore, we measured the credibility and expectations at six weeks instead of three months because it would be illogical to measure expectations of the outcome at the end of the treatment. We transformed all change scores so that absolute positive values reflect a positive change. For example, a positive change in pain corresponds with pain reduction and a positive change in expectations means more optimistic expectations.

Data sources

Data was collected as part of routine outcome measurement using GemsTracker electronic data capture tools. GemsTracker (GEneric Medical SurveyTracker) is a secure web-based application for the distribution and storage of questionnaires and forms during clinical research and quality registrations; details of this methodology have been published earlier¹⁹.

Bias

We hypothesized that confounders for the relationship between change in patients' mindset and change in pain are – among others – patient characteristics (e.g., age, sex, BMI, and work type) and frequency of treatment. We will adjust the analysis for these confounding variables. Finally, we will test for collinearity

and exclude factors that have a correlation of 0.8 and higher with the outcome expectations, illness perceptions, psychological distress, or pain catastrophizing scale.

Study Size

An a priori power analysis was conducted using G*Power³²⁰ to test a single regression coefficient in a model with 20 predictors using a two-tailed test. To find a small to medium effect size ($d = .10$), with an alpha of .05 and power of 0.95, a total sample size of 133 was needed.

Statistical analysis

We assessed if the patients' mindset changed over time using a paired t-test.

We made a linear regression model to assess the association between change in pain and change in mindset, adjusting for potential confounders (e.g., sex, type of work, and treatment frequency). We also adjusted for baseline pain catastrophizing based on previous literature^{1, 5}. In this model, we introduced the change of different aspects of the mindset in individual steps, giving us insight into how much each aspect contributes to the model. To assess the contribution of the different sets of variables to change in pain in the first three months, we report the explained variance (R^2). In the first step, we introduced patient and disease characteristics into the model (this included baseline pain catastrophizing (PCS)); in the second step, we added change in psychological distress (PHQ); in the third step, we added change in treatment credibility and outcome expectations (CEQ), and in the final step we added change in illness perceptions (B-IPQ).

All analyses were conducted using R statistical computing, version 3.6.0²¹. For all tests, a p-value ≤ 0.05 was considered statistically significant. We assumed that all relationships were linear and the model residuals were normally distributed and we confirmed these assumptions by plotting fitted values and residuals.

RESULTS

Out of 756 patients who completed baseline MHQ and mindset questionnaire, 376 patients also completed the MHQ at three months and psychosocial questionnaires, both at baseline and follow-up, see Figure 1. The included patients were predominantly female (74%) and had a mean age of 62 (SD 8; see Table 1).

On average, patients improved on most patient reported outcome measures after the nonsurgical treatment (Figure 2). MHQ pain improved with an average of 11 points ($p < 0.001$). We found no change in the MHQ general hand function and aesthetics subscales. Regarding psychosocial factors, the IPQ personal control domain improved (0.94, $p < 0.001$), but the CEQ credibility and expectations subscales became less optimistic (-0.86, $p < 0.001$; -1.13, $p < 0.001$). There were no changes in anxiety, depression, and illness understanding.

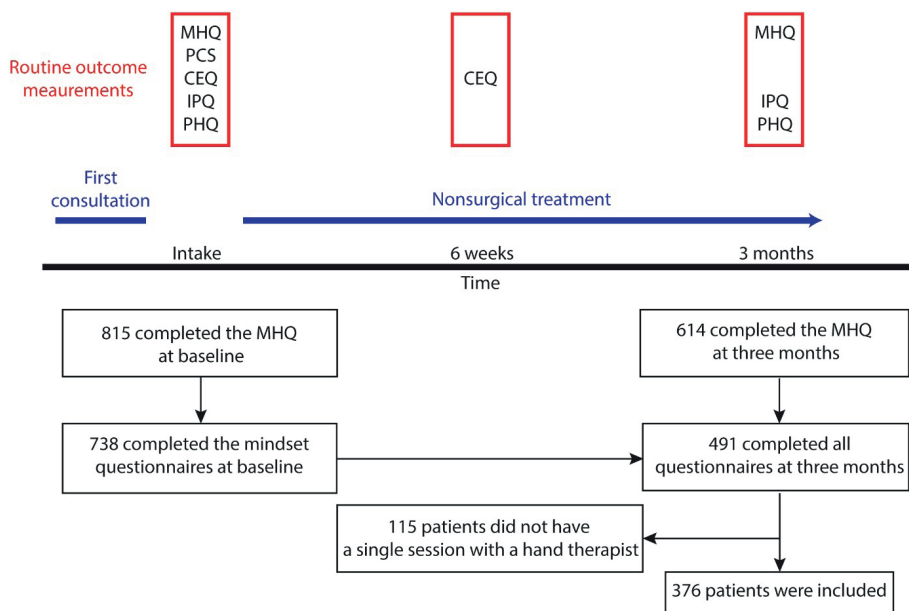
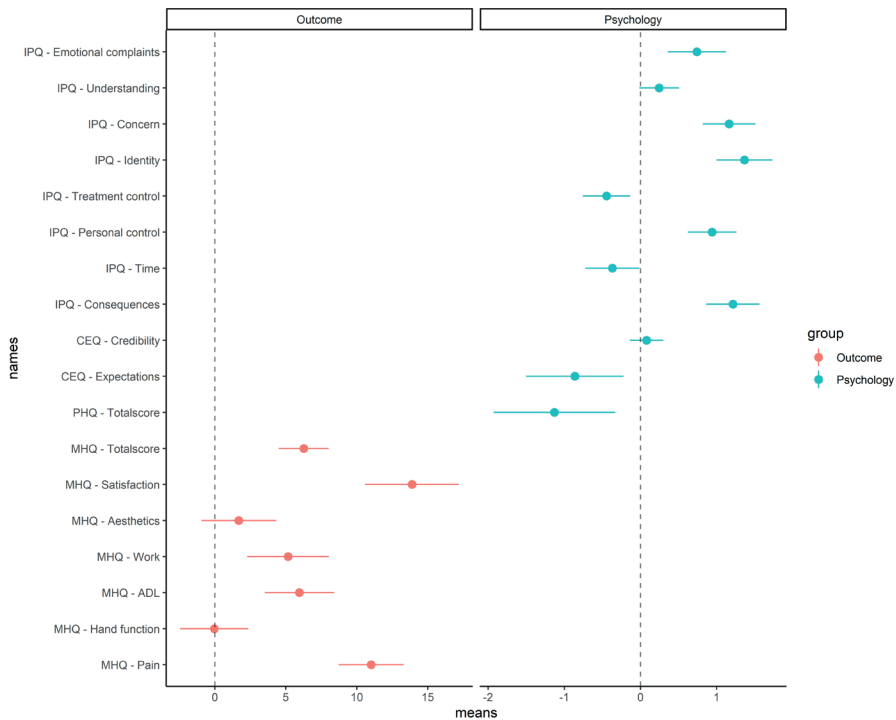


Figure 1. Flow diagram. Shows when patients receive which questionnaires and how many patients complete the questionnaires. MHQ Michigan Hand Outcome Questionnaire, PCS Pain catastrophizing scale, CEQ Credibility/Expectations Questionnaire, IPQ (brief) Illness Perceptions Questionnaire, PHQ Patient Health Questionnaire

Table 1. Patient characteristics of the 376 patients

	Overall
Age, mean(SD)	61 (8)
Sex, female %	74
Duration of complaints, median (IQR)	9 (4-24)
BMI, mean (SD)	27 (5)
Smoking status, yes %	9
Work, %	
No paid labor	43
Light physical labor	23
Moderate physical labor	25
Heavy physical labor	10
Number of physical therapist sessions (IQR)	5 (3-7)
Number of ergo therapist sessions (IQR)	4 (2-5)
Baseline MHQ pain score, mean (SD)	47 (17)
Baseline MHQ hand function score, mean (SD)	62 (17)
Baseline MHQ total score, mean (SD)	62 (15)

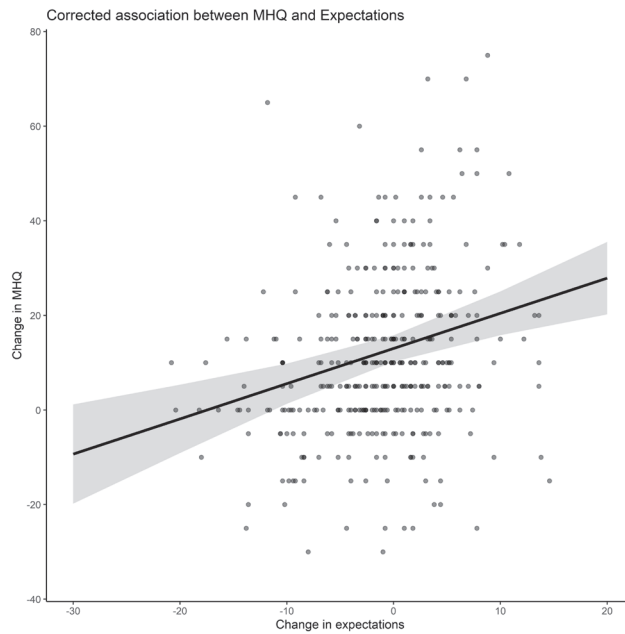
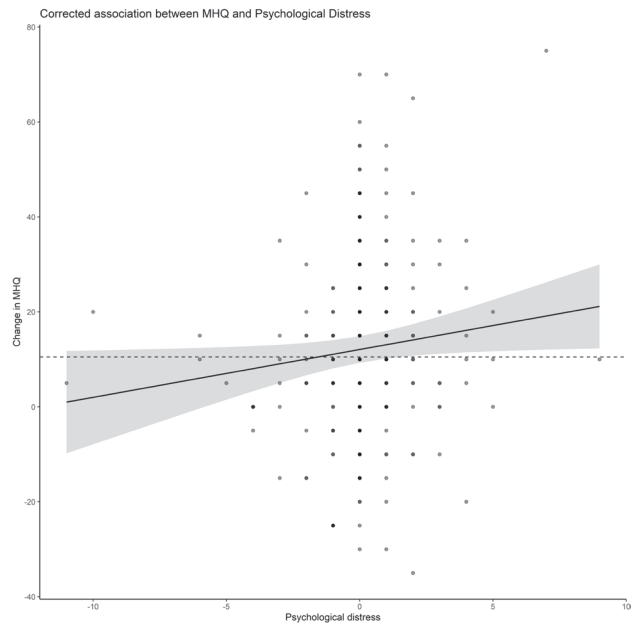
**Figure 2.** Change in patients' mindset and MHQ subscales. Dots indicate the average change, the line through the points displays the 95% confidence interval.

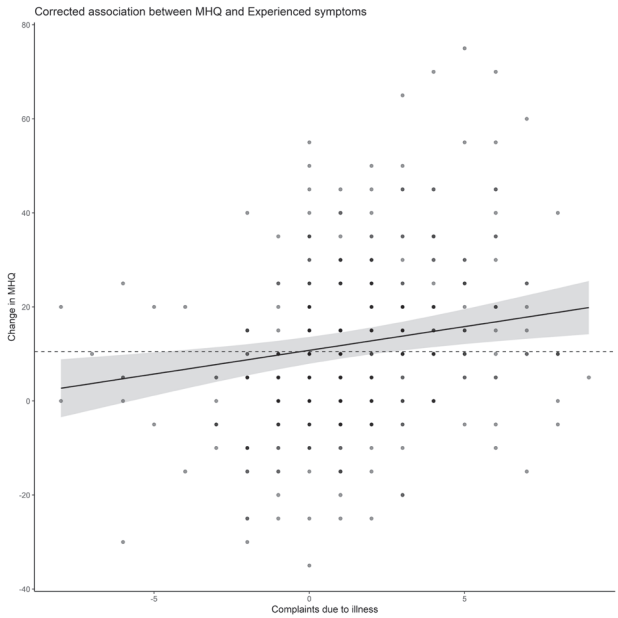
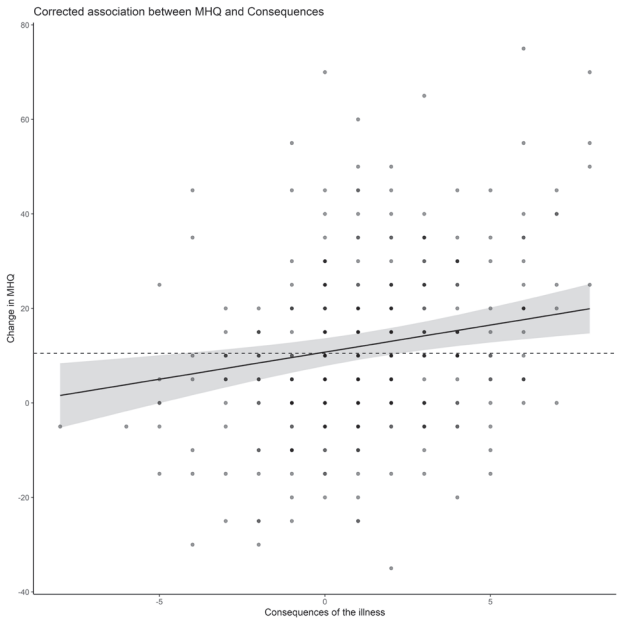
In the first step, no patient characteristics were significant and the adjusted explained variance (R^2) was 0.01. The second and third step, adding the number of therapist sessions and pain catastrophizing, did not change the R^2 . In the fourth step, we added the change in psychological distress (PHQ). A decrease in psychological distress was associated with an increase in pain ($B = 1.56$, $p < 0.001$). In the fifth step, adding CEQ outcome expectations and credibility of the treatment, becoming more optimistic about the outcome was associated with more increase in pain ($B = 0.71$, $p < 0.001$). The explained variance raised to 0.08. In the final step, we added illness perceptions (IPQ) to the model. The R^2 of the finale model was 0.26. Supplementary Table 1 shows the entire stepwise regression model.

In this final model (Table 2 and Figures 3A-F), decreased psychological distress ($B = 1.11$, $p = 0.006$), more optimistic outcome expectations ($B = 0.73$, $p < 0.001$), decreased experienced consequences ($B = 0.9$, $p = 0.003$), decreased amount of symptoms that are contributed to the illness ($B = 1.16$, $p < 0.001$), decreased concern ($B = 0.80$, $p = 0.01$), and decreased emotional consequences ($B = 0.96$, $p < 0.001$) were all independently associated with a decrease in MHQ pain during the first three months of treatment. The extent to which patients catastrophize pain was not associated with change in pain.

Table 2. Final multivariable linear regression model. The table displays the regression coefficient(B), corresponding 95% confidence interval (CI) and p-value.

	B	95%CI	P-value
Age	-0,04	[-0,3 ; 0,2]	0,73
Sex, male	-2,57	[-6,2 ; 1,1]	0,17
Duration of complaints	-0,06	[-0,1 ; 0]	0,03
Job type (ref: no job)			
Light physical labor	-1,39	[-5,8 ; 3]	0,54
Moderate physical labor	1,24	[-3,4 ; 5,9]	0,60
Heavy physical labor	0,97	[-5 ; 6,9]	0,75
Smoking, no	4,53	[-0,9 ; 9,9]	0,10
BMI	0,10	[-0,2 ; 0,4]	0,52
Number of physiotherapist visits	-0,20	[-0,8 ; 0,4]	0,51
Number of ergo therapist visits	0,41	[-0,4 ; 1,2]	0,30
PCS score (baseline)	0,02	[-0,1 ; 0,2]	0,78
PHQ score(change)	1,01	[0,1 ; 1,9]	0,04
CEQ expectations (change)	0,74	[0,4 ; 1,1]	0,00
CEQ credibility (change)	-0,29	[-0,7 ; 0,1]	0,19
IPQ consequences (change)	1,15	[0,5 ; 1,8]	0,00
IPQ timeline (change)	-0,31	[-0,9 ; 0,3]	0,31
IPQ treatment control (change)	0,58	[-0,1 ; 1,2]	0,09
IPQ identity (change)	1,01	[0,4 ; 1,6]	0,00
IPQ concern (change)	0,85	[0,1 ; 1,6]	0,03
IPQ coherence (change)	-0,22	[-1 ; 0,6]	0,58
IPQ emotional consequences (change)	0,96	[0,3 ; 1,6]	0,00





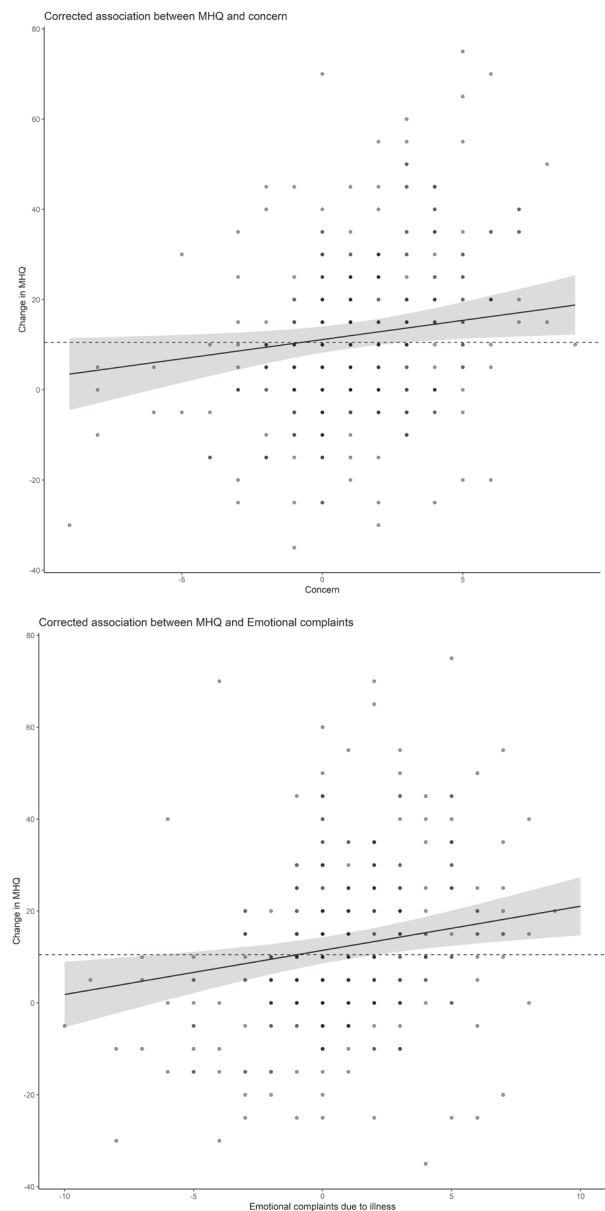


Figure 3A-F. Effect plots of association between change in psychological distress (A), outcome expectations (B), consequences of the illness (C), experienced symptoms (D), concern (E) and emotional consequences (F), and change in pain. All points represent individual patients. Transparency has been added to display overlapping points. Higher Michigan Hand outcome Questionnaire (MHQ) pain score on the y-axis represents more pain relief. Higher scores on the x-axes represent more positive mindset. All figures show that a higher, more positive mindset is associated with more decrease in pain.

DISCUSSION

In this study, we examined the change in patients' mindset during the first three months of nonsurgical treatment. We hypothesized that a change toward a more positive mindset is associated with more pain reduction. We found that becoming more optimistic about the outcome and gaining a more positive perception of the illness (both symptomatic and emotional complaints) was associated with more pain reduction. This association study may encourage a randomized intervention to assess if actively changing the patients' mindset can cause an additional decrease in pain.

The connection between patients' mindset and outcomes has been established by many previous studies. Since the start of this century, studies in orthopedic surgery have found associations between baseline patients' mindset and outcomes²². For example, after distal radius fracture, more catastrophic thinking is associated with more finger stiffness²³ and patients with low expectations have been reported to have worse outcomes of lower back pain treatments²⁴. Most studies suggest that changing patients' mindset might improve outcomes. Our results further support the hypothesis that the change in the patients' mindset is associated with the efficacy of treatment²⁵⁻²⁸.

Actively changing the patients' mindset as part of treatment could increase the pain reduction. Depending on which part of the patients' mindset we want to change, different interventions will be suitable. More specifically, for patients illness perceptions and outcome expectations other types interventions might be suitable than for pain catastrophizing and psychological distress. Tsai et al.²⁵ provided patients with a more extensive rationale for the use of cognitive behavior therapy for depression. Offering patients more information about the treatment did not increase expectations on a group level, but patients with improved expectations did show less depression. If we extend this to nonsurgical treatment for thumb base OA, providing patients with a more detailed treatment plan and rationale for the treatment could increase the effectiveness of the treatment. Petrie et al.²⁹ randomly assigned patients with a first myocardial infarction to an additional three sessions in which they provided more information about the illness, developed an action plan, and increased control beliefs of patients. Patients that received the intervention left the hospital more optimistic, reported fewer angina symptoms, returned to work sooner, and more often attended the rehabilitation program.

Optimizing the patients' mindset might also result in more treatment adherence and thereby further improve outcomes. For example, in patients with lower back pain improving the sense of personal control over the disease was associated with less stress during cardiac rehabilitation³⁰. The same was found when expectations were optimized in patients with cardiac rehabilitation⁴. Better adherence to treatment protocols might (partially) explain why the patients mindset and outcomes of treatment are causally connected.

In contrast to other studies, we did not find effects of pain catastrophizing. We assumed that pain catastrophizing is a trait; therefore, we did not examine the change in pain catastrophizing. Since other studies have shown that cognitive behavior therapy can alter how patients catastrophize their pain, this could also be beneficial for patients with thumb base OA. Since hand therapists are not trained to conduct cognitive behavior therapy, we assumed this trait does not change during regular hand surgery treatment. Future research could confirm that pain catastrophizing is indeed not change during hand surgery treatments. If this is indeed the case, we could investigate to what extend additional sessions with a psychologist would result in less catastrophic thinking and better outcomes. Evaluating whether this is cost-effective would be essential in these studies.

This study has several strengths and limitations. First, in contrast to most other studies, we were able to observe the patients' mindset at multiple time points. This allowed us to study the relationship between the patients' mindset and pain more extensively than previous studies. This longitudinal study of the patients' mindset provides more evidence that a causal relationship is present, without having to intervene in patient care. There also were some limitations. First, when working with routine outcome measurements, missing data is always a limitation. Patients are not included, but are asked to complete questionnaires as part of regular care. When specific patients do not complete questionnaires, this can introduce bias. Apart from a small significant difference in the amount of smokers, there were no differences on baseline MHQ scores or psychosocial variables. We therefore conclude that the missing data is not conditional on any measured variables. Second, we hypothesized that change would occur naturally in most domains of the patients' mindset. Figure 3 shows that this is not true for all mindset variables. Illness understanding and psychological distress do

not change significantly over time. However, on an individual level, change in psychological distress was associated with the change in pain. Third, while we tried to adjust for all possible confounders we had measured, there still is unmeasured confounding. Several factors could confound the relationship between change in patients' mindset and change in pain. For example, previous research has shown that when patients have a better experience of the treatment or rate their doctor to be more professional have less pain and more hand function. Finally, since our study was observational in nature, we cannot prove a causal effect. However, our results confirm what interventions studies in other field have already shown ^{4, 28}; change in the patients' mindset causes change in pain. To confirm this causal effect, an intervention study could investigate whether actively changing the patients' mindset changes pain.

Several examples of interventions before or during treatment are available. For example, in cardiac bypass surgery, patients were randomized to treatment as usual or treatment combined with additional consultations to discuss and optimize expectations, some of which included a psychologist⁴. The group with optimized expectations experienced a 50% reduction in patient-reported disability, compared to only 10% in the treatment-as-usual group. During the current nonsurgical treatment for thumb base OA, patients have a lot of interaction with a hand therapist. Training hand therapists to modify the patients' mindset alongside the standard treatment could benefit outcomes. For example, future intervention studies could investigate if therapists can approach the effect of the intervention by a psychologist, this training program could prove to be a cost-effective intervention to improve outcomes. Alternatively, if hand therapists are not able to modify (parts of) the patients' mindset, the cost-effectiveness of interventions by psychologists could be explored.

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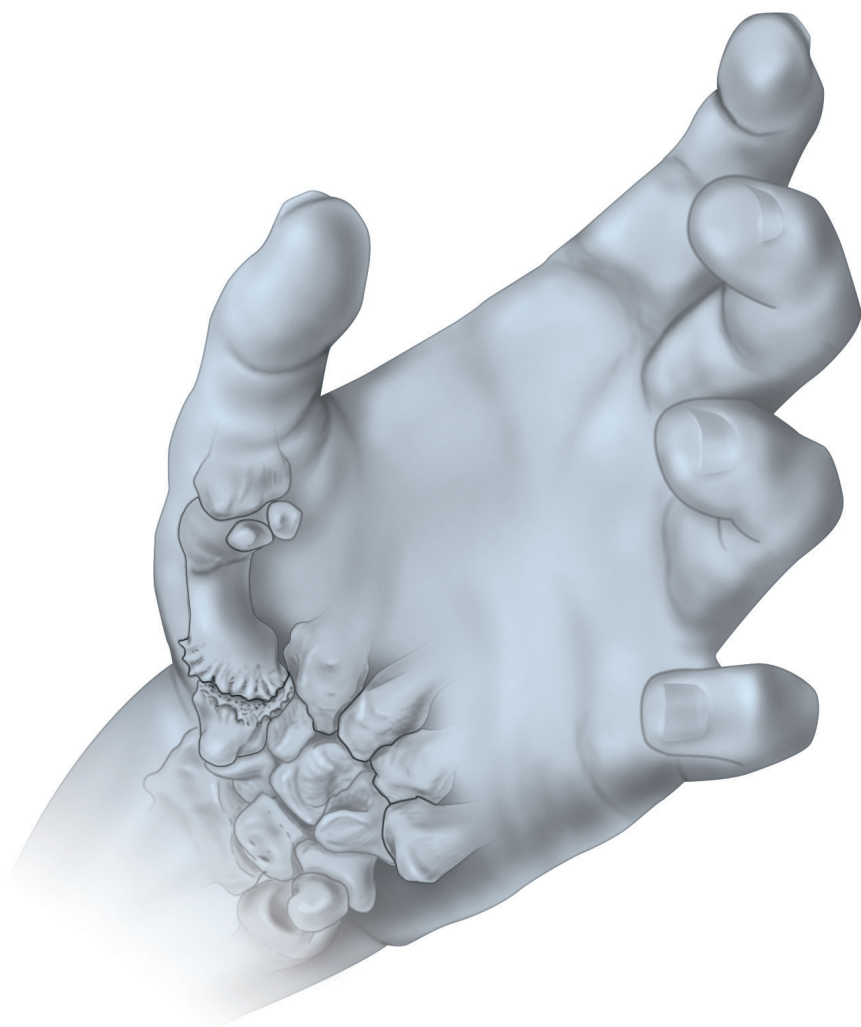
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Supplementary table 1.

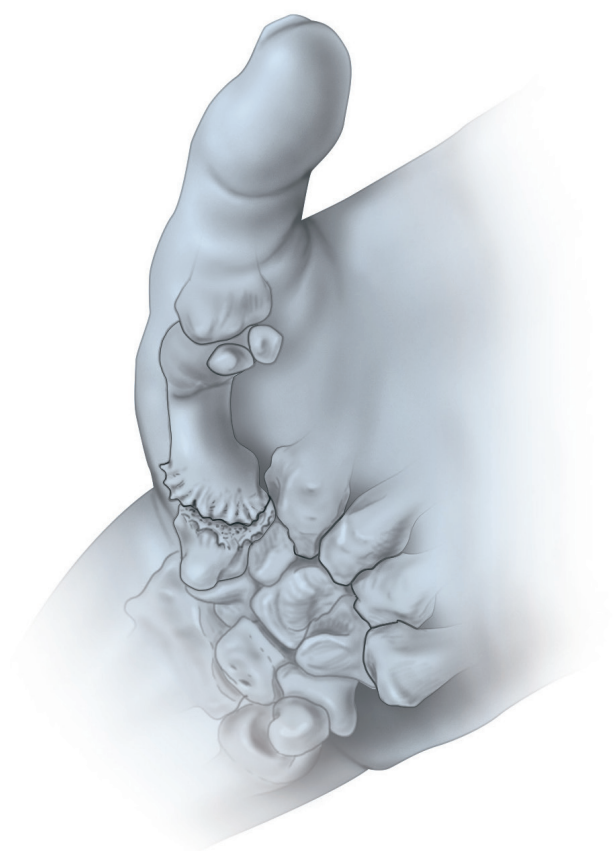
	Patient characteristics			Hand therapist sessions added			Pain catastrophizing added		
	B	95%CI	P-value	B	95%CI	P-value	B	95%CI	P-value
Age	0.01	[-0,3 ; 0,3]	0.96	0.00	[-0,3 ; 0,3]	0.99	0.00	[-0,3 ; 0,3]	0.99
Sex, male	-3.12	[-7,2 ; 1]	0.14	-2.78	[-7 ; 1,4]	0.19	-2.78	[-7 ; 1,4]	0.20
Duration of complaints	-0.06	[-0,1 ; 0]	0.05	-0.06	[-0,1 ; 0]	0.05	-0.06	[-0,1 ; 0]	0.05
Job type (ref: no job)									
Light physical labor	-0.07	[-5,1 ; 4,9]	0.98	0.02	[-5 ; 5]	0.99	0.00	[-5 ; 5]	1.00
Moderate physical labor	4.29	[-0,9 ; 9,4]	0.10	4.46	[-0,7 ; 9,7]	0.09	4.43	[-0,8 ; 9,6]	0.10
Heavy physical labor	-0.06	[-6,8 ; 6,7]	0.99	0.33	[-6,5 ; 7,1]	0.92	0.33	[-6,5 ; 7,1]	0.92
Smoking, no	3.78	[-2,3 ; 9,9]	0.22	4.24	[-1,9 ; 10,4]	0.18	4.16	[-2 ; 10,4]	0.19
BMI	0.08	[-0,3 ; 0,4]	0.63	0.09	[-0,2 ; 0,4]	0.60	0.09	[-0,2 ; 0,4]	0.60
Number of physiotherapist visits				-0.19	[-0,9 ; 0,5]	0.57	-0.19	[-0,9 ; 0,5]	0.58
Number of ergotherapist visits				0.55	[-0,3 ; 1,4]	0.22	0.55	[-0,3 ; 1,4]	0.22
PCS score (baseline)							-0.01	[-0,2 ; 0,2]	0.88
PHQ score(change)									
CEQ expectations (change)									
CEQ credibility (change)									
IPQ consequences (change)									
IPQ timeline (change)									
IPQ treatment control (change)									
IPQ identity (change)									
IPQ concern (change)									
IPQ coherence (change)									
IPQ emotional respons (change)									
R2		0.01			0.01			< 0,008	

	Psychological distress added			Credibility and Expectations added			Illness perceptions added		
	B	95%CI	P-value	B	95%CI	P-value	B	95%CI	P-value
Age	0.04	[-0.2; 0.3]	0.78	0.01	[-0.3; 0.3]	0.92	-0.04	[-0.3; 0.2]	0.73
Sexs, male	-2.98	[-7.1; 1.2]	0.16	-1.44	[-5.5; 2.6]	0.49	-2.57	[-6.2; 1.1]	0.17
Duration of complaints	-0.06	[-0.1; 0]	0.05	-0.07	[-0.1; 0]	0.02	-0.06	[-0.1; 0]	0.03
Job type (ref: no job)									
Light physical labor	0.15	[-4.8; 5.1]	0.95	0.27	[-4.6; 5.1]	0.91	-1.39	[-5.8; 3]	0.54
Moderate physical labor	4.68	[-0.5; 9.9]	0.08	3.83	[-1.2; 8.9]	0.14	1.24	[-3.4; 5.9]	0.60
Heavy physical labor	-0.03	[-6.8; 6.7]	0.99	2.36	[-4.3; 9]	0.49	0.97	[-5; 6.9]	0.75
Smoking, no	4.44	[-1.7; 10.6]	0.16	4.11	[-1.9; 10.2]	0.18	4.53	[-0.9; 9.9]	0.10
BMI	0.13	[-0.2; 0.5]	0.46	0.10	[-0.2; 0.4]	0.54	0.10	[-0.2; 0.4]	0.52
Number of physiotherapist visits	-0.12	[-0.8; 0.6]	0.72	-0.11	[-0.8; 0.6]	0.75	-0.20	[-0.8; 0.4]	0.51
Number of ergotherapist visits	0.47	[-0.4; 1.3]	0.29	0.50	[-0.3; 1.3]	0.25	0.41	[-0.4; 1.2]	0.30
PCS score (baseline)	-0.04	[-0.2; 0.1]	0.65	-0.03	[-0.2; 0.2]	0.79	0.02	[-0.1; 0.2]	0.78
PHQ score(change)	1.37	[0.3; 2.4]	0.01	1.39	[0.3; 2.4]	0.01	1.01	[0.1; 1.9]	0.04
CEQ expectations (change)				0.77	[0.4; 1.2]	0.00	0.74	[0.4; 1.1]	0.00
CEQ credibility (change)				-0.12	[-0.6; 0.4]	0.62	-0.29	[-0.7; 0.1]	0.19
IPQ consequences (change)							1.15	[0.5; 1.8]	0.00
IPQ timeline (change)							-0.31	[-0.9; 0.3]	0.31
IPQ treatment control (change)							0.58	[-0.1; 1.2]	0.09
IPQ identity (change)							1.01	[0.4; 1.6]	0.00
IPQ concern (change)							0.85	[0.1; 1.6]	0.03
IPQ coherence (change)							-0.22	[-1; 0.6]	0.58
IPQ emotional respons (change)							0.96	[0.3; 1.6]	0.00
R2		0.06			0.08			0.27	



PART 3

PSYCHOSOCIAL AND OCCUPATION EFFECTS IN PATIENTS WHO RECEIVE SURGICAL TREATMENT FOR THUMB BASE OSTEOARTHRITIS



CHAPTER 12

PATIENTS WITH THUMB BASE OSTEOARTHRITIS SCHEDULED FOR SURGERY HAVE MORE SYMPTOMS, WORSE PSYCHOLOGICAL PROFILE AND HIGHER EXPECTATIONS COMPARED TO NON-SURGICAL COUNTERPARTS: A LARGE COHORT ANALYSIS

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ABSTRACT

Background: Psychological characteristics, such as depression, anxiety or negative illness perception are highly prevalent in patients with several types of OA. It is unclear whether there are differences in the clinical and psychological characteristics of patients with thumb carpometacarpal (CMC-1) osteoarthritis (OA) scheduled for non-surgical treatment and those with surgical treatment.

Questions/purposes: (1) What are the differences in baseline sociodemographic characteristics and clinical characteristics (including pain, hand function, and health-related quality of life) between patients with thumb CMC-1 OA scheduled for surgery and those treated non-operatively? (2) What are the differences in psychological characteristics between patients scheduled for surgery and those treated non-surgically, for treatment credibility, expectations, illness perception, pain catastrophizing, and anxiety and depression? (3) What is the relative contribution of baseline sociodemographic, clinical, and psychological characteristics to the probability of being scheduled for surgery?

Methods: This was a cross-sectional study using observational data. Patients with CMC-1 OA completed outcome measures before undergoing either non-surgical or surgical treatment. Between September 2017 and June 2018, 1273 patients were screened for eligibility. In total, 584 participants were included: 208 in the surgery group and 376 in the nonsurgery group. Baseline sociodemographic, clinical, and psychological characteristics were compared between groups, and a hierarchical logistic regression analysis was used to investigate the relative contribution of psychological characteristics to being scheduled for surgery, over and above clinical and sociodemographic variables. Baseline measures included pain, hand function, satisfaction with the patient's hand, health-related quality of life, treatment credibility and expectations, illness perception, pain catastrophizing, and anxiety and depression.

Results: Patients in the surgery group had longer symptom duration, more often a second opinion, higher pain, treatment credibility and expectations and worse hand function, satisfaction, HRQoL, illness perception and pain catastrophizing compared with the non-surgery group (effect sizes ranged from 0.20 to 1.20; *p* values ranged from < 0.001 to 0.044). After adjusting for sociodemographic, clinical, and psychological factors, we found that the following increased the probability of being scheduled for surgery: longer

symptom duration (standardized odds ratio [SOR], 1.86; $p = 0.004$), second-opinion visit (SOR, 3.81; $p = 0.027$), lower satisfaction with the hand (SOR, 0.65; $p = 0.004$), higher treatment expectations (SOR, 5.04; $p < 0.001$), shorter perceived timeline (SOR, 0.70; $p = 0.011$), worse personal control (SOR, 0.57; $p < 0.001$) and emotional response (SOR, 1.40; $p = 0.040$). The hierarchical logistic regression analysis including sociodemographic, clinical, and psychological factors provided the highest area under the curve (sociodemographics alone: 0.663 [95% confidence interval 0.618 to 0.709]; sociodemographics and clinical: 0.750 [95% CI 0.708 to 0.791]; sociodemographics, clinical and psychological: 0.900 [95% CI 0.875 to 0.925]).

Conclusions: Patients scheduled to undergo surgery for CMC-1 OA have a worse psychological profile than those scheduled for non-surgical treatment. Our findings suggest that psychological characteristics should be considered during shared decision-making, and they might indicate if psychological interventions, training in coping strategies, and patient education are needed. Future studies should prospectively investigate the influence of psychological characteristics on the outcomes of patients with CMC-1 OA.

INTRODUCTION

Thumb carpometacarpal (CMC-1) osteoarthritis (OA) is common, with a symptomatic prevalence of 7% and 2% among women and men [Bijlsma, 2011 #390] aged at least 50 years, respectively¹⁻³. Patients with CMC-1 OA often have thumb pain and limitations to activities of daily life and present with clinical features such as thenar muscle wasting or a thumb deformity^{1,4}. Usually, initial treatment is non-surgical (for example, hand therapy), including exercises, orthotics, or both⁵⁻¹². Increasing evidence shows that non-operative treatment decreases pain and improves hand function and patient satisfaction^{5, 7, 8, 10, 13, 14}. When non-surgical treatment does not alleviate symptoms, surgery may be considered^{15, 16}. Tsehaie et al.¹⁴ reported that after non-surgical treatment, 15% of the patients eventually underwent surgical treatment after a mean period of 2.2 years, indicating that most patients with CMC-1 OA respond well to non-surgical treatment. In another study, Tsehaie et al.¹⁷ found that baseline sociodemographic and clinical variables (such as pain intensity or hand function) account for 31% to 42% of the variance in outcome when predicting the results of non-surgical treatment and subsequent surgery, indicating that not all relevant covariates were covered.

During the past decade, studies have demonstrated that psychological characteristics such as depression, anxiety, negative illness perception, and pain catastrophizing are highly prevalent in patients with several types of OA¹⁸⁻²⁷. However, little is known about differences in psychological characteristics and treatment expectations between patients with CMC-1 OA who have non-surgical treatment and those with surgical treatment. Hypothetically, when a non-surgical treatment fails (perhaps repeatedly), this suggests that a different psychological profile may be present at the start of surgical treatment. Only one study, by Lozano-Calderon et al.²⁸, evaluated differences between patients electing to undergo surgical and those choosing to undergo non-surgical treatment, using a relatively small sample of 72 participants and evaluating DASH scores, pain anxiety, catastrophizing, and depression. However, important domains such as illness perception, treatment credibility and expectations, and health-related quality of life were not studied, and the study might have been underpowered to determine between-group differences or predictors of whether a patient would elect to undergo surgery. More insight into the psychological profiles and treatment expectations of patients with CMC-1 OA treated non-surgically and those treated surgically is needed. This would provide clinicians and patients with valuable information for shared decision-making; decrease the number of surgeries performed; improve the outcomes of surgery; or indicate if psychological interventions, training in coping strategies, and patient education are needed.

Therefore, we formulated the following research questions: (1) What are the differences in baseline sociodemographic characteristics and clinical characteristics (including pain, hand function, and health-related quality of life) between patients with thumb CMC-1 OA scheduled for surgery and those treated non-operatively? (2) What are the differences in psychological characteristics between patients scheduled for surgery and those treated non-surgically, for treatment credibility, expectations, illness perception, pain catastrophizing, and anxiety and depression? (3) What is the relative contribution of baseline sociodemographic, clinical, and psychological characteristics to the probability of being scheduled for surgery?

PATIENTS AND METHODS

Study Design

This was a cross-sectional study using baseline data collected before non-surgical or surgical treatment in a large observational cohort, following the STROBE statement ²⁹.

Setting

Data were collected as part of routine outcome measurements using GemsTracker electronic data capture tools (Erasmus MC and Equipe Zorgbedrijven, Rotterdam/Eindhoven, The Netherlands) ³⁰. GemsTracker is a secure web-based application for distributing questionnaires and documents during clinical research and quality registration ^{31, 32}. Data were collected at 18 outpatient hand surgery and therapy clinics in the Netherlands between September 2017 and June 2018. The study was approved by the local medical research ethical committee. Following the Dutch treatment guideline ³³, all patients with CMC-1 OA diagnosed by a certified hand surgeon were initially referred for hand therapy and non-surgical treatment. Follow-up with the hand surgeon occurred after approximately 3 months, after which the decision to proceed to further (surgical) treatment could be made, based on persistent symptoms and patient preference. We classified patients who started with the non-surgical, hand therapy treatment as the nonsurgery group, and patients who proceeded to surgical treatment were classified as the surgery group.

Participants

Participants were eligible for inclusion if they were adults with CMC-1 OA diagnosed by a Federation of European Societies for Surgery of the Hand (FESSH)-certified hand surgeon and if they were scheduled for either non-surgical or surgical treatment. Non-surgical treatment included an orthosis combined with exercise therapy, which consisted hand therapy sessions (guided by an physical/occupational hand therapist, nationally certified in most cases) and exercises performed at home by the patient to improve active stability of the CMC-1 ^{9, 11, 13, 14, 34}. Surgical procedures included ligament reconstruction and tendon interposition as described by Burton and Pellegrini ³⁵ and Weilby ³⁶ (using either the flexor carpi radialis or abductor pollicis longus tendon)

³⁶, simple trapeziectomy, and arthrodesis. Participants were excluded from this study if they had a comorbidity (such as de Quervain's tenosynovitis) that interfered with the treatment or outcome, prior surgery of the CMC-1 in the same hand, steroid injection in the affected hand or wrist within 6 weeks, surgery that targeted multiple pathologies (for example, an additional carpal tunnel release in the same session), or missing data for any measure being studied. Additionally, 13 patients were excluded because they completed the same measures both before their non-surgical and their subsequent surgical treatment. After applying the eligibility criteria, 584 participants were included: 208 in the surgery group and 376 in the nonsurgery group (Fig. 1).

Variables, Data Sources, and Measurement

Similar to other studies ³⁷⁻³⁹, we classified variables into three categories: sociodemographic, clinical, and psychological. All data represented baseline values before non-surgical or surgical treatment. Sociodemographic characteristics included age, sex, symptom duration, treatment side, dominance, type of work, whether the patient was seen for a second opinion, and type of surgery (for the surgery group).

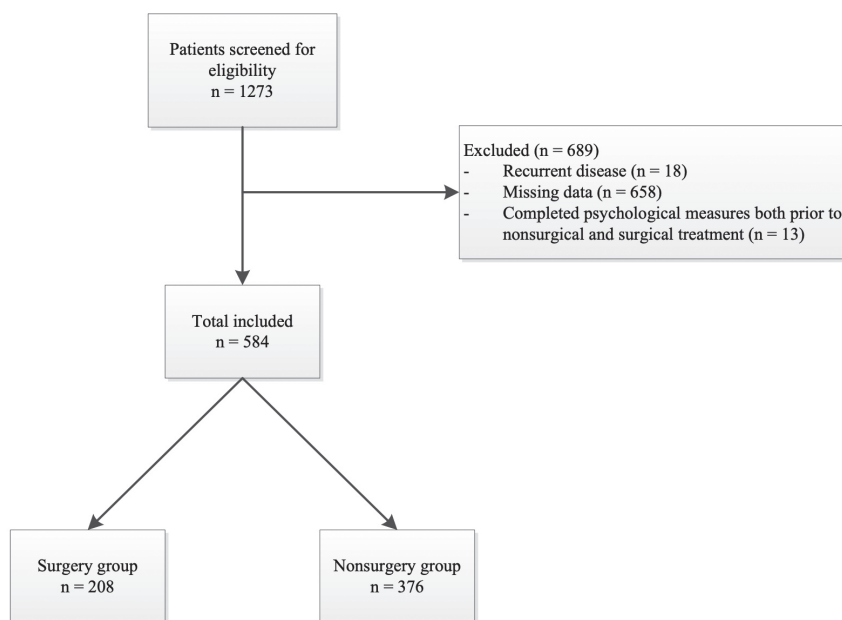


Figure 1. This flowchart illustrates the exclusions criteria for this study.

Clinical characteristics included pain, hand function, satisfaction, and health-related quality of life. We used the VAS ⁴⁰ to measure pain (VAS score ranges from 0 to 100; higher scores indicate more pain) and the patients' satisfaction with their hand (exact question: "How satisfied are you with your hand at this moment?"; higher scores indicate better satisfaction). To assess hand function, we used the Michigan Hand outcomes Questionnaire (MHQ, range 0 to 100; higher scores indicate better performance, except for the subscale of pain), which is particularly applicable to patients with OA of the hand ⁴¹. Health-related quality of life was measured using the EuroQol-5D-5L (EQ-5D-5L) ⁴².

Psychological characteristics included treatment credibility, treatment expectations, illness perception, pain catastrophizing, and anxiety and depression. Treatment credibility and expectations were measured using the Credibility/Expectancy Questionnaire (CEQ), consisting of a credibility and expectancy subscale (score range is 3 to 27; higher scores indicate higher credibility or expectations) ⁴³. Illness perception was measured using the brief Illness Perception Questionnaire ([IPQ]; item scores range from 0 to 10; higher scores indicate worse illness perception) ⁴⁴. Pain catastrophizing was measured with the Pain Catastrophizing Scale ([PCS]; score range is 0 to 52; higher scores indicate more catastrophizing) ⁴⁵. Furthermore, anxiety and depression were measured with the Patient Health Questionnaire for anxiety and depression ([PHQ-4]; score range: 0 to 6 for the subscales of anxiety and depression; higher scores indicate more anxiety and depression), which is a tool for detecting depressive disorders ⁴⁶. Scores of 3 or higher for the subscales indicate a potential anxiety or depression disorder ⁴⁶.

Study Size

A power analysis using an independent sample t-test (the primary analysis) with a conventional effect size ⁴⁷ of 0.25 and power of 0.80 ($\alpha = 0.05$) and an allocation ratio of 0.57 showed that 546 participants were needed, which was well below the sample of 584 participants we were able to include.

Statistical Methods

We compared baseline sociodemographic, clinical, and psychological characteristics between patients with CMC-1 OA scheduled for non-surgical treatment and those with surgical treatment, using independent sample t-tests

and chi-square tests. Additionally, to more specifically investigate the relative contribution of sociodemographic, clinical, and psychological characteristics to the probability of being scheduled for surgery, we used a hierarchical logistic regression analysis with the treatment group as a dependent variable. Using this method, the relative contribution of psychological characteristics can be studied in more detail after adjusting for sociodemographic characteristics (for example, symptom duration) and clinical characteristics (such as VAS pain levels). Variables were added to this hierarchical model in separate steps. To illustrate the fit of the different models, we determined the area under the curve, Nagelkerke's r^2 , and receiver operating characteristic curves for these different models. In this analysis, we carefully selected each variable for inclusion in every step based on the construct it measures. This means that not all variables from the primary analysis were used in the hierarchical model; we excluded variables for which there was overlap in the measured construct (for example, the EQ-5D-5L anxiety/depression index and PHQ-4). All available variables are reported in the primary analyses to provide an overview of both groups that was as clear as possible.

In the first step of the hierarchical model, only sociodemographic characteristics including age, sex, symptom duration, treatment side, dominance, type of work, and second-opinion visit were added. In the second step, we added clinical characteristics, including VAS scores for pain at rest and during physical loading; VAS satisfaction; MHQ subscales of hand function, activities of daily life, work, and aesthetics; and the EQ-5D-5L index score. In the third step, we added psychological characteristics, including the CEQ subscales of credibility and expectancy; IPQ items of consequences, timeline, personal control, identity, concern, coherence, and emotional response; the PCS; and the PHQ anxiety and depression subscales. We evaluated multicollinearity using correlation coefficients and the variance inflation factor. A variance inflation factor greater than 10 was considered an indication of multicollinearity⁴⁸.

Table 1. Final model following hierarchical logistic regression analyses ($n = 584$) using sociodemographic, clinical and psychological characteristics explaining the relative contribution of being in the surgery group. Unstandardized and standardized odds ratios (SOR), 95% confidence intervals for the unstandardized ORs are displayed, along with the area under the curve (AUC) and Nagelkerke R² for the model. *Significant at < 0.05 level. MHQ = Michigan Hand outcomes Questionnaire, CEQ = Credibility and Expectancy Questionnaire, IPQ = brief Illness Perception Questionnaire, PCS = Pain Catastrophizing Scale, PHQ = Patient Health Questionnaire.

Variables	Final model	
	Unstandardized OR (95% CI)	Standardized OR
Step 1: Sociodemographic characteristics		
Treatment side	0.84 (0.54 to 1.30)	0.84
Dominance	1.01 (0.50 to 2.05)	1.01
Gender	0.77 (0.42 to 1.43)	0.77
Age onset	1.01 (0.97 to 1.05)	1.05
Symptom duration	1.01* (1.00 to 1.02)	1.86
Second opinion	3.81* (1.17 to 12.4)	3.81
Type of work category		
Type of work category (1)	1.07 (0.54 to 2.14)	1.07
Type of work category (2)	0.73 (0.37 to 1.42)	0.73
Type of work category (3)	1.31 (0.55 to 3.13)	1.31
Step 2: Clinical characteristics		
VAS pain at rest	1.00 (0.99 to 1.01)	1.01
VAS pain during physical load	1.01 (1.00 to 1.03)	1.34
VAS satisfaction with the patient's hand	0.98* (0.97 to 0.99)	0.65
MHQ hand function	1.00 (0.99 to 1.02)	1.01
MHQ activities of daily living	1.00 (0.99 to 1.01)	0.87
MHQ work	0.99 (0.98 to 1.01)	0.86
MHQ aesthetics	0.99 (0.98 to 1.01)	0.86
EQ-5D-5L index score	0.40 (0.05 to 3.58)	0.87
Step 3: Psychological characteristics		
CEQ credibility	1.04 (0.94 to 1.15)	1.18
CEQ expectancy	1.42* (1.29 to 1.56)	5.04
IPQ consequences	1.04 (0.88 to 1.23)	1.09
IPQ timeline	0.86* (0.77 to 0.97)	0.70
IPQ personal control	0.78* (0.70 to 0.87)	0.57
IPQ symptoms due to illness	1.00 (0.89 to 1.13)	1.01
IPQ concern	1.00 (0.88 to 1.14)	1.00
IPQ understanding	1.02 (0.90 to 1.16)	1.03

Variables	Final model	
	Unstandardized OR (95% CI)	Standardized OR
IPQ emotional response	1.12* (1.01 to 1.25)	1.40
PCS	1.01 (0.97 to 1.04)	1.05
PHQ anxiety subscale	0.92 (0.71 to 1.19)	0.89
PHQ depression subscale	0.89 (0.65 to 1.22)	0.87
AUC (95% CI; p value)	0.900 (0.875 to 0.925; p < 0.001)	
Nagelkerke R ²	0.56	

RESULTS

After adjusting for sociodemographic, clinical, and psychological factors, we found that longer symptom duration (standardized odds ratio [SOR], 1.86; $p = 0.004$), second-opinion visit (SOR, 3.81; $p = 0.027$), lower satisfaction with the hand (SOR, 0.65; $p = 0.004$), higher treatment expectations (SOR, 5.04; $p < 0.001$), shorter perceived timeline (SOR, 0.70; $p = 0.011$), worse personal control (SOR, 0.57; $p < 0.001$) and emotional response (SOR, 1.40; $p = 0.040$) increased the probability of being scheduled for surgery to an area under the curve (AUC) of 0.900 (Table 1). In an examination of sociodemographics alone, we found that patients in the surgery group reported a longer symptom duration (36 months) than did those in the nonsurgery group (23 months; $p = 0.001$) and visited our center more often for a second opinion (7% versus 2%; $p = 0.001$). There were no other between-group differences in sociodemographic characteristics (Table 2).

Considering clinical characteristics, patients in the surgical treatment group reported worse symptom severity scores for the VAS and MHQ (except for the subscale of aesthetics) than did those in the non-surgical treatment group ($p < 0.001$ to 0.006; absolute effect sizes ranging from 0.24 to 0.67) (Table 3). Additionally, patients in the surgery group reported worse scores for the EQ-5D-5L domains of self-care, daily activities, pain and discomfort indexes, and total index score ($p < 0.001$ to 0.016; absolute effect sizes ranging from 0.22 to 0.46) (Table 3).

Table 2. Sociodemographic characteristics for the surgery group (N=208) and the non-surgery group (N=376). Abbreviations: LRTI = Ligament Reconstruction and Tendon Interposition, FCR = Flexor Carpi Radialis, APL = Abductor Pollicis Longus

Variable	Surgery group (N=208)	Non-surgery group (N=376)	p-value
Age, mean \pm SD	60.7 \pm 7.9	60.3 \pm 7.6	0.532
Female gender, %	78.8%	77.7%	0.740
Symptom duration in months, mean \pm SD	36.3 \pm 36.5	22.7 \pm 57.1	0.001
Treatment Side*, %			0.893
- Left	48.6%	46%	
- Right	51.4%	47.6%	
- Both	-	6.4%	
*statistics are used to test left/right only, since bilateral surgical treatment is not employed			
Dominance, %			0.854
- Left	7.2%	6.6%	
- Right	89.4%	90.7%	
- Both	3.4%	2.7%	
Type of surgery, %:			NA
- LRTI (Burton-Pellegrini)	23.1%	-	
- LRTI (Weilby-FCR)	57.7%	-	
- LRTI (Weilby-APL)	7.7%	-	
- Simple trapeziectomy	10.1%	-	
- Arthrodesis	1.4%	-	
Type of work, %			0.079
- Unemployed	45.7%	41.2%	
- Light physical labor	16.8%	22.9%	
- Moderate physical labor	23.1%	26.6%	
- Heavy physical labor	14.4%	9.3%	
Second opinion, %	7.2%	1.9%	0.001

Table 3. Baseline mean \pm SD values for clinical characteristics and symptom severity for the Visual Analogue Scales (VAS, score range: 0–100), the Michigan Hand outcomes Questionnaire (MHQ, score range: 0–100) and EQ-5D-5L (score range: 0–100 for self-rated health, 1–5 for subscales and -0.33–1.0 for the index score).

Variable	Surgery group (N=208)	Non-surgery group (N=376)	Effect size (Cohen's d)	p-value
VAS past week	67.2 \pm 17.3	54.6 \pm 21.5	0.65	<0.001
VAS rest	51.4 \pm 22.7	40.2 \pm 25.9	0.46	<0.001
VAS physical load	75.6 \pm 17.4	63.3 \pm 22.4	0.61	<0.001
VAS satisfaction with the patient's hand ("How satisfied are you with your hand at this moment?")	25.3 \pm 20.4	37.2 \pm 22.1	-0.56	<0.001
MHQ hand function	52.1 \pm 17.9	57.9 \pm 17.9	-0.32	<0.001
MHQ Activities of daily living	57.2 \pm 27	69.1 \pm 24.4	-0.46	<0.001
MHQ Work	49.1 \pm 26.8	60.5 \pm 25.8	-0.43	<0.001
MHQ Pain	64.5 \pm 14.8	53.8 \pm 17.1	0.67	<0.001
MHQ Aesthetics	78.9 \pm 19.6	81.5 \pm 19.6	-0.13	0.124
MHQ Satisfaction	42.2 \pm 27.6	48.5 \pm 24.9	-0.24	0.006
MHQ Total	50.1 \pm 14.3	58.4 \pm 14.7	-0.58	<0.001
EQ-5D-5L Self-rated health	75.6 \pm 18.3	75.8 \pm 18.4	0.00	0.859
EQ-5D-5L Mobility	1.36 \pm 0.69	1.48 \pm 0.82	-0.16	0.054
EQ-5D-5L Self care	1.44 \pm 0.68	1.30 \pm 0.61	0.22	0.016
EQ-5D-5L Daily activities	2.56 \pm 0.97	2.30 \pm 0.91	0.28	0.002
EQ-5D-5L Pain and discomfort	3.18 \pm 0.72	2.85 \pm 0.73	0.46	<0.001
EQ-5D-5L Anxiety	1.38 \pm 0.73	1.32 \pm 0.67	0.09	0.360
EQ-5D-5L index value	0.68 \pm 0.16	0.73 \pm 0.15	-0.31	0.001

When we compared the groups in terms of psychological characteristics, patients in the surgery group reported higher credibility and expectancy of their treatment than did those in the nonsurgery group ($p < 0.001$), with effect sizes of 0.81 and 1.20, respectively (Table 4). For the IPQ, patients in the surgery group reported having worse consequences, identity, concern, and emotional response because of their illness and a shorter expected timeline of their illness than did those in the nonsurgery group ($p < 0.001$ to 0.018; absolute effect sizes ranging from 0.20 to 0.47). Additionally, patients in the surgery group reported less personal control but more treatment control than did those in the nonsurgery group, suggesting a more external locus of control ($p < 0.001$; absolute effect sizes 0.46 and 0.90, respectively). Furthermore, patients in the

surgery group reported more pain catastrophizing on the PCS ($p < 0.001$; effect size = 0.31) than did those in the non-surgical treatment group. No differences were found in PHQ scores (Table 4).

Table 4. Baseline mean \pm SD scores on psychological questionnaires for treatment expectations, illness perception, pain catastrophizing and anxiety and depression. CEQ = Credibility and Expectancy Questionnaire (score range: 3–27), IPQ = brief Illness Perception Questionnaire (score range 0–10), PCS = Pain Catastrophizing Scale (score range: 0–52) PHQ = Patient Health Questionnaire-4 (PHQ, score range: 0–6 for the subscales)

Variable	Surgery group (n = 208)	Nonsurgery group (n = 376)	Effect size (Cohen's d)	p value
CEQ credibility	23.5 \pm 2.8	20.8 \pm 3.8	0.81	< 0.001
CEQ expectancy	22.3 \pm 3.1	17.6 \pm 4.6	1.20	< 0.001
IPQ consequences: How much does your illness affect your life? (10 = severely affects my life)	7.4 \pm 1.8	6.4 \pm 2.3	0.47	< 0.001
IPQ timeline: How long do you think your illness will continue? (10 = forever)	6.7 \pm 2.5	7.7 \pm 2.3	-0.42	< 0.001
IPQ personal control: How much control do you feel you have over your illness? (0 = absolutely no control)	4.3 \pm 2.5	5.3 \pm 2.1	-0.46	< 0.001
IPQ treatment control: How much do you think your treatment can help your illness? (10 = extremely helpful)	8.3 \pm 1.4	6.8 \pm 1.8	0.90	< 0.001
IPQ identity: How much do you experience symptoms from your illness? (10 = many severe symptoms)	6.9 \pm 2.4	6 \pm 2.5	0.38	< 0.001
IPQ concern: How concerned are you about your illness? (10 = extremely concerned)	6.5 \pm 2.5	5.9 \pm 2.7	0.20	0.018
IPQ coherence: How well do you feel you understand your illness? (10 = understand very clearly)	8.4 \pm 2	8.4 \pm 1.8	0.00	0.974
IPQ emotional response: How much does your illness affect you emotionally? (for example, does it make you angry, scared, upset or depressed? (10 = extremely affected emotionally)	5.2 \pm 3	4.2 \pm 2.9	0.37	< 0.001

Variable	Surgery group (n = 208)	Nonsurgery group (n = 376)	Effect size (Cohen's d)	p value
PCS	14.4 ± 10.3	11.4 ± 9.1	0.31	< 0.001
PHQ subscale anxiety	0.80 ± 1.35	0.77 ± 1.31	0.02	0.765
PHQ subscale depression	0.67 ± 1.28	0.55 ± 1.09	0.10	0.252
PHQ anxiety cutoff (score 3 or higher), n (%)	25 (12%)	32 (8.5%)	NA	0.171
PHQ depression cutoff (score 3 or higher), n (%)	17 (8.2%)	20 (5.3%)	NA	0.175
PHQ total	1.47 ± 2.44	1.32 ± 2.22	0.06	0.437

When analyzing the different models resulting from our hierarchical regression, the model including sociodemographic, clinical, and psychological factors provided the highest areas under the curve (sociodemographics alone: 0.663 [95% CI 0.618 to 0.709]; sociodemographics and clinical: 0.750 [95% CI 0.708 to 0.791]; sociodemographics, clinical and psychological: 0.900 [95% CI 0.875 to 0.925], Supplementary Table 1). The ROC curve indicates that the probability of being scheduled for surgery is for the largest part explained by the last model, including sociodemographic, clinical, and psychological characteristics (Fig. 2).

DISCUSSION

Psychological characteristics, such as depression, anxiety or negative illness perception are highly prevalent in patients with OA. Before our study, it was unclear whether there are differences in the clinical and psychological characteristics of patients with CMC-1 OA scheduled for non-surgical or surgical treatment. More insight in psychological profile of these patients would provide clinicians and patients with valuable information for shared decision-making and indicate if psychological interventions, training in coping strategies, and patient education are needed. We found that patients with CMC-1 OA scheduled for surgery have a worse psychological profile than do those undergoing non-surgical treatment. Additionally, the probability of being scheduled for surgery is best explained by our model, including sociodemographic, clinical, and psychological characteristics.

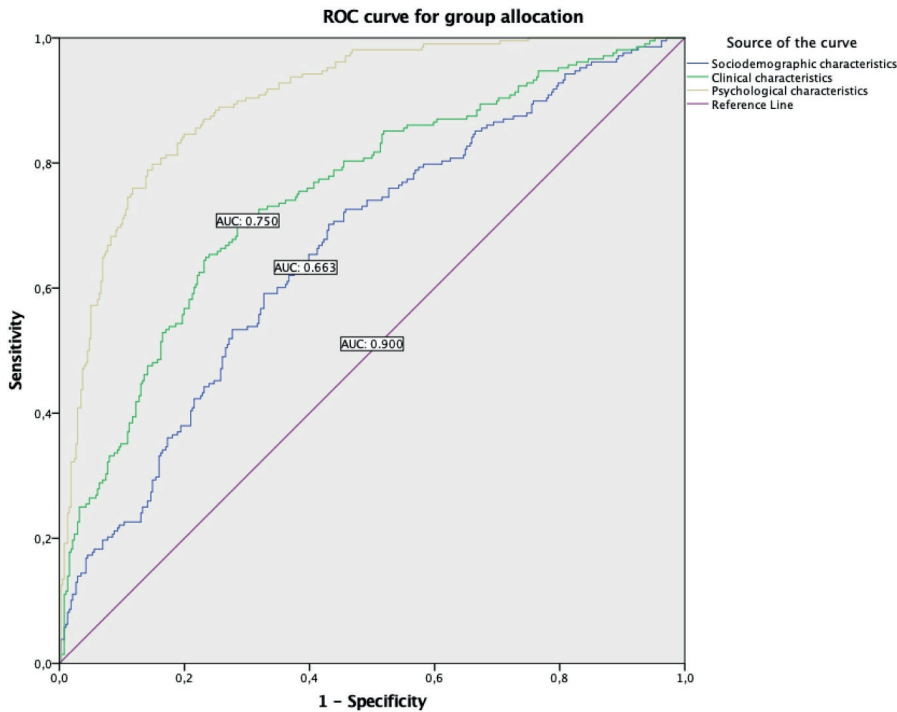


Figure 2. Receiver operating characteristic curve for the hierarchical models, with AUCs of 0.663, 0.750, and 0.900 for sociodemographic, plus clinical and plus psychological characteristics, respectively, indicating that the probability of being in the surgery group is for the largest part of explained by the model with sociodemographic, clinical and psychological characteristics. ROC = receiver operating characteristic; AUC = area under the curve.

Limitations

The results of these between-group comparisons should be interpreted with caution because patients undergoing surgical treatment usually receive non-surgical treatment first but do not improve. In the present study, we do not know whether between-group differences occurred because of deterioration in clinical and psychological characteristics over time after initiating non-surgical treatment or if these differences were predetermined and predictors of conversion to surgery. Furthermore, the amount of missing data that lead to our final sample ($n = 584$ patients) and surgeon's preferences may have resulted in selection bias. Hence, our sample may be a different representation compared with the target population of patients with CMC-1 OA. Another limitation is that although we reported effect sizes, which allow comparisons across populations

and measurement instruments, the between-group differences in this study should be interpreted in light of minimal clinical important difference values established in other disease populations, such as for the VAS and the MHQ^{40, 49, 50}.

Differences in Baseline Characteristics between Patients Treated Surgically and Those Treated Non-operatively

We found that patients scheduled for surgical treatment had longer symptom duration, more often sought a second opinion, had higher pain, treatment credibility and expectations and worse hand function, satisfaction, HRQoL, illness perception, and pain catastrophizing compared with those scheduled for non-surgical treatment. We did not find between-group differences in anxiety or depression.

Although several studies investigated the psychological profiles of patients with OA¹⁸⁻²⁷, only one other study²⁸ specifically compared the psychological profiles of patients with CMC-1 OA scheduled for surgical or non-surgical treatment. However, the study by Lozano-Calderon et al.²⁸ had a sample that was too small to find any between-group differences, and many different measurement tools were used compared with our study (that is, the DASH versus the MHQ for evaluating hand function), making it difficult to compare findings. Our study confirms prior reports¹⁸⁻²⁷, which showed that psychological characteristics are of major importance in patients with chronic musculoskeletal diseases such as OA, and these characteristics influence clinical decision-making, although perhaps unconsciously^{18, 20-27}. Because the underlying pathology of OA of the CMC-1 is chronic, our study results might be generalizable to patients scheduled to undergo surgical or non-surgical treatment of other chronic diseases or body regions; for example, hip or knee OA. Therefore, future research should address other chronic diseases or body regions.

In the present study, we did not find between-group differences in anxiety or depression. However, Becker et al.²² found differences in depression between patients visiting a clinician for CMC-1 OA and patients with coincidentally diagnosed CMC-1 OA. Becker et al.²² used the nine-item version of the PHQ, which is a more extensive screening tool than the four-item tool used in the present study. However, a score of 5 or higher on the nine-item version of the

PHQ indicates mild depression ⁵¹, and in the study by Becker et al. ²², a mean score of 4.5 was found in the group visiting a clinician for CMC-1 OA. This indicates that on average, no depression was present, which is comparable to our results.

Factors Contributing to the Probability of Being Scheduled for Surgery

Our findings suggest that patients with CMC-1 OA scheduled for surgical treatment have a worse psychological profile compared with patients scheduled for non-surgical treatment. The decision to undergo surgery might be influenced by potentially modifiable psychological characteristics, and addressing these factors may decrease the number of surgeries performed or improve the outcomes of surgery. Psychological interventions, training in coping strategies, and more extensive patient education may be indicated before surgical treatment is performed. However, although the correlation of psychological characteristics with the outcome of non-surgical or surgical treatment of CMC-1 OA is currently unknown, this correlation is known in patients who undergo surgery for carpal tunnel syndrome or trigger finger ⁵². Future longitudinal studies should address the correlation of psychological characteristics with the outcomes of both non-surgical and surgical treatment of CMC-1 OA.

We found that patients in the nonsurgery group expected to have a longer illness duration and had more personal control, less treatment control (IPQ scores), and lower treatment expectations (CEQ scores) than did those in the surgical group. Patients scheduled for non-surgical treatment may cope with chronic disease differently than those with surgical treatment, implying that they are more willing to accept aging processes and adapt to daily life than patients who undergo surgery. Furthermore, the participants in the surgery group reported having higher treatment credibility and expectations but worse clinical and other psychological characteristics, suggesting that more research on how to manage treatment credibility and expectations is needed, especially in this population.

In the final model, we found a relatively large OR for whether a second opinion contributed to the probability of surgery. This finding may be explained by the theory that patients seeking a second opinion already had a relatively long clinical course, and they may have postponed surgery for a longer time period.

However, this hypothesis cannot be confirmed with the present cross-sectional study design and should be investigated in a longitudinal setting.

CONCLUSIONS

In conclusion, we found worse clinical and psychological characteristics in patients scheduled for surgical treatment of CMC-1 OA than in patients at the initiation of non-surgical treatment. Furthermore, the probability of being scheduled for surgery was mostly explained by the model including sociodemographic, clinical, and psychological characteristics. A more thorough psychological evaluation might be considered before surgery is performed, especially in patients with high expectations, worse illness perception, and pain catastrophizing. Additionally, addressing these factors might decrease the number of surgeries performed, improve the outcomes of surgery or indicate if psychological interventions, training in coping strategies, and patient education might be indicated before converting to surgery. Future studies should investigate the influence of psychological characteristics on the outcomes of patients with CMC-1 OA.

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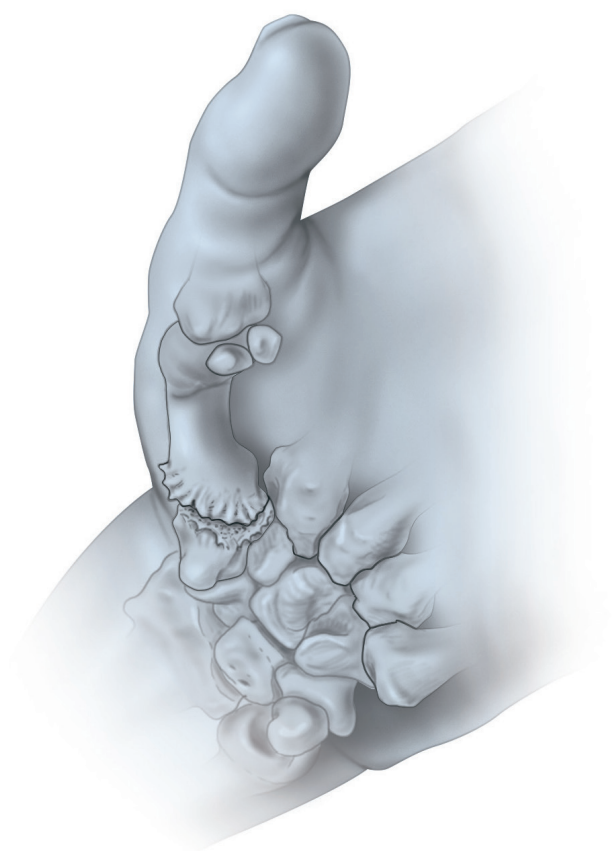
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Supplementary Table 1. Entire hierarchical logistic regression analysis (n = 594) explaining the relative contribution of being in the surgery group using sociodemographic characteristics (model 1), clinical characteristics (model 2) and psychological characteristics (model 3). Unstandardized and standardized odds ratios (OR), the 95% confidence intervals (CI) for the unstandardized ORs, along with the area under the curve (AUC), the significance of the change of the AUC, and Nagelkerke R² for the different models. *Significance at < 0.05 level. MHQ = Michigan Hand outcomes Questionnaire, CEQ = Credibility and Expectancy Questionnaire, IPQ = brief Illness Perception Questionnaire, PCS = Pain Catastrophizing Scale, PHQ = Patient Health Questionnaire.

Variables	Model 1		Model 2		Model 3	
	Unstandardized OR (95% CI)	Standardized OR	Unstandardized OR (95% CI)	Standardized OR	Unstandardized OR (95% CI)	Standardized OR
<i>Step 1: Sociodemographic characteristics</i>						
Treatment side	0.74 (0.55 to 1.01)	0.74	0.72 (0.51 to 1.00)	0.72	0.84 (0.54 to 1.30)	0.84
Dominance	0.91 (0.52 to 1.59)	0.91	1.00 (0.55 to 1.83)	1.00	1.01 (0.50 to 2.05)	1.01
Gender	1.13 (0.72 to 1.76)	1.13	0.79 (0.49 to 1.29)	0.79	0.77 (0.42 to 1.43)	0.77
Age onset	1.01 (0.98 to 1.03)	1.05	1.02 (0.99 to 1.05)	1.15	1.01 (0.97 to 1.05)	1.05
Symptom duration	1.01* (1.00 to 1.01)	1.53	1.01* (1.00 to 1.01)	1.33	1.01* (1.00 to 1.02)	1.86
Second opinion	4.03* (1.57 to 10.31)	4.03	4.06* (1.47 to 11.22)	4.06	3.81* (1.17 to 12.4)	3.81
<i>Type of work category</i>						
Type of work category (1)	0.69 (0.41 to 1.17)	0.69	0.83 (0.47 to 1.46)	0.83	1.07 (0.54 to 2.14)	1.07
Type of work category (2)	0.81 (0.49 to 1.34)	0.81	1.01 (0.59 to 1.74)	1.01	0.73 (0.37 to 1.42)	0.73
Type of work category (3)	1.56 (0.84 to 2.89)	1.56	1.85 (0.96 to 3.59)	1.85	1.31 (0.55 to 3.13)	1.31

Variables	Model 1		Model 2		Model 3	
	Unstandardized OR (95% CI)	Standardized OR	Unstandardized OR (95% CI)	Standardized OR	Unstandardized OR (95% CI)	Standardized OR
<i>Step 2: Clinical characteristics</i>						
VAS pain at rest			1.01 (1.00 to 1.01)	1.13	1.00 (0.99 to 1.01)	1.01
VAS pain during physical load			1.02* (1.00 to 1.03)	1.44	1.01 (1.00 to 1.03)	1.34
VAS patient satisfaction with their hand			0.98* (0.97 to 0.99)	0.67	0.98* (0.97 to 0.99)	0.65
MHQ hand function			1.00 (0.99 to 1.01)	0.98	1.00 (0.99 to 1.02)	1.01
MHQ activities of daily living			0.99* (0.98 to 1.00)	0.77	1.00 (0.99 to 1.01)	0.87
MHQ work			0.99 (0.99 to 1.00)	0.83	0.99 (0.98 to 1.01)	0.86
MHQ aesthetics			1.00 (0.99 to 1.01)	1.06	0.99 (0.98 to 1.01)	0.86
EQ-5D-5L index score			2.43 (0.53 to 11.10)	1.15	0.40 (0.05 to 3.58)	0.87
<i>Step 3: psychological characteristics</i>						
CEQ credibility					1.04 (0.94 to 1.15)	1.18
CEQ expectancy					1.42* (1.29 to 1.56)	5.04
IPQ consequences					1.04 (0.88 to 1.23)	1.09
IPQ timeline					0.86* (0.77 to 0.97)	0.70
IPQ personal control					0.78* (0.70 to 0.87)	0.57
IPQ symptoms due to illness					1.00 (0.89 to 1.13)	1.01
IPQ concern					1.00 (0.88 to 1.14)	1.00
IPQ understanding					1.02 (0.90 to 1.16)	1.03
IPQ emotional response					1.12* (1.01 to 1.25)	1.40
PCS					1.01 (0.97 to 1.04)	1.05
PHQ anxiety subscale					0.92 (0.71 to 1.19)	0.89
PHQ depression subscale					0.89 (0.65 to 1.22)	0.87
AUC (95% CI; p value)	0.663 (0.618 to 0.709; p < 0.001)		0.750 (0.708 to 0.791; p < 0.001)		0.900 (0.875 to 0.925; p < 0.001)	
Nagelkerke R²	0.07		0.22		0.56	



CHAPTER 13

PAIN CATASTROPHIZING AND ILLNESS PERCEPTIONS ARE ASSOCIATED WITH PREOPERATIVE PAIN AND HAND FUNCTION IN PATIENTS WITH CARPOMETACARPAL OSTEOARTHRITIS OF THE THUMB; A COHORT STUDY

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ABSTRACT

Background and purpose: For carpometacarpal osteoarthritis (OA) of the thumb, it is known that baseline hand function and pain are associated with surgical outcomes; however, it is unknown how psychosocial factors correlate with pain and hand function before surgery. If these associations exist, it could indicate that psychosocial interventions can improve pain and hand function.

Patients and methods: Between September 2017 and December 2018, patients with carpometacarpal osteoarthritis of the thumb who were scheduled for surgery were included. All patients received at least three months of treatment with a hand splint and hand therapy before choosing to undergo surgery. Measurements were part of routine outcome prospective data collection. A stepwise linear regression analysis was used to assess the relative contribution of patients' characteristics, psychological distress, pain catastrophizing, and illness perceptions to baseline pain and hand function.

Results: 204 patients were included in this cross-sectional study. We found patient demographics explained 10% of the variance in pain, psychological distress and pain catastrophizing explained an additional 21%, and illness perception a final 10%. For hand function, patient demographic explained 8%, psychological distress, and pain catastrophizing explained an additional 2% and illness perceptions explained 10%.

Interpretation: Modifiable psychological factors explained a substantial amount of variance of preoperative pain and hand function in patients with carpometacarpal osteoarthritis of the thumb, much more than other non-modifiable patient characteristics such as female sex. Psychological interventions targeting pain catastrophizing and illness perception may improve pain and hand function and may decrease requests for surgery.

INTRODUCTION

Psychosocial factors, such as low treatment expectations, high pain catastrophizing, anxiety, and elevated symptoms of depression, are known to negatively impact surgical outcomes ¹⁻³.

Specifically for the treatment of carpometacarpal osteoarthritis of the thumb (CMC-1 OA), we know that baseline low hand function and high pain are associated with surgical outcomes ⁴. Further, we know that higher pain catastrophizing and more psychological distress result in worse outcomes of both surgical and nonsurgical treatment for CMC-1 OA ⁵⁻⁸. We know from other fields of surgery that more negative illness perceptions are associated with worse outcomes after total knee replacement ^{9,10}, but we are yet to study the effect of illness perceptions on CMC-1 OA outcomes.

While the above-mentioned studies evaluate the effect of psychological factors on the postoperative outcome, the association of psychosocial factors with preoperative pain and hand function is less known. Zyrianova et al. ¹¹, found that in patients with chronic rheumatoid arthritis, negative illness perceptions and poor coping are associated with more pain. Calfee et al. ¹² found that self-reported depression was associated with worse overall hand function before surgery in patients with symptomatic CMC-1 OA. Although psychosocial factors such as pain catastrophizing, depression and anxiety are correlated with each other ¹³⁻¹⁶, none of the aforementioned studies adjust for this in analyses.

Here, we aim to investigate the independent effect of psychological distress, pain catastrophizing, and illness perceptions on the preoperative pain and hand function for patients with CMC-1 OA who are scheduled for surgery under undergoing unsuccessful nonoperative treatment. Previous research indicated that in patients at the start of non-surgical treatment for CMC-1 OA psychosocial factors explain 42% of the variance in pain. We hypothesize that this is still the case after non-successful non-surgical treatment.

METHODS

Patients

We included patients who were scheduled for surgical treatment of CMC-1 OA after unsuccessful nonoperative treatment between September 2017 and

December 2018. Nonoperative treatment generally consisted of at least three months of hand therapy and was focused on reducing pain and increasing Activities of Daily Living (ADL) function. Hand therapy consisted of exercises combined with wearing of an orthosis and was strictly protocolled and monitored by one of our trained therapists in one of our 23 sites for hand therapy. This nonoperative treatment has been described in more detail in earlier publications¹⁷. Patients that completed questionnaires as part of routine outcome measurements were included in the study. The process of data collection is extensively described by Selles et al.¹⁸. Patients were excluded when they had not completed the Michigan Hand Outcome Questionnaire (MHQ) or questionnaires about psychological factors. All patients provided written informed consent for the use of their data.

Measurements

Patients completed the Dutch version of the Michigan Hand Questionnaire (MHQ)^{19, 20}, to assess the preoperative pain and hand function. For this study, only the pain and general hand function subscale were used. Scores on these scales ranged from 0 (severe pain or dysfunction) – 100 (no pain or dysfunction). We only used the MHQ function scores of the affected hand. Patients also completed questionnaires about their demographics and psychological well-being before surgery.

To assess psychological distress, pain catastrophizing, and illness perceptions, patients completed the Patient Health Questionnaire (PHQ-4)²¹, Pain Catastrophizing Scale (PCS)²², and Brief Illness perceptions questionnaire²³. Validated Dutch versions were used^{24, 25}. The PHQ is a 4-item questionnaire designed to assess psychological distress in two domains: depression and anxiety. The questionnaire consists of two questions for each domain and results in a total score between 0 – 12 (no psychological distress – severe psychological distress). The PCS used 13 questions, resulting in a score between 0 – 52 (no pain catastrophizing – severe pain catastrophizing). The B-IPQ asks one question for eight separate domains, using a single 0-10 question for each domain. We analyzed these eight separate domains.

Radiographs of the CMC and scaphotrapeziotrapzoid (STT) joints were made with a mini C arch. The treating surgeon reported the Eaton-Glickel stage²⁶ and

separately the presence of STT OA. For the analysis, only the presence of STT OA was deemed reliable enough to use ²⁷.

Statistical analysis

For normally-distributed data, we computed means and standard deviations (SD), for non-normal distributed data, we calculated a median with interquartile range (IQR). We used a stepwise multivariable linear regression (sometimes referred to as hierarchical regression) to evaluate how psychological factors, in addition to patient and disease characteristics, contribute to baseline pain and hand function. This was done by entering the covariates in a stepwise fashion. In the first step, we only included patient demographics in the model. In the second step, we added the presence of STT OA. In the third step, we added pain catastrophizing and psychological distress into the model. In the final step, we also incorporated illness perceptions in the model. We calculated the explained variance (R^2) for each group of variables to assess the additive explained variance attributed to a step. This procedure was performed twice, one for the MHQ pain subscale and one for the MHQ general function subscale.

RESULTS

A total of 204 patients was included in the study. 20% of all patients scheduled for surgery did not complete questionnaires and were thus excluded. There was no significant difference in patient characteristics between the included and excluded patients (table 1 shows all variables that were tested). The mean age of all included patients was 61 years and 19% were male. Other baseline characteristics are displayed in Table 1. Mean pain (SD) and hand function on baseline were 36 (13) and 54 (19).

For pain, the first step of the stepwise multivariable model (supplementary table 1) showed that all patient demographics together only explained 10% of the variance in baseline pain. Adding the presence of STT osteoarthritis in the second step did not increase the explained variance (Figure 1). As a next step, adding psychological distress and pain catastrophizing explained an additional 21%. In the final step, illness perceptions explained another 10% of the variance in pain.

In the final model that included all variables (Table 2), female sex ($B = -4.4$, $p = 0.03$), performing light physical labor ($B = 5.22$, $p = 0.02$), higher PCS score ($B = -0.4$, $p < 0.001$), higher IPQ consequences ($B = -1.54$, $p < 0.001$), and higher IPQ identity ($B = -0.8$, $p = 0.03$) were associated with more reported pain. Effect plots (Figure 4A-C) further show the magnitude of the effect of these psychosocial variables on baseline pain.

Table 1. Baseline patient and psychosocial characteristics of the study population ($n = 204$)

	Value	Range
Age, year (SD)	61 (7)	
Gender, Male, %	19	
Duration of complaints, months, median (IQR)	24 (12-48)	
BMI, mean (SD)	26 (4)	
Current non-smoker, %	80	
Workload, %		
No paid labor	44	
light physical labor	20	
medium physical labor	22	
heavy physical labor	14	
STT osteoarthritis, No, %	57	
PHQ Psychological Distress, median (IQR)	0 (0-2)	0 - 12
Pain Catastrophizing Score, median (IQR)	12 (6-19)	0 - 52
IPQ consequences, mean (SD)	7 (2)	0 - 10
IPQ timeline, mean (SD)	6 (2)	0 - 10
IPQ personal control, mean (SD)	4 (2)	0 - 10
IPQ treatment control, mean (SD)	8 (1)	0 - 10
IPQ identity, mean (SD)	7 (2)	0 - 10
IPQ concern, mean (SD)	6 (3)	0 - 10
IPQ illness comprehensibility, median (IQR)	9 (8-10)	0 - 10
IPQ emotional consequences, median (IQR)	5 (3-7)	0 - 10

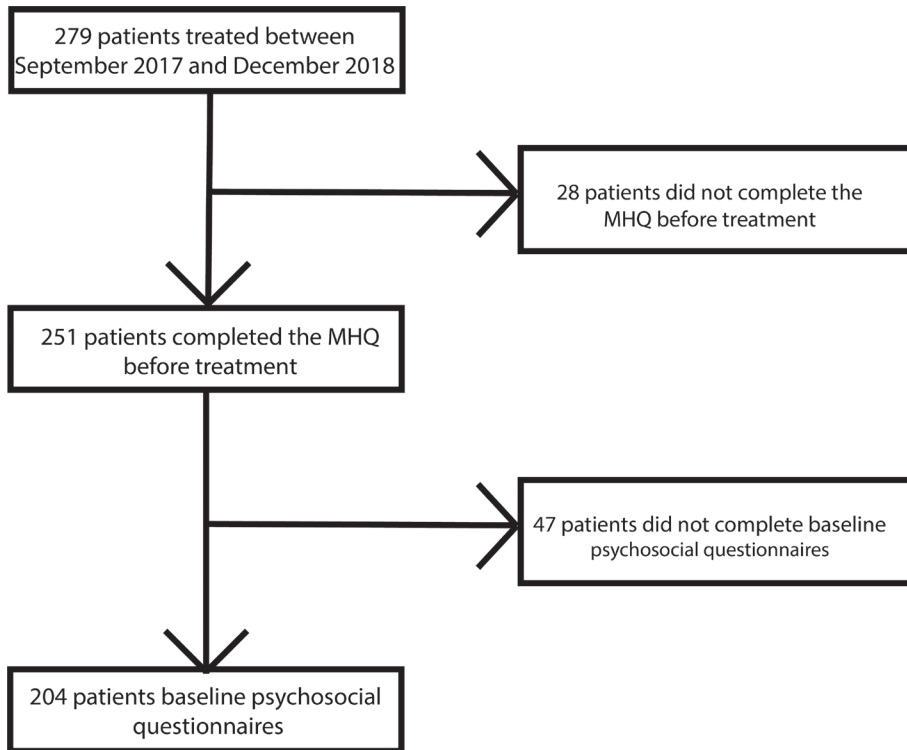


Figure 1. flow diagram of included patients

Table 2. Multivariable linear regression model for pain and hand function at three months corrected for all covariates. We report both the normal (B) and standardized (β) estimates. Standardized estimates facilitate comparison across different scales.

	MHQ Pain			MHQ Hand function		
	β	B	95% CI	β	B	95% CI
Age	0,12	0,20	[0-0,4]	-0,15	-0,39	[-0,8-0]
Gender, Male	0,34	4,41	[0,5-8,3]*	0,21	3,99	[-3,1-11,1]
Months of complaints	-0,01	0,00	[0-0]	-0,12	-0,06	[-0,1-0]
BMI	-0,02	-0,07	[-0,5-0,3]	-0,06	-0,31	[-1,0-0,4]
Current non-smoker	-0,18	-2,28	[-6,2-1,7]	0,30	5,75	[-1,2-12,7]
Workload						
ref (no paid labor)						
light physical labor	0,40	5,22	[0,8-9,6]*	-0,05	-0,99	[-8,9-7]
medium physical labor	0,14	1,78	[-2,5-6]	0,04	0,69	[-6,8-8,2]
heavy physical labor	0,26	3,34	[-1,6-8,3]	-0,12	-2,41	[-11,2-6,4]
STT osteoarthritis	0,02	0,27	[-2,7-3,3]	0,33	6,34	[1-11,7]*
Psychological Distress Score	-0,13	-0,79	[-1,6-0]	0,07	0,63	[-0,8-2,1]
Catastrophizing Score	-0,28	-0,35	[-0,5--0,2]*	-0,06	-0,12	[-0,4-0,2]
IPQ consequences	-0,22	-1,54	[-2,6--0,5]*	-0,08	-0,83	[-2,6-1]
IPQ timeline	0,07	0,39	[-0,3-1,1]	0,11	0,84	[-0,4-2,1]
IPQ personal control	0,05	0,23	[-0,4-0,9]	0,08	0,61	[-0,5-1,7]
IPQ treatment control	0,01	0,14	[-1,3-1,6]	0,16	2,47	[0-5]
IPQ identity	-0,16	-0,83	[-1,6--0,1]*	-0,19	-1,55	[-2,9--0,2]*
IPQ concern	0,10	0,49	[-0,3-1,3]	0,06	0,47	[-0,9-1,9]
IPQ illness comprehensibility	0,08	0,59	[-0,2-1,4]	0,02	0,21	[-1,2-1,7]
IPQ emotional consequences	-0,10	-0,45	[-1,2-0,3]	-0,15	-1,01	[-2,3-0,3]

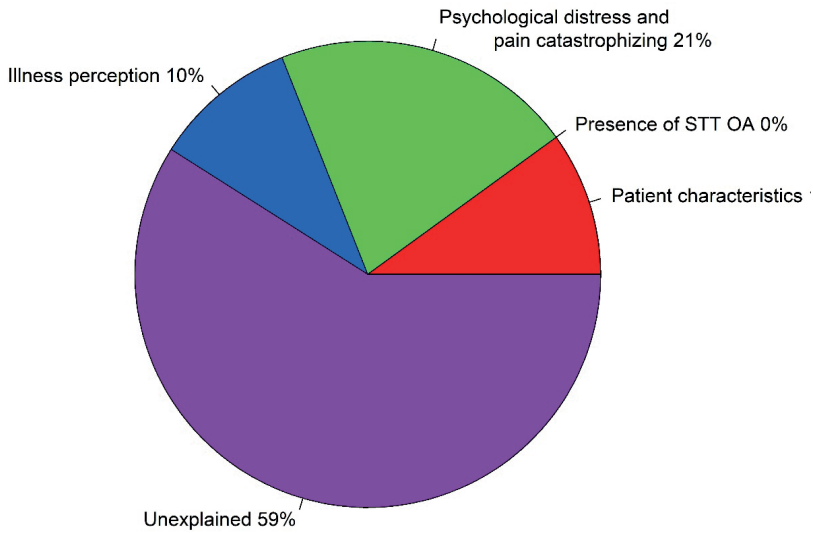


Figure 2. The relative contribution of variable groups to pain at baseline

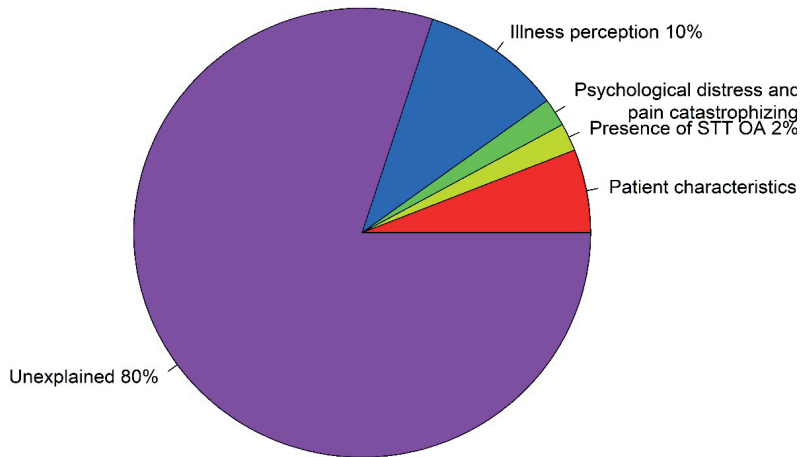


Figure 3. The relative contribution of variable groups to hand function at baseline

For hand function, the stepwise multivariable model (supplementary table 2) showed that patient demographics explained 6% of the hand function at baseline, STT osteoarthritis explained 2%, psychological distress and pain catastrophizing another 2%, and illness perceptions 10% (see Figure 3). In the final model, only the presence of STT osteoarthritis ($B = 6.34$, $p = 0.02$) and higher IPQ consequences ($B = -1.55$, $p = 0.02$) were associated with less hand function. Figure 5 further shows the magnitude of the effect of illness perceptions on hand function.

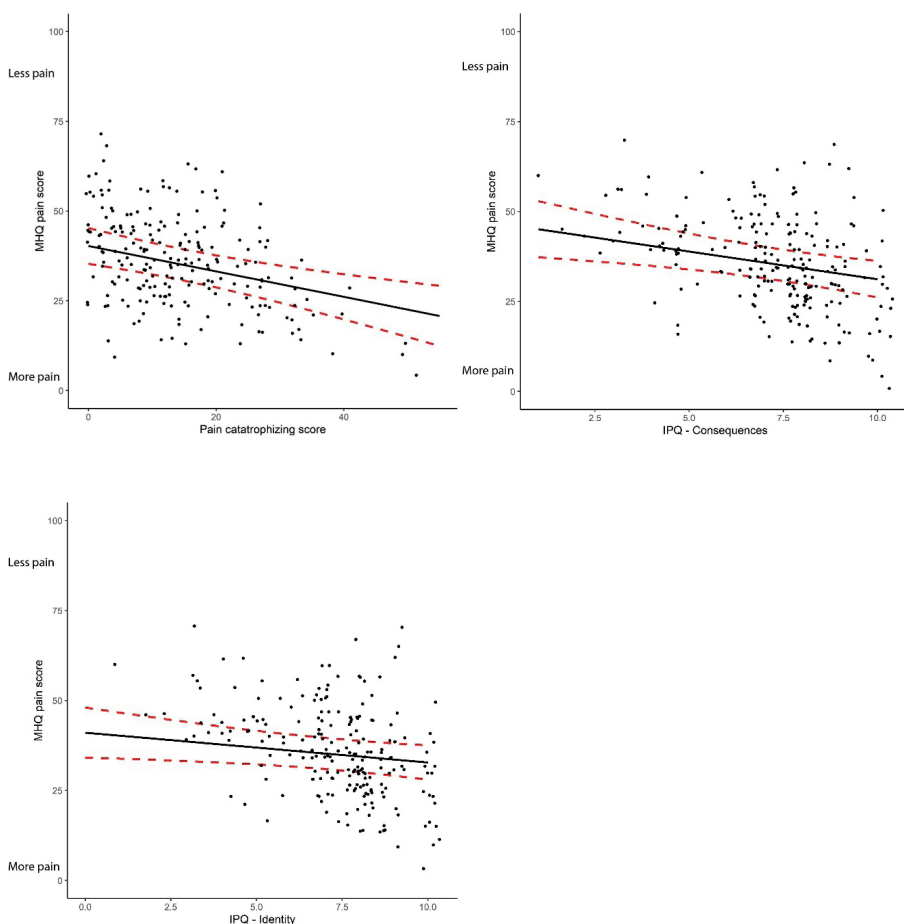


Figure 4A-C. Association between pain catastrophizing (A), experienced consequences (B), and perceived symptoms (C) and the pain scale of the MHQ at baseline. A higher score on the psychosocial variables (x-axis) is associated with a worse score on the MHQ pain scale (y-axis). The points represent individual patients. The black line is the linear relationship, the red, dotted lines make the upper and lower bound of the 95% CI.

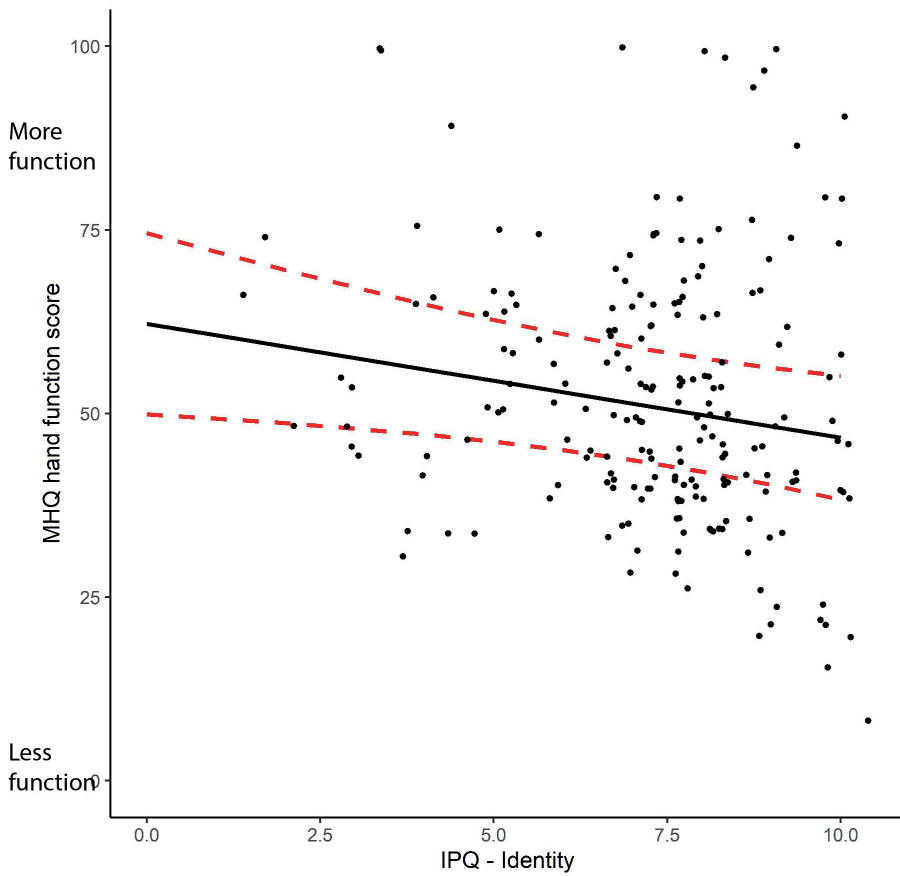


Figure 5. Association between perceived symptoms and the hand function scale of the MHQ at baseline. A higher score on the psychosocial variables (x-axis) is associated with a worse score on the MHQ hand function scale (y-axis). The points represent individual patients. The black line is the linear relationship, the red, dotted lines make the upper and lower bound of the 95% CI.

DISCUSSION

This study aimed to investigate the independent association of psychological distress, pain catastrophizing, and illness perceptions with the preoperative pain and hand function for patients with CMC-1 OA who are scheduled for surgery after unsuccessful non-operative treatment. We found that patients who catastrophize their pain, who perceive more consequences from their illness, and patients who contribute more symptoms to their illness have more pain. Furthermore, we found that patients with STT osteoarthritis and patients who contribute more symptoms to their illness reported worse hand function. Psychological distress was not independently associated with pain or hand function. Psychological distress and catastrophizing were more strongly related with pain than with hand function, while illness perception had the same magnitude of association with both. Together psychological factors explained 31% variance in pain, and 12% in hand function.

Our findings confirm prior report. Hoogendam et al.²⁷ assessed the association between baseline pain and psychosocial factors at the start of nonoperative treatment for CMC-1 OA and found that pain catastrophizing, how much symptoms patients experience from illness (IPQ identity), and how much consequences a patient perceives from the disease (IPQ consequences) are associated with pain. Prior research also shows that patients have more severe pain, worse hand function and worse psychological mindset at the start of operative treatment than at the start of nonoperative treatment²⁸.

The finding that psychological factors play a role in baseline pain and hand function adds to previous studies in other hand surgery conditions, reporting that psychosocial factors are associated with surgery outcomes. For example, Taloei-Khoei et al²⁹ found a level of pain catastrophizing in patients with an upper-extremity musculoskeletal illness similar to patients in our population. Furthermore, they found that the pain catastrophizing scale (PCS) mediated 22% of the association between pain intensity and pain inference. Other studies report a similar explained variance of the PCS for outcomes of hand surgery (between 17% and 23%;^{8, 30, 31}). While all these studies only report on post-operative associations, the resemblance in these associations between pain catastrophizing and outcomes is striking. Our study shows that these associations are already present before surgery.

This study has several strengths and limitations. A major strength of this study is the use of observational clinical data, collected as part of routine outcome measurements. This allows for an evaluation of patients, without subjecting them to a trial setting. It shows that associations between psychosocial factors and pain and hand function are present in the day to day hand surgery practice. Furthermore, in contrast to many previous studies^{6, 9, 32}, we measured more than one psychosocial factor. This allowed us to make a multivariable model and report associations adjusted for other psychosocial factors. In this adjusted model, we did not find the association between depression and anxiety and pain or hand function, as reported by others. This suggests that the effect of depression and anxiety found by others is captured in the associations between pain catastrophizing and illness perceptions and pain and hand function.

This study also has several limitations; A general limitation of using routine outcome measurements is missing data. While a substantial part of patients does complete all questionnaires, some do not. Because we could not find any difference between responders and nonresponders, we assume all data were missing completely at random (MCAR). Thus, the outcome of this study is most likely not affected by missing data. Furthermore, since in our routine outcome measurement setting it is not feasible to perform an elaborate psychosocial assessment, thus we used short (screening) questionnaires. This might lead to a less accurate estimate of the patient's mindset. However, all shortened questionnaires were extensively studied and showed good reliability and validity in relation to the full questionnaires^{21, 23}. Finally, while our results may suggest an underlying causal relation, the results of our study are associative. To further study causality between psychosocial factors and outcomes, a randomized trial could be designed to investigate if altering psychosocial factors leads to different outcomes.

This study has important clinical implications. Psychosocial distress, pain catastrophizing and illness perception are all modifiable through brief psychosocial interventions. Assessing psychological factors at the first visit and encouraging, surgeons to discuss with their patients how the way they perceive their illness has a role in the magnitude of their symptoms and hand function may be enough to increase outcomes^{33, 34} in many CMC-1 patients. For those who also endorse depression and catastrophic thinking, psychosocial interventions

should be prescribed. Brief interventions, particularly those conducted through live video are well received by orthopedic patients and associated with decrease in pain and psychological distress, and increase in coping and physical function³⁵.

Another clinical implication regards the decision to convert to surgery in CMC-1 OA patients. This is usually made based on pain, hand function, and/or failure of nonoperative treatment. In this study, we showed that pain and hand function are associated with psychosocial factors and previous studies showed that the same associations are present for the outcome of nonoperative treatment. This study indicates that the parameters that drive the decision to elect surgery are strongly associated with psychosocial factors, maybe more than with more clinical joint properties such as cartilage damage as recorded with imaging²⁷. Therefore, psychosocial factors should be considered as part of our decision-making process. Future research could look at the effectiveness of psychosocial interventions to see if surgery can be postponed or should be avoided.

This study provides hand surgeon and hand therapists with insight into how psychosocial factors are associated with pain. While this knowledge might be helpful in consultations, more research needs to be conducted to fully incorporate psychosocial factors into our consultations. An important question is whether to focus interventions on patients that have an extremely negative psychosocial profile or to intervene in the entire group. For example, a 60-second mindfulness exercise was found to be effective in reducing momentary pain, depression, and anxiety in patients with upper extremity diseases³⁶. An advantage of such interventions could be that small changes on an individual level could have a big impact on the average outcome of the entire group.

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Supplementary Table 1. Stepwise multivariable linear regression model for pain before surgery. The final column corresponds with the linear model reported in table 2.

	Patient characteristics		Radiological findings		Known psychosocial factors		Unknown psychosocial factors		p-value
	B	95%CI	B	95%CI	B	95%CI	B	95%CI	
Age	0,34	[0,1-0,6]	0,34	[0,1-0,6]	0,27	[0-0,5]	0,20	[0-0,4]	0,09
Gender, Male	4,17	[-0,4-8,8]	3,83	[-0,7-8,4]	5,17	[1,1-9,2]	4,41	[0,5-8,3]	0,03
Months of complaints	0,01	[0-0,1]	0,01	[0-0,1]	0,00	[0-0]	0,00	[0-0]	0,86
BMI	-0,31	[-0,8-0,2]	-0,31	[-0,8-0,1]	-0,18	[-0,6-0,2]	-0,07	[-0,5-0,3]	0,75
Current non-smoker	0,36	[-4,3-5]	0,08	[-4,6-4,7]	-1,24	[-5,3-2,9]	-2,28	[-6,2-1,7]	0,26
Workload									
ref (no paid labor)									
light physical labor	9,72	[4,6-14,8]	9,30	[4,1-14,5]	5,98	[1,4-10,6]	5,22	[0,8-9,6]	0,02
medium physical labor	4,28	[-0,7-9,3]	3,78	[-1,2-8,8]	2,37	[-2-6,8]	1,78	[-2,5-6]	0,41
heavy physical labor	5,49	[-0,3-11,3]	5,06	[-0,8-10,9]	2,94	[-2,2-8,1]	3,34	[-1,6-8,3]	0,19
STT osteoarthritis			-0,27	[-3,8-3,3]	-0,07	[-3,2-3,1]	0,27	[-2,7-3,3]	0,86
Psychological Distress Score					-1,16	[-2--0,4]	-0,79	[-1,6-0]	0,06
Catastrophizing Score					-0,46	[-0,6--0,3]	-0,35	[-0,5--0,2]	0,00
IPQ consequences							-1,54	[-2,6--0,5]	0,00
IPQ timeline							0,39	[-0,3-1,1]	0,27
IPQ personal control							0,23	[-0,4-0,9]	0,46
IPQ treatment control							0,14	[-1,3-1,6]	0,84
IPQ identity							-0,83	[-1,6--0,1]	0,03
IPQ concern							0,49	[-0,3-1,3]	0,22
IPQ illness comprehensibility							0,59	[-0,2-1,4]	0,16
IPQ emotional consequences							-0,45	[-1,2-0,3]	0,23
R ²		0,10		0,10		0,31		0,41	

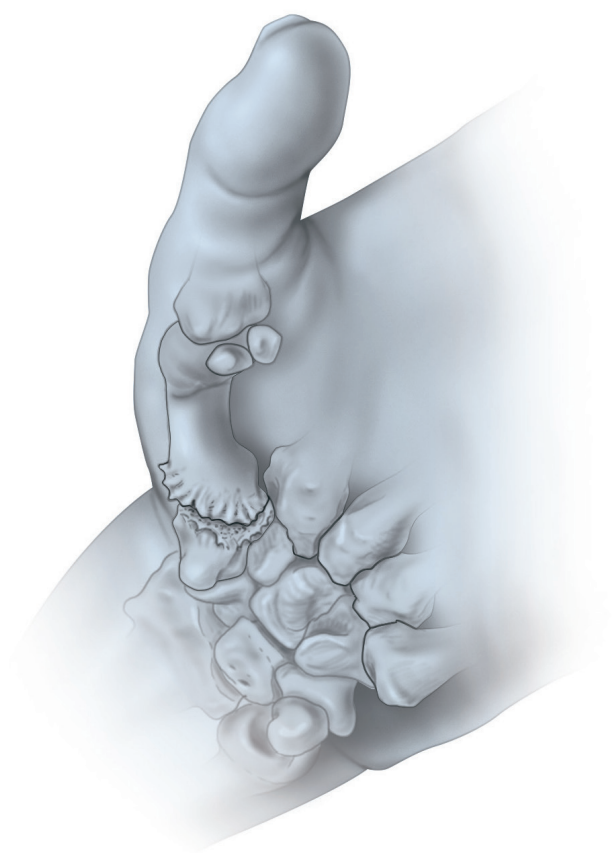
STT - scaphotrapeziotrapzoid

IPQ – Illness perception questionnaire

Supplementary Table 2. Stepwise multivariable linear regression model for hand function before surgery. The final column corresponds with the linear model reported in table 2.

	B	95%CI	B	95%CI	B	95%CI	B	95%CI	p-value
Age	-0,33	[-0,8-0,1]	-0,28	[-0,7-0,2]	-0,31	[-0,7-0,1]	-0,39	[-0,8-0]	0,07
Gender, Male	4,56	[-2,7-11,8]	4,31	[-2,9-11,5]	5,28	[-1,9-12,5]	3,99	[-3,1-11,1]	0,27
Months of complaints	-0,03	[-0,1-0]	-0,04	[-0,1-0]	-0,04	[-0,1-0]	-0,06	[-0,1-0]	0,09
BMI	-0,55	[-1,3-0,2]	-0,57	[-1,3-0,1]	-0,49	[-1,2-0,2]	-0,31	[-1-0,4]	0,39
Current non-smoker	7,89	[0,8-15]	8,39	[1,3-15,5]	7,86	[0,8-15]	5,75	[-1,2-12,7]	0,11
Workload									
ref (no paid labor)									
light physical labor	2,72	[-5,3-10,7]	1,58	[-6,4-9,6]	0,18	[-7,9-8,3]	-0,99	[-8,9-7]	0,81
medium physical labor	3,40	[-4,3-11,1]	2,26	[-5,4-10]	1,71	[-6-9,4]	0,69	[-6,8-8,2]	0,86
heavy physical labor	-0,37	[-9,3-8,6]	-1,89	[-10,8-7,1]	-3,09	[-12-5,8]	-2,41	[-11,2-6,4]	0,59
STT osteoarthritis			6,36	[0,9-11,8]	6,26	[0,8-11,7]	6,34	[1-11,7]	0,02
Psychological Distress Score					-0,19	[-1,6-1,2]	0,63	[-0,8-2,1]	0,40
Catastrophizing Score					-0,30	[-0,6-0]	-0,12	[-0,4-0,2]	0,46
IPQ consequences							-0,83	[-2,6-1]	0,36
IPQ timeline							0,84	[-0,4-2,1]	0,18
IPQ personal control							0,61	[-0,5-1,7]	0,27
IPQ treatment control							2,47	[0-5]	0,05
IPQ identity							-1,55	[-2,9--0,2]	0,02
IPQ concern							0,47	[-0,9-1,9]	0,51
IPQ illness comprehensibility							0,21	[-1,2-1,7]	0,78
IPQ emotional consequences							-1,01	[-2,3-0,3]	0,13
R2		0,06		0,08		0,10		0,20	

STT - scaphotrapezotrapzoid
IPQ – Illness perception questionnaire



CHAPTER 14

PSYCHOLOGICAL CHARACTERISTICS, FEMALE SEX, AND OPIOID USAGE PREDICT ACUTE POSTOPERATIVE PAIN IN PATIENTS SURGICALLY TREATED FOR THUMB BASE OSTEOARTHRITIS — A COHORT STUDY

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ABSTRACT

Background: It is unclear which factors predict acute postoperative pain in patients surgically treated for thumb base (CMC-1) osteoarthritis (OA). We investigated the influence of type of surgery, preoperative sociodemographics, preoperative patient-reported outcome measures (PROMS), psychological characteristics, and postoperative opioid usage on acute postoperative pain 24h postoperatively following surgery for CMC-1 OA. Secondly, preoperative and acute postoperative pain were compared.

Methods: In this prospective cohort study, 215 patients surgically treated for CMC-1 OA were included. Data were collected in sixteen clinics for hand surgery and therapy in the Netherlands. Hierarchical regression was used to identify if type of surgery, preoperative sociodemographics, preoperative PROMS, psychological characteristics (including treatment credibility and expectations, illness perception, pain catastrophizing, anxiety, and depression), and postoperative opioid usage predicted acute postoperative pain 24h postoperatively, measured using a Numeric Pain Rating Scale (NPRS, range 0-10).

Results: Female sex, opioid usage, higher preoperative satisfaction with hand, and higher self-reported consequences and coherence predicted greater postoperative pain, with 31% explained variance in the final model including psychological factors. Mean postoperative NPRS score was lower (5.1 ± 2.4) than preoperative pain, measured using Visual Analogue Scales (during past week: 6.7 ± 1.7 and physical load: 7.5 ± 1.7) and Michigan Hand Questionnaire (6.4 ± 1.4 , $p < 0.001$).

Conclusions: Psychological factors, female sex, and opioid usage enhance the prediction of acute postoperative pain beyond surgery type, preoperative sociodemographics, and PROMS. Female sex and opioid usage were the strongest predictors, even after controlling for psychological factors. Future studies may investigate sex-based approaches and patient education for reducing acute postoperative pain.

INTRODUCTION

Thumb carpometacarpal (CMC-1) osteoarthritis (OA) has a symptomatic prevalence of 7% for females and 2% for males aged >50 ¹⁻³ and often causes pain, limitations in activities of daily life (ADL), thenar muscle wasting, or thumb deformity^{1,4}. Treatment for CMC-1 OA usually starts non-surgically, for which increasing evidence shows beneficial effects on pain, hand function, and satisfaction⁵⁻¹³. Conversion to surgical treatment may be considered if non-surgical treatment provides insufficient relief of symptoms, e.g. by performing a trapeziectomy, with or without Ligament Reconstruction and/or Tendon Interposition (LRTI)^{14,15}. We recently reported a conversion rate of 15% after 2.2 years in a large cohort of patients (n=809) treated non-surgically¹². In another study, we found that patients at the start of surgical treatment for CMC-1 OA had worse pre-treatment patient-reported outcome measures (PROMS) and psychological characteristics compared to patients at the start of non-surgical treatment¹⁶. While our model including psychological characteristics (e.g., treatment expectations or factors of illness perception, such as personal control) explained the largest part of the probability to be scheduled for surgery in that study¹⁶, the influence of psychological characteristics on outcomes, or acute postoperative pain in particular following CMC-1 surgery, is unknown.

Previous research indicates that pain catastrophizing¹⁷⁻²², female sex^{17, 18, 20}, preoperative pain^{17-19, 21, 22}, expected pain²², higher age^{17-19, 21, 22}, previous chronic pain^{17, 19}, higher anxiety^{17-19, 21, 22}, surgical fear²² and less optimism^{17, 18} results in higher acute postoperative pain after hip, knee or other elective surgery¹⁷⁻²², but it is unknown which factors predict acute postoperative pain in patients surgically treated for CMC-1 OA. Furthermore, while long-term outcomes are not different for different types of surgery for CMC-1 OA (e.g., different types of LRTI)^{14, 23}, it is unknown if there are differences in acute postoperative pain following different types of surgery for CMC-1 OA. Better understanding of factors contributing to acute postoperative pain following surgery for CMC-1 OA can provide valuable insights, to prevent long-term chronic pain^{24, 25}, improve clinical decision making and facilitate customized healthcare for individuals. Therefore, this study aimed to determine the influence of type of surgery, preoperative sociodemographics, preoperative PROMS, psychological characteristics, and postoperative opioid usage on acute postoperative pain

24h postoperatively following CMC-1 resection arthroplasty. Secondly, we compared preoperative and acute postoperative pain levels.

METHODS

Study design

This is a cohort study using data collected in usual care, reported following the STROBE statement and SAGER guidelines^{26, 27}.

Setting

Data collection was part of routine outcome measurement using GemsTracker²⁸, which is a secure web-based application for distributing questionnaires and forms in clinical research and quality registrations. Data were collected in sixteen outpatient clinics for hand surgery and hand therapy in the Netherlands between September 2017 and October 2018. Written informed consent was obtained from all participants and the local Medical Research Ethical Committee approved this study. Following the Dutch treatment guideline²⁹, all participants were offered three months of non-surgical treatment first. The decision to proceed to surgical treatment was a shared-decision by the hand surgeon and patient, which could be made at any time point and was based on persistent pain and limitations in ADL.

Participants

Participants were included if they were aged ≥ 18 y, received unilateral surgical treatment for CMC-1 OA, had complete preoperative data and completed a Numeric Pain Rating Scale (NPRS) 24h postoperatively.

Participants were excluded if there was either comorbidity interfering with treatment/outcome (e.g. carpal tunnel syndrome), prior CMC-1 surgery in the same hand, steroid injection <6 weeks in the same hand/wrist or combined surgery (e.g. concurrent carpal tunnel release). After applying the eligibility criteria, 215 participants were included (Figure 1).

Treatment

Surgical procedures included: 1) Weilby procedure with Abductor Pollicis Longus (APL) slip or; 2) Flexor Carpi Radialis (FCR) strip³⁰; 3) Burton-Pellegrini LRTI with FCR³¹ or 4) other (includes a range of procedures that were present in small numbers). All procedures were performed under brachial plexus block. Directly postoperatively, volar plaster cast immobilization was applied similarly for every patient, including metacarpophalangeal flexion, CMC-1 palmar and radial abduction and $\pm 20^\circ$ wrist extension, allowing elbow, finger and interphalangeal joint motion. A sling was provided for hand elevation and tendon gliding exercises for the fingers and thumb interphalangeal joint were initiated.³² Postoperative medication was prescribed similarly for every patient, including paracetamol (2x500mg, 4/day) and diclofenac (50mg, 3/day) during the first 5-10 days postoperatively. Additionally, opioids were prescribed (e.g. oxycontin 5-10mg, 2/day) for the first 5 days and patients were advised to use those only when needed. Every patient received a strict medication scheme before surgery, including predetermined time points for medication intake and weaning from medication starting 5 days postoperatively.

Variables, data sources/measurement

Acute postoperative pain was administered over the phone by a nurse 24h postoperatively using an NPRS (0-10, higher scores indicate more pain), which is valid and reliable for measuring pain intensity and has a minimal clinical important difference of 2 or 30% change³³. In addition, during this phone call, the patient was asked if opioids were used. Opioid usage was registered as a dichotomous variable (yes/no).

Similar to other studies¹⁶⁻¹⁹, variables other than type of surgery and opioid usage were classified into three categories: sociodemographics, PROMS, and psychological characteristics. All data, except type of surgery, and opioid usage, represent preoperative values and were administered prior to surgery. Sociodemographic characteristics included age, sex, symptom duration, dominant side treated, workload and second opinion (yes/no). Preoperative PROMS included pain, hand function, satisfaction with hand and Health-Related Quality of Life (HRQoL). We used Visual Analogue Scales (VAS, range 0-100), which are reliable and valid³³, to measure pain (higher

scores indicate more pain) and satisfaction with the hand (exact question: “How satisfied are you with your hand at this moment?” higher scores indicate higher satisfaction with the affected hand). To assess hand function, the Michigan Hand outcomes Questionnaire (MHQ) was used (range 0-100, higher scores indicate better performance except for the subscale pain), which has high internal consistency & validity, acceptable reliability and is particularly applicable for hand OA patients³⁴. HRQoL was measured using the EQ-5D-5L, which is reliable and valid for measuring health status³⁵. Psychological characteristics included treatment credibility, treatment expectations, illness perception, pain catastrophizing, anxiety, and depression. Treatment credibility and expectations were measured using the Credibility/Expectancy Questionnaire (CEQ), which is valid and reliable and consists of credibility and expectancy subscales (score range 3-27, higher scores indicate higher credibility/expectations)³⁶. Illness perception was measured using the brief Illness Perception Questionnaire (IPQ), which has good reliability and concurrent validity to briefly assess illness perception (items scores ranging 0-10, higher scores indicate negative illness perception except for items personal control, treatment control and coherence)³⁷. Pain catastrophizing was measured using the 13-item Pain Catastrophizing Scale (PCS), which is valid and reliable (score range 0-52, higher scores indicate more catastrophizing)³⁸. Anxiety and depression were measured by the 4-item Patient Health Questionnaire (PHQ), which is a valid and reliable tool for detecting anxiety or depressive disorders (score range 0-12, subscale scores ≥ 3 indicate a potential anxiety/depression disorder)³⁹.

Study size

Power analysis for multiple regression analysis, conventional medium effect size⁴⁰ of 0.15 and power of 0.80 ($\alpha=0.05$) showed that a total sample of 181 participants was needed. To account for potential missing data, we enlarged our sample to >200 .

Statistical methods

Missing value analysis was performed to investigate if patients with or without a response 24h postoperatively systematically differed, demonstrating a non-significant Little's test ($p=1.000$), suggesting that missing values were missing

completely at random⁴¹⁻⁴³. To further evaluate non-response, significance testing on preoperative characteristics was performed, comparing participants with and without presence of NPRS score 24h postoperatively, demonstrating that in 40 variables, only one differed (Supplemental Digital Content 1). Normality was checked by QQ-/normal probability plots and residual analysis. Differences in preoperative and postoperative values between males and females were analysed using independent samples t-tests and Chi-square tests. To investigate the relative contribution of type of surgery, preoperative sociodemographics, preoperative PROMS, opioid usage and psychological characteristics to the amount of acute postoperative pain, hierarchical multiple regression analysis was used. NPRS acute postoperative pain was used as dependent variable. By using this hierarchical model and adding variables in separate, sequential steps, we were able to distinguish between the specific influence of each (group of) variable(s), while correcting for the variables that were already included in the previous step(s). In addition to the hierarchical regression, univariable regression analyses were run and compared with the multivariable models. To illustrate the explained variance of the different models, R square, adjusted R square and significance of F change are reported for each model. Not all variables that were analysed in the univariable analysis were included within the hierarchical model because some variables had conceptual overlap (e.g. EQ-5D-5L anxiety/depression index and PHQ). In the first step of the hierarchical model, only sociodemographic characteristics were added, which included age, sex, symptom duration, dominant side treated, workload and second opinion. In the second step, type of surgery was added. Subsequently, preoperative PROMS were added, including preoperative VAS mean pain during past week, at rest, during physical load and VAS satisfaction with hand, the MHQ hand function, ADL, work and aesthetics subscales and EQ-5D-5L index score. In the fourth step, opioid usage (yes/no) was added and psychological characteristics were added in the fifth step, including: CEQ credibility and expectancy, IPQ consequences, timeline, personal control, identity, concern, coherence, and emotional representation, PCS and the PHQ anxiety and depression subscales. Multicollinearity was checked using correlation coefficients and variance inflation factor (VIF). A VIF >10 was considered an indication for multicollinearity⁴⁴.

Results

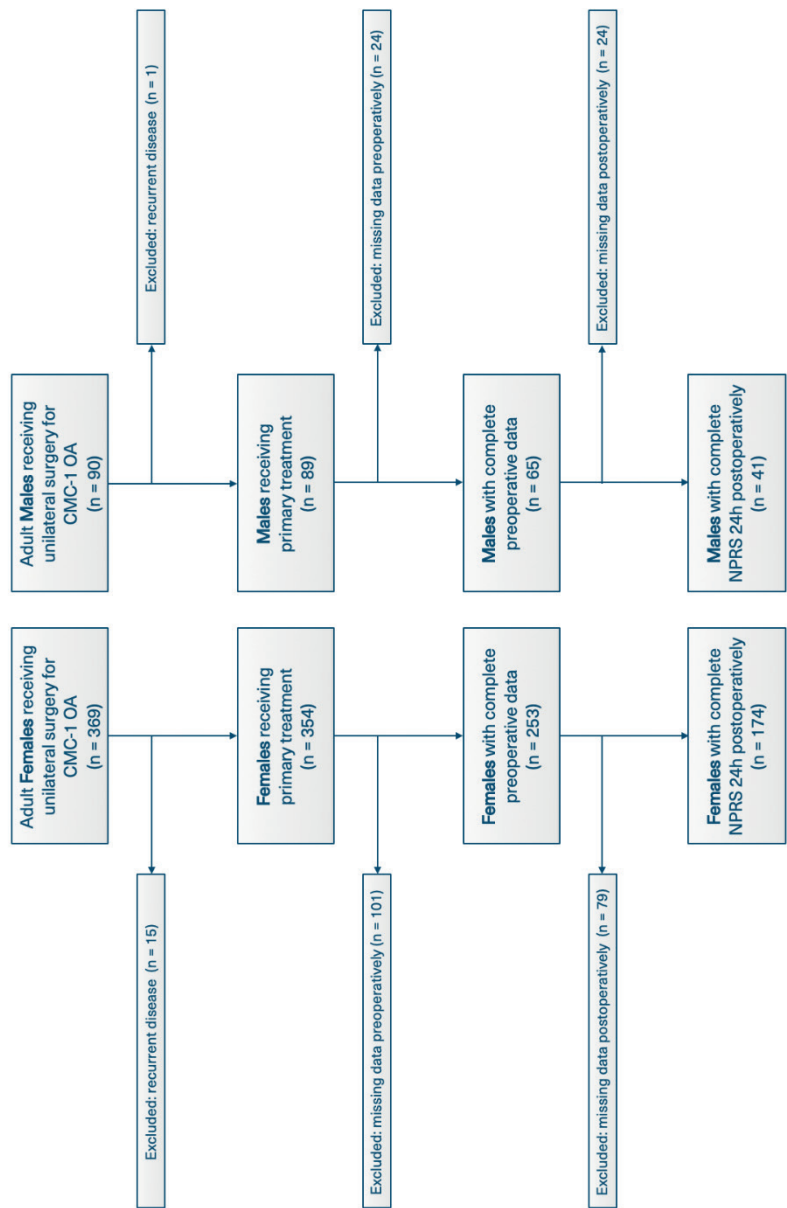


Figure 1. Flowchart of how the study sample was obtained, separately for females and males. CMC-1 = Thumb carpometacarpal joint, OA = Osteoarthritis, NPRS = Numeric Pain Rating Scale.

Table 1 shows the characteristics of the included participants. When comparing males and females, there were significant differences in age, symptom duration, type of surgery and postoperative opioid usage. Figure 2 demonstrates that converted preoperative MHQ pain (6.4 ± 1.4), VAS mean past week (6.7 ± 1.7) and physical load (7.5 ± 1.7) scores were higher than acute postoperative NPRS scores (5.1 ± 2.3 , $p < 0.001$). Figure 2 also demonstrates that no differences between males and females were present in preoperative pain scores, but 24h postoperatively, mean NPRS score was 3.9 ± 2.6 for males and 5.4 ± 2.2 for females ($p < 0.001$). Supplemental Digital Content 2 presents all preoperative values, demonstrating that females reported worse MHQ ADL, MHQ total and EQ5D self-care, higher CEQ credibility and better PCS score compared to males.

Table 1. Sociodemographic characteristics, type of surgery, and postoperative opioid usage displayed for all, male and female participants. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ when testing differences between males and females

Variable	All (N=215)	Males (N=41, 19%)	Females (N=174, 81%)
Age, mean \pm SD	60.3 ± 7.9	$62.6^* \pm 7.4$	$59.9^* \pm 7.6$
Symptom duration in months, mean \pm SD	35.9 ± 34.8	$24.1^{***} \pm 19.4$	$40.2^{***} \pm 39.4$
Dominant side treated, %			
No	51.6%	41.5%	54%
Yes	43.7%	53.7%	41.4%
Ambidexter	4.7%	4.9%	4.6%
Workload, %			
Unemployed	42.8%	46.3%	42%
Light physical labor	17.7%	9.8%	19.5%
Moderate physical labor	21.9%	14.6%	23.6%
Heavy physical labor	17.7%	29.3%	14.9%
Second opinion, %	7.4%	7.3%	7.5%
Type of surgery, %:			
LRTI: Weilby – APL	10.7%	22%*	8%*
LRTI: Weilby – FCR	58.1%	39%*	62.6%*
LRTI: Burton \square /Pellegrini FCR	23.3%	26.8%*	22.4%*
Other	7.9%	12.2%*	6.9%*
Postoperative opioid usage = yes	60%	46.3%*	63.2%*

Abbreviations: SD = Standard Deviation, LRTI = Ligament Reconstruction Tendon Interposition, APL = Abductor Pollicis Longus, FCR = Flexor Carpi Radialis

Univariable and hierarchical multivariable regression

Table 2 demonstrates the significant predictors from the final model of the hierarchical regression analysis and explains the influence of each predictor on acute postoperative pain, indicating that female sex, higher VAS satisfaction with hand, opioid usage and the IPQ items consequences and coherence predicted higher NPRS acute postoperative pain. Supplemental Digital Content 3 demonstrates all models entirely. Figure 3 displays the explained variance for NPRS acute postoperative pain of the final model, separately for sociodemographic characteristics, type of surgery, preoperative PROMS, opioid usage, and psychological characteristics.

The first model with only sociodemographic characteristics showed an R^2 of 0.08. When adding type of surgery, the R^2 increased to 0.10 and further increased to 0.16 when adding preoperative PROMS. When adding opioid usage, the R^2 increased to 0.23, and when adding the psychological characteristics, the R^2 increased to 0.31, indicating that the largest part of acute postoperative pain is explained by the model including psychological characteristics. Female sex and using opioids were the strongest predictors, with unstandardized and standardized betas of respectively 1.39 and 0.24 for female sex, and 1.31 and 0.28 for opioid usage. This indicates that being female is associated with a 1.39-point increase in NPRS acute postoperative pain and that using opioids (compared to not using opioids) is associated with a 1.31-point increase in NPRS acute postoperative pain. In the final model, VAS satisfaction with hand and IPQ coherence were significant predictors, while they were not in the univariable analyses. Within our analyses, there were no indications for multicollinearity.

Table 2. Significant variables and associated interpretation from the final model of our hierarchical regression analysis. The entire hierarchical model, including all variables and all separate steps is displayed in Supplementary Table 3. * $p<0.05$, ** $p<0.01$, *** $p<0.001$, B = unstandardized beta coefficient, CI = Confidence Interval, NPRS = Numeric Pain Rating Scale, VAS = Visual Analogue Scale, IPQ = brief Illness Perception Questionnaire.

Significant variable	Beta [95% CI]	Interpretation
Sex = female (reference = male)	1.39** [0.51:2.26]	Being female <i>increases</i> NPRS for acute postoperative pain by 1.39 points
VAS Satisfaction with hand (exact question: “How satisfied are you with your hand at this moment?”)	0.02* [0.00:0.04]	Every point <i>increase</i> on 100-point VAS satisfaction <i>increases</i> NPRS for acute postoperative pain by 0.02 points.
Opioid usage = yes (reference = no)	1.31*** [0.66:1.95]	Using opioids <i>increases</i> NPRS for acute postoperative pain by 1.31 points.
IPQ Consequences	0.24* [0.01:0.47]	Every point <i>increase</i> in IPQ consequences <i>increases</i> NPRS for acute postoperative pain by 0.24 points.
IPQ Coherence	0.20* [0.02:0.39]	Every point <i>increase</i> in IPQ coherence <i>increases</i> NPRS for acute postoperative pain by 0.20 points.

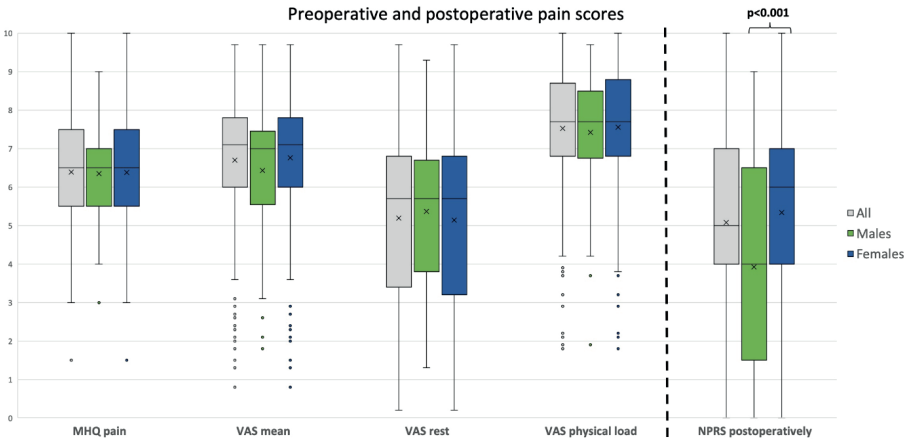


Figure 2. Measurements of pain preoperatively (left four clusters) versus postoperatively (right cluster). Boxplots are displayed for all patients and males and females separately. The horizontal line displays the median, ‘x’ displays the mean and the dots display outlier values. No differences were present between males and females preoperatively, but acute postoperative pain was significantly different for males and females ($p<0.001$). When comparing preoperative and postoperative scores, preoperative Michigan Hand outcomes Questionnaire (MHQ) pain, Visual Analogue Scale (VAS) past week and VAS physical load scores were higher than acute postoperative Numeric Pain Rating Scale (NPRS) scores ($p<0.001$). To facilitate comparisons within this figure, the preoperative pain scores are converted to a 10-point scale.

Explained variance for NPRS acute postoperative pain

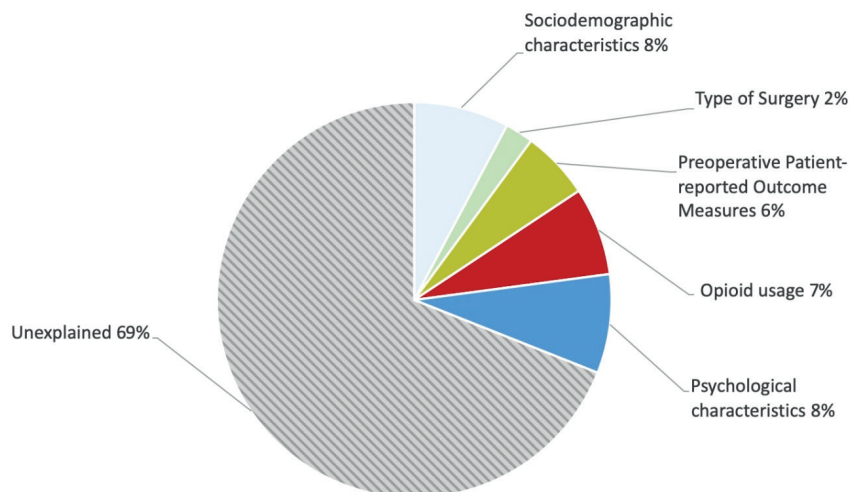


Figure 3. Increase in explained variance (R square change) of acute postoperative pain, for sociodemographic characteristics, type of surgery, preoperative patient-reported outcome measures (PROMS), opioid usage and preoperative psychological characteristics.

DISCUSSION

We found that psychological characteristics, female sex, and opioid usage enhance the prediction of acute postoperative pain beyond type of surgery, preoperative sociodemographics and preoperative PROMS in patients surgically treated for CMC-1 OA. Within the final model, female sex, opioid usage, preoperative higher satisfaction with hand, self-reported consequences and coherence predicted higher acute postoperative pain. While Weilby with APL predicted lower acute postoperative pain in the univariable analyses, type of surgery did not predict acute postoperative pain after adjusting for the other characteristics.

Whereas other studies also reported higher postoperative pain in females^{17, 18, 20} and opioid users⁴⁵, no previous studies found that higher preoperative satisfaction with hand and self-reported consequences and coherence predicted higher acute postoperative pain. While we found that pain catastrophizing was not predictive, others¹⁷⁻²² did find that pain catastrophizing predicted

acute postoperative pain. These different findings may be due to differences in populations, assessment time points, pain management protocols, or surgical procedures.

A noteworthy finding is that, while suppressed by analgesics and having large variation, NPRS acute postoperative pain was lower than preoperative MHQ pain, VAS pain during physical load, past week and similar to preoperative VAS pain at rest. This suggests that the postoperative regime was effective in managing acute postoperative pain following CMC-1 surgery. However, the large variation in NPRS scores should be considered, suggesting that this pattern differs per patient. This is supported by our finding that, for example, females reported higher pain and more often used opioids. Future studies that investigate a risk-based pain management strategy could reduce this variance.

The finding that female sex predicts higher acute postoperative pain has been previously reported^{17, 18, 20}. Although the explanatory power for female sex decreased first when adding opioid usage, it remained significant and it increased again when controlling for the psychological characteristics we measured. Hence, we can surmise that although some of the sex differences we found may in part be explained or confounded by opioid usage and psychological characteristics, an independent effect of sex remained after taking these differences into account. This suggests that the postoperative regime was not as effective for females as for males, which is confirmed by previous studies reporting differences between males and females in opioid response^{17, 18, 20, 21, 46, 47}. Another remarkable finding regarding sex is that many differences between males and females were present preoperatively. While there were many differences in preoperative sociodemographic characteristics, type of surgery, opioid usage, preoperative PROMS, and psychological characteristics, the difference between males and females in NPRS acute postoperative pain remained after adjusting for these characteristics. This is especially noteworthy since there were no differences in preoperative pain levels. This suggests that males and females with CMC-1 OA have different characteristics preoperatively except for pain scores and respond different postoperatively. Ideally, hierarchical regression analyses are conducted for males and females separately²⁷, but building stable separate models was not possible due to the small number of males (N=41).

Hence, although this distribution of males and females is representative of the CMC-1 OA population, future studies should emphasize the inclusion of males to further explore sex differences, allowing for a disaggregated analysis to determine whether our findings on sex are consistent and the other predictors are the same for males and females.

We found that higher preoperative satisfaction with the hand predicts higher acute postoperative pain. An explanation might be that if a person is more satisfied beforehand, the experience of postoperative pain might be worse than anticipated since people might calibrate their pain in relation to prior experience. The finding that higher self-reported disease coherence predicts higher acute postoperative pain might be explained by the hypothesis that someone who thinks to understand the disease quite well, might be surprised or disappointed by the actual amount of postoperative pain. Lastly, the finding that higher experienced consequences of illness predicted higher acute postoperative pain suggests that the experience of postoperative pain might be difficult to bear if a person already experiences many consequences of the illness. However, these are all hypothesized mechanisms that need further exploration.

This study has several limitations. First, although the postoperative medication was standardized and monitored, deviations on the actual reported opioid usage may have occurred. This may have contributed to random error or bias, explaining why there was a small explained variance. Another reason for the small explained variance may be that we might not have included all relevant variables influencing acute postoperative pain. It was, for example, impossible to adjust for possible previous experiences with contralateral surgery or for preoperative medication usage. Any such experience might have influenced our results.

An additional limitation is that the NPRS was administered at a specific moment in time, which might be an incorrect representation of the average pain since the particular moment of administering might have been a moment at which the pain temporarily decreased or increased, e.g. influenced by medication just taken. Hence, future studies might investigate acute postoperative pain using multiple measurements, e.g. 22, 24 and 26h postoperatively. Another limitation of this study might be that our psychological measures describe the patients'

psychological characteristics, but do not include in-depth psychological evaluation. Therefore, future studies might incorporate this to validate our findings.

In conclusion, psychological factors, opioid usage, and female sex enhance the prediction of postoperative pain over type of surgery, preoperative sociodemographics and PROMS in patients surgically treated for CMC-1 OA. Female sex and opioid usage were the largest predictors of higher acute postoperative pain, even after controlling for psychological factors. Preoperative factors such as sex, satisfaction with hand and illness perception should be recognized by healthcare providers to better cope with postoperative pain and prevent chronic pain^{24, 25}, e.g. by adjusting medication or improving patient education. Future studies should investigate the influence of psychological characteristics on long-term outcomes following surgery for CMC-1 OA.

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SUPPLEMENTAL DIGITAL CONTENT

Table, Supplemental Digital Content 1. Preoperative sociodemographic, preoperative Patient-Reported Outcome Measures (PROMS) and psychological characteristics for patients with and without a response on the Numeric Pain Rating Scale 24 hours postoperatively. Significant testing was performed using independent samples t-tests and chi-square tests. Mean \pm SD values are displayed. * $p < 0.05$ when testing differences between responders and non-responders.

Variable	Sociodemographic characteristics		p-value
	Non-responders (n=103)	Responders (n=215)	
Age	60.6 \pm 8.1	60.4 \pm 7.6	0.901
Female sex, %	76.7%	80.9%	0.377
Symptom duration in months	39 \pm 38.6	37.1 \pm 37	0.687
Dominant side treated, %*	46.6%	51.9%	0.262
- No	51.5%	43.5%	
- Yes	1.9%	4.6%	
- Ambidexter			
Workload, %			0.080
- Unemployed	51.5%	43%	
- Light physical labor	17.5%	17.8%	
- Moderate physical labor	24.3%	22%	
- Heavy physical labor	6.8%	17.3%	
Second opinion, %	5.8%	7.4%	0.814
Type of surgery, %:			0.731
- LRTI: Weilby – APL	6.8%	10.7%	
- LRTI: Weilby – FCR	61.2%	58.1%	
- LRTI: Burton/Pellegrini FCR	23.3%	23.3%	
- Other	8.7%	7.9%	
Variable	Preoperative PROMS		p-value
	Non-responders	Responders	
VAS Pain past week	66.3 \pm 17.6	67 \pm 17.1	0.743
VAS Rest	53.2 \pm 22.2	52 \pm 22.3	0.655
VAS Physical load	75.2 \pm 18.4	75.3 \pm 16.7	0.953
VAS Satisfaction with hand	24.9 \pm 22.2	25.6 \pm 19.3	0.783
MHQ Hand Function affected	54.3 \pm 20.5	53.3 \pm 17.8	0.642
MHQ ADL affected	48.8 \pm 25	49.5 \pm 23.2	0.793
MHQ Work	45.6 \pm 28.2	50.2 \pm 24.9	0.145
MHQ Pain	63.3 \pm 15.5	63.9 \pm 13.8	0.715
MHQ Aesthetics affected	40 \pm 26.8	41.4 \pm 26.3	0.651
MHQ Satisfaction affected	33.5 \pm 22.1	33.8 \pm 17.3	0.91

MHQ Total affected	43.2 ± 14.7	44.1 ± 12.7	0.578
EQ5D mobility	1.5* ± 0.8	1.3* ± 0.6	0.008
EQ5D selfcare	1.5 ± 0.7	1.4 ± 0.6	0.476
EQ5D ADL	2.6 ± 1	2.5 ± 0.9	0.271
EQ5D pain/discomfort	3.2 ± 0.7	3.2 ± 0.7	0.425
EQ5D Anxiety/depression	1.4 ± 0.7	1.4 ± 0.7	0.707
EQ5D index score	0.7 ± 0.2	0.7 ± 0.1	0.275
EQ5D general health VAS	72.9 ± 19.9	76.5 ± 18.3	0.108

Psychological characteristics			
Variable	Non-responders	Responders	p-value
CEQ credibility	23.4 ± 3	23.7 ± 2.6	0.319
CEQ Expectancy	21.8 ± 2.8	21.9 ± 2.8	0.64
IPQ consequences: How much does your illness affect your life? (10 = severely affects my life)	7.6 ± 1.8	7.3 ± 1.8	0.191
IPQ timeline: How long do you think your illness will continue? (10 = forever)	6.9 ± 2.6	6.5 ± 2.4	0.107
IPQ personal control: How much control do you feel you have over your illness? (0 = absolutely no control)	4.6 ± 2.6	4.4 ± 2.4	0.39
IPQ treatment control: How much do you think your treatment can help your illness? (10 = extremely helpful)	8.2 ± 1.4	8.3 ± 1.1	0.434
IPQ identity: How much do you experience symptoms from your illness? (10 = many severe symptoms)	6.9 ± 2.6	7 ± 2.3	0.835
IPQ concern: How concerned are you about your illness? (10 = extremely concerned)	6.4 ± 2.9	6.5 ± 2.5	0.786
IPQ coherence: How well do you feel you understand your illness? (10 = understand very clearly)	8.3 ± 2.2	8.5 ± 1.8	0.588
IPQ emotional representation: How much does your illness affect you emotionally? e.g. does it make you angry, scared, upset or depressed? (10 = extremely affected emotionally)	5.1 ± 3	5.1 ± 2.9	0.983
IPQ total	42.1 ± 10.1	41.3 ± 9.1	0.456
PCS	14.5 ± 11.3	13.7 ± 9.5	0.498
PHQ subscale anxiety	0.9 ± 1.3	0.8 ± 1.3	0.645
PHQ subscale depression	0.7 ± 1.3	0.6 ± 1.1	0.346
PHQ total score	1.4 ± 2	1.3 ± 2.1	0.65

Abbreviations: LRTI = Ligament Reconstruction Tendon Interposition, APL = Abductor Pollicis Longus, FCR = Flexor Carpi Radialis, PROMS = Patient Reported Outcome Measures, VAS = Visual Analogue Scale, MHQ = Michigan Hand outcomes Questionnaire, CEQ = Credibility/Expectancy Questionnaire, IPQ = brief Illness Perception Questionnaire, PCS = Pain Catastrophizing Scale, PHQ = Patient Health Questionnaire.

Table, Supplemental Digital Content 2. Preoperative Patient-Reported Outcome Measures (PROMS) and psychological characteristics displayed for all, male and female participants. Mean \pm SD values are displayed. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ when testing differences between males and females

Variable	Preoperative PROMS		
	All (n=215)	Males (n=41)	Females (n=174)
VAS pain past week	67 \pm	64.3 \pm	67.6 \pm
	17.1	17.6	17
VAS rest	52 \pm	53.7 \pm	51.6 \pm
	22.3	21.2	22.6
VAS physical load	75.3 \pm	74.3 \pm	75.5 \pm
	16.7	16.8	16.7
VAS satisfaction with hand	25.6 \pm	27.4 \pm	25.1 \pm
	19.3	19.3	19.3
MHQ hand function	53.3 \pm	54 \pm	53.1 \pm
	17.8	18.8	17.5
MHQ ADL	49.5 \pm	61.7***	46.7*** \pm
	23.2	\pm 23.6	22.3
MHQ work	50.2 \pm	54 \pm	49.3 \pm
	24.9	26.1	24.6
MHQ pain	63.9 \pm	63.5 \pm	64 \pm 13.8
	13.8	14.1	
MHQ aesthetics	41.4 \pm	42.2 \pm	41.2 \pm
	26.3	25.5	26.6
MHQ satisfaction	33.8 \pm	38.2 \pm	32.8 \pm
	17.3	19.3	16.7
MHQ total	44.1 \pm	47.8* \pm	43.3* \pm
	12.7	14.3	12.1
EQ5D mobility	1.3 \pm	1.2 \pm	1.3 \pm 0.6
	0.6	0.6	
EQ5D selfcare	1.4 \pm	1.6* \pm	1.4* \pm 0.6
	0.6	0.7	
EQ5D ADL	2.5 \pm	2.5 \pm 1	2.5 \pm 0.9
	0.9		
EQ5D pain/discomfort	3.2 \pm	3.1 \pm	3.2 \pm 0.7
	0.7	0.7	
EQ5D anxiety/depression	1.4 \pm	1.4 \pm	1.4 \pm 0.7
	0.7	0.8	

EQ5D index score	0.7 ± 0.1	0.7 ± 0.1	0.7 ± 0.1
EQ5D general health VAS	76.5 ± 18.3	77.7 ± 14.7	76.3 ± 19
Psychological characteristics			
Variable	All	Males	Females
CEQ credibility	23.7 ± 2.6	22.9* ± 2.7	23.9* ± 2.6
CEQ expectancy	21.9 ± 2.8	21.7 ± 2.9	22 ± 2.8
IPQ consequences: How much does your illness affect your life? (10 = severely affects my life)	7.3 ± 1.8	7.6 ± 1.7	7.2 ± 1.8
IPQ timeline: How long do you think your illness will continue? (10 = forever)	6.5 ± 2.4	6.1 ± 2.6	6.5 ± 2.4
IPQ personal control: How much control do you feel you have over your illness? (0 = absolutely no control)	4.4 ± 2.4	4.3 ± 2.4	4.4 ± 2.4
IPQ treatment control: How much do you think your treatment can help your illness? (10 = extremely helpful)	8.3 ± 1.1	8.3 ± 1.1	8.3 ± 1.1
IPQ identity: How much do you experience symptoms from your illness? (10 = many severe symptoms)	7 ± 2.3	7.1 ± 2.2	6.9 ± 2.3
IPQ concern: How concerned are you about your illness? (10 = extremely concerned)	6.5 ± 2.5	6.7 ± 2.8	6.5 ± 2.4
IPQ coherence: How well do you feel you understand your illness? (10 = understand very clearly)	8.4 ± 1.8	8.6 ± 1.4	8.4 ± 1.9
IPQ emotional representation: How much does your illness affect you emotionally? e.g. does it make you angry, scared, upset or depressed? (10 = extremely affected emotionally)	5.1 ± 2.9	5.7 ± 2.9	4.9 ± 2.8
IPQ total	41.3 ± 9	42 ± 8.3	41.1 ± 9.2
PCS	13.6 ± 9.5	17.2** ± 10.5	12.8** ± 9.0
PHQ subscale anxiety	0.8 ± 1.3	0.8 ± 1.5	0.8 ± 1.3
PHQ subscale depression	0.6 ± 1.1	0.8 ± 1.3	0.5 ± 1.1
PHQ total score	1.3 ± 2.1	1.6 ± 2.6	1.2 ± 2

Abbreviations: VAS = Visual Analogue Scale, MHQ = Michigan Hand outcomes Questionnaire, CEQ = Credibility/Expectancy Questionnaire, IPQ = brief Illness Perception Questionnaire, PCS = Pain Catastrophizing Scale, PHQ = Patient Health Questionnaire.

Table, Supplemental Digital Content 3. Hierarchical multivariable and univariable regression analysis. First, only sociodemographic characteristics are used(model 1), then type of surgery is added (model 2), preoperative Patient-Reported Outcome Measures (PROMS) were added (model 3), opioid usage was added (model 4) and psychological characteristics were added (model 5). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

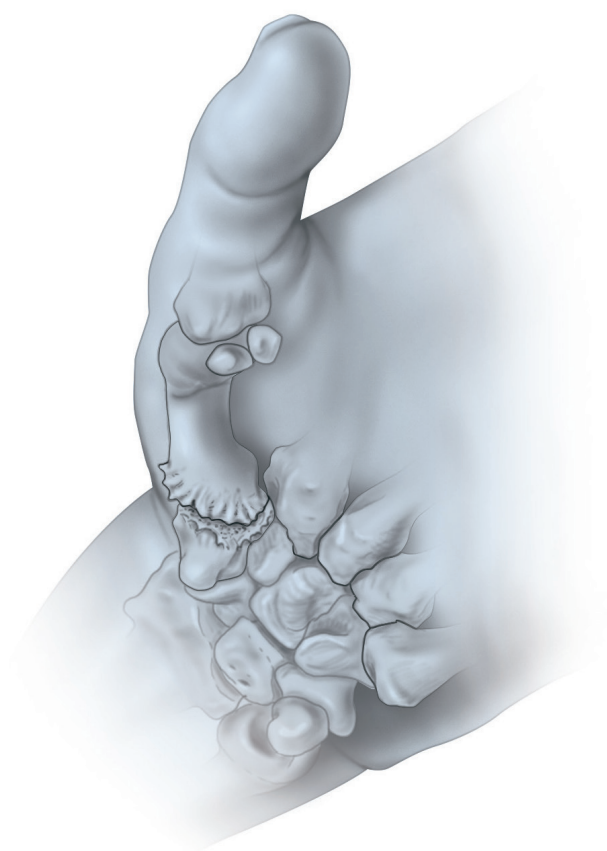
	Model 1		Model 2		Model 3		Model 4		Model 5		Univariable	
	B	[95% CI]	β	B	[95% CI]	β	B	[95% CI]	β	B	[95% CI]	β
<i>Step 1: Sociodemographic characteristics</i>												
Dominant side treated=yes (ref = no)	0.18	0.04	0.26	0.06	0.19	0.04	-0.03	-0.01	-0.02	0.00	-0.05	-0.01
	[-0.47;0.83]		[-0.38;0.91]		[-0.47;0.86]		[-0.67;0.62]		[-0.66;0.63]		[-0.68;0.56]	
Dominant side treated=ambidexter, 1 side treated (ref = no)	0.04	0.00	-0.10	-0.01	-0.07	-0.01	-0.25	-0.02	-0.65	-0.06	-0.08	-0.01
	[-1.47;1.55]		[-1.64;1.44]		[-1.64;1.50]		[-1.76;1.25]		[-2.16;0.85]		[-1.57;1.40]	
Age onset	-0.03	-0.10	-0.03	-0.10	-0.01	-0.04	-0.01	-0.05	0.00	-0.01	-0.04	-0.12
	[-0.08;0.02]		[-0.08;0.02]		[-0.07;0.04]		[-0.07;0.04]		[-0.06;0.05]		[-0.08;0.01]	
Sex=female (ref = male)	1.25**	0.21**	1.14**	0.19**	1.19**	0.20**	0.93*	0.16*	1.39**	0.24**	1.42***	0.24***
	[0.43;2.07]		[0.30;1.97]		[0.32;2.05]		[0.09;1.77]		[0.51;2.26]		[0.66;2.20]	
Second opinion = yes (ref = no)	-0.23	-0.03	-0.14	-0.02	-0.05	-0.01	-0.15	-0.02	0.13	0.02	-0.15	-0.17
	[-1.43;0.96]		[-1.35;1.07]		[-1.26;1.16]		[-1.30;1.01]		[-1.04;1.30]		[-1.35;1.04]	
Workload = light (ref = unemployed)	0.35	0.06	0.29	0.05	0.57	0.09	0.65	0.11	0.51	0.08	0.67	0.11
	[-0.62;1.31]		[-0.68;1.25]		[-0.41;1.56]		[-0.29;1.59]		[-0.45;1.47]		[-0.15;1.49]	
Workload = moderate (ref = unemployed)	-0.19	-0.03	-0.13	-0.02	-0.06	-0.01	-0.06	-0.01	-0.25	-0.05	-0.02	0.00
	[-1.09;0.70]		[-1.03;0.77]		[-0.97;0.86]		[-0.94;0.81]		[-1.13;0.63]		[-0.78;0.74]	
Workload = heavy (ref = unemployed)	-0.21	-0.03	-0.23	-0.04	-0.1	-0.02	-0.17	-0.03	-0.25	-0.04	-0.29	-0.05
	[-1.23;0.81]		[-1.24;0.79]		[-1.12;0.93]		[-1.15;0.82]		[-1.23;0.74]		[-1.11;0.53]	
Symptom duration	0.00	0.07	0.00	0.06	0.00	0.05	0.00	0.03	0.00	0.00	0.01	0.10
	[0.00;0.01]		[-0.01;0.01]		[-0.01;0.01]		[-0.01;0.01]		[-0.01;0.01]		[-0.00;0.02]	

	Model 1		Model 2		Model 3		Model 4		Model 5		Univariable	
	B	[95% CI]	β	B [95% CI]	β	B [95% CI]	β	B [95% CI]	β	B [95% CI]	β	B [95% CI]
<i>Step 2: Type of surgery</i>												
LRTI: Weilby/APL (ref = Weilby/FCR)	-1.04	[-2.09;0.01]	-0.14	-0.92	-0.12	-0.65	-0.09	-0.63	-0.08	-1.40**	-0.19**	[-2.40;-0.41]
LRTI: Burton/Pellegrini	0.26	[-0.51;1.04]	0.05	0.30	0.05	0.31	0.06	0.33	0.06	0.39	0.07	[-0.35;1.13]
FCR (ref = Weilby/FCR)	0.06	[-1.15;1.26]	0.01	0.08	0.01	-0.13	-0.02	-0.26	-0.03	0.04	0.00	[-1.12;1.20]
Other (ref = Weilby/FCR)												
<i>Step 3: Preoperative PROMS</i>												
VAS Pain past week				0.03	0.21	0.03*	0.25*	0.03	0.19	0.02*	0.15*	0.00;0.04
VAS Rest				[0.00;0.06]	-0.01	[0.00;0.07]	-0.02	[0.00;0.06]	0.01	0.01	0.08	[-0.01;0.02]
VAS Physical load				0.00	-0.09	[-0.02;0.02]	-0.02	[-0.02;0.02]	-0.14	0.01	0.06	[-0.01;0.03]
VAS Satisfaction with hand				[-0.04;0.02]	0.12	[-0.04;0.01]	0.13	[-0.05;0.01]	0.16*	0.01	0.04	[-0.01;0.02]
MHQ Hand Function				[0.00;0.03]	0.10	[0.00;0.03]	0.09	[0.00;0.04]	0.09	0.01	0.06	[-0.01;0.03]
MHQ ADL				[-0.01;0.03]	0.04	[-0.01;0.03]	0.05	[-0.01;0.03]	0.11	-0.01	-0.08	[-0.02;0.01]
MHQ Work				[-0.01;0.02]	-0.08	[-0.01;0.02]	-0.13	[-0.03;0.01]	-0.09	-0.01	-0.07	[-0.02;0.01]
MHQ Aesthetics				[-0.02;0.01]	0.01	[-0.03;0.00]	0.03	[-0.01;0.01]	-0.01	0.00	0.01	[-0.01;0.01]
EQ5D index score				[-0.01;0.01]	-0.14	[-0.01;0.01]	-0.10	[-0.01;0.01]	-0.16	-2.22*	-0.14*	[-4.34;-0.10]
				[-4.90;0.45]		[-4.18;0.98]		[-5.43;0.41]				

	Model 1	Model 2	Model 3	Model 4	Model 5	Univariable
	B [95% CI]	β B [95% CI]	β B [95% CI]	β B [95% CI]	β B [95% CI]	β B [95% CI]
<i>Step 4: Opioid usage</i>						
Opioid usage = yes (ref = no)				1.35*** [0.72;1.97]	1.31*** [0.66;1.95]	1.45*** [0.84;2.06]
<i>Step 5: Expectations & Psychological characteristics</i>						
CEQ credibility					-0.07 [-0.21;0.08]	-0.08 [-0.16;0.08]
CEQ Expectancy					-0.02 [-0.15;0.12]	-0.02 [-0.17;0.05]
IPQ Consequences					0.24* [0.01;0.47]	0.18* [0.01;0.36]
IPQ Timeline					-0.02 [-0.16;0.12]	0.02 [-0.11;0.15]
IPQ Personal control					0.06 [-0.06;0.19]	0.07 [-0.05;0.21]
IPQ Identity					0.11 [-0.05;0.26]	0.11 [-0.02;0.25]
IPQ Concern					0.01 [-0.16;0.17]	0.01 [-0.10;0.15]
IPQ Coherence					0.23* [0.05;0.41]	0.18* [-0.07;0.28]
IPQ Emotional representation					-0.08 [-0.21;0.06]	-0.10 [-0.14;0.08]
PCS					0.01 [-0.03;0.06]	0.01 [-0.03;0.04]

	Model 1		Model 2		Model 3		Model 4		Model 5		Univariable	
	B	[95% CI]	β	B	[95% CI]	β	B	[95% CI]	β	B	[95% CI]	β
PHQ subscale anxiety												
									-0.25	-0.15	-0.18	-0.11
									[-0.61;0.10]		[-0.42;0.05]	
PHQ subscale depression									0.04	0.02	-0.11	0.05
									[-0.39;0.46]		[-0.38;0.17]	
R Square	0.08			0.10		0.16	0.23		0.31		NA	
Adjusted R Square	0.04			0.05		0.07	0.14		0.18		NA	
Sig. F Change	0.050			0.170		0.175	<0.001		0.059		NA	

Abbreviations: , B = unstandardized beta coefficient, β = standardized beta, CI = Confidence Interval, ref = Reference value, LRTI = Ligament Reconstruction Tendon Interposition, APL = Abductor Pollicis Longus, FCR = Flexor Carpi Radialis, PROMS = Patient Reported Outcome Measures, VAS = Visual Analogue Scale, MHQ = Michigan Hand outcomes Questionnaire, CEQ = Credibility/Expectancy Questionnaire, IPQ = brief Illness Perception Questionnaire, PCS = Pain Catastrophizing Scale, PHQ = Patient Health Questionnaire.



CHAPTER 15

BASELINE PSYCHOSOCIAL FACTORS ARE ASSOCIATED WITH PATIENT REPORTED OUTCOMES ONE YEAR AFTER TRAPEZIOMETACARPAL ARTHROPLASTY

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ABSTRACT

Background: Studies of people presenting with symptoms related to osteoarthritis of the trapeziometacarpal joint (TMC OA) and people with incidental TMC OA suggest that levels of comfort and capability may relate to misconceptions and psychological distress (mental health) more than severity of pathophysiology. The relationship of mental health factors prior to surgery and comfort and capability one year after surgery is less studied. This study assessed factors associated with 1) comfort (pain intensity) and 2) capability (self-reported hand function) one year after TMC arthroplasty for OA.

Methods: A cohort of 353 patients completed measures of psychological distress, catastrophic thinking, belief that treatment will help, and illness perceptions prior to TMC arthroplasty for OA. Furthermore, patients completed the Michigan Hand Outcome Questionnaire (MHQ) prior to and 1 year after surgery. We performed stepwise linear regression models to identify factors associated with comfort (MHQ pain subscale) and capability (MHQ function subscale) one year after arthroplasty.

Results: Greater pain intensity one year after TMC arthroplasty for OA was associated with pre-operative measures of greater psychological distress ($B = -2.03$, $p = 0.015$), greater concern about the illness ($B = -1.92$, $p = 0.002$), greater expected duration of the illness ($B = -1.47$, $p = 0.008$), and greater baseline pain ($B = 0.25$, $p = 0.028$). Less capability (self-reported hand function) one year after surgery was associated with less pre-operative rating of the effect of the illness on life (IPQ item 1, $B = 1.69$, $p = 0.01$), greater concern about the illness (IPQ item 6; $B = -1.46$, $p = 0.007$), and less baseline capability ($B = 0.22$, $p < 0.001$).

Conclusion: The measured relationship of preoperative mental health on one-year post-arthroplasty comfort and capability adds additional evidence to support the biopsychosocial paradigm in TMC arthrosis treatment. Surgeons can anticipate psychological distress and greater concern about the illness as opportunities for improved comfort and capability, develop care strategies to address them, and measure the impact of those strategies.

INTRODUCTION

Osteoarthritis of the trapeziometacarpal joint (TMC OA) is an expected part of aging and nearly universal after age 80¹. Previous studies demonstrated that symptom intensity related to TMC OA is associated more with psychological factors than with objective pathology as measured on radiographs²⁻⁴. TMC OA is often incidental and well-accommodated^{1,5-7}. People visiting a specialist for advice about TMC OA are usually satisfied with a single visit and choose nonoperative treatment⁸⁻¹⁵. Several population-based studies document that age-associated changes such as knee arthritis^{16,17} and rotator cuff tendinopathy¹⁸ are often accommodated even when the pathology is fairly advanced.

Operative treatment is an option for patients with TMC OA that are not satisfied with accommodation and palliative measures.^{19,20} Prior studies found that people who request TMC arthroplasty for OA have a greater tendency to limit activity owing to pain²¹, a more negative cognitive and emotional representation of the illness²², and greater catastrophic thinking²³ compared to people that accommodate TMC OA. The influence of mental health prior to surgery on patient reported outcomes 1 year after surgery is less studied.

Using data from a large cohort of patients with one year of data collected before and after TMC arthroplasty for OA, we tested the hypotheses that baseline factors are associated with pain intensity 1 year after surgery (comfort), including patient perceptions of the illness, psychological distress (symptoms of anxiety and depression), catastrophic thinking, belief that the treatment will help, and preoperative pain intensity. We also addressed the hypothesis that there are no factors associated with self-reported hand function (capability) one year after surgery, including patient perceptions regarding the illness, psychological distress, catastrophic thinking, belief that treatment will help, and preoperative capability.

METHODS

Patients

All patients who underwent TMC arthroplasty for OA between September 2017 and November 2019 in a multi-city hand specialty practice were eligible

for the study. The data for analysis was acquired from routine questionnaire administration in our practices using a process of electronic data collection that was previously described. Completing the questionnaires is optional. Seventeen percent of the patients did not complete questionnaires after their first visit, which is typical for our setting. About half of the eligible patients did not complete the full year of questionnaires needed for this study (Figure 1). This percentage of missing data is representative of routine longitudinal data collection; For example, Crijns et al. found similar rates of missing data in hand surgery patients.²⁴ When patients complete questionnaires, they check a box indicating their consent to use the data for research. The Institutional Review Board decreed that this study does not need formal approval.

Among the 718 patients having TMC arthroplasty for OA during the study period, 361 (50%) did not complete all questionnaires necessary for this study during routine administration. Four patients were identified as influential outliers using Cook's distance. As recommend by Aguinis et al.,²⁵ we reran the model and confirmed that the fit of the model was better without the outliers. A total of 353 patients were available for study. There was no significant difference in patient demographics between patients that did and did not complete questionnaires. The mean age of the patients was 61 years and 21% were men (Table 1).

Treatment

Patients were treated with a trapeziectomy and ligament reconstruction as described by Weilby or Burton²⁶. Patients wore a plaster cast for the first three days after surgery. This plaster was replaced with a custom-made orthosis during the first postoperative appointment with a hand therapist. Patients visited with a hand therapist once every week for 12 weeks for guidance on supervised exercises. The first 6 weeks are focused on exercises to reduce swelling, regain motion, and restore dexterity. The last 6 weeks involve exercises for strength and stability.

Measurements

Patients completed the validated Dutch version of the Michigan Hand Questionnaire (MHQ)^{27,28} preoperatively and one year after surgery. The

primary outcome was the MHQ subscale quantifying pain intensity, referred to herein as comfort, one year after surgery. The secondary outcome was the MHQ subscale quantifying self-reported hand function of the affected hand, referred to herein as capability, one year after surgery. Scores on these scales ranged from 0 (severe pain or dysfunction) to 100 (no pain or dysfunction). During the first consultations with the hand therapist the physical intensity of the job is assessed. We distinguish light physical work (e.g., office work), moderate physical work (e.g., work in a shop) and heavy physical work (e.g., carpentry).

Patients completed the Patient Health Questionnaire (PHQ-4), Pain Catastrophizing Scale (PCS), Credibility/Expectancy Questionnaire (CEQ), and Brief Illness Perceptions questionnaire (B-IPQ). Validated Dutch versions were used^{29,30}. The PHQ is a 4-item questionnaire designed to assess psychological distress in two domains: symptoms of depression (from the PHQ-2) and symptoms of anxiety (from the GAD-2). The questionnaire results in a total score between 0 – 12 (no symptoms of psychological distress to severe symptoms of psychological distress)^{31,32}. The PCS has 13 questions, resulting in a score between 0 and 52 (no catastrophic thinking regarding pain to severe catastrophic thinking)³³. The CEQ consists of 6 questions about belief that a treatment will help. There are 4 questions regarding their thoughts and 2 questions regarding their feelings with respect to confidence that treatment will improve their health and by how much. The result is an expectations subscale and a credibility subscale, each with scores between 3 and 27.³⁴ The B-IPQ asks one question addressing patient perceptions of the illness in 8 separate domains, using a single 0-10 ordinal rating scale for each³⁵: the degree to which the illness affects life, expected duration, sense of control over the illness, beliefs that the treatment will help, the level of symptoms, the level of concern regarding the illness, the degree the illness affects emotions, and the degree of understanding of the illness. Because the belief that the treatment will help is already evaluated using the CEQ, we did not use that IPQ subdomain. We analyzed the other seven domains separately, as recommended by the authors of the IPQ³⁵.

Statistical Analysis

For normally-distributed data, we computed means and standard deviations (SD); for non-normal distributed data, we calculated a median with interquartile

range (IQR). We used a stepwise multivariable linear regression (sometimes referred to as hierarchical regression) to evaluate how psychological factors, in addition to patient and disease characteristics, contribute to baseline pain and hand function. This was done by entering the covariates in a stepwise fashion. We started with the most basic model and added covariates if the previous model and estimates were stable, to account for potential collinearity. Estimates were deemed stable if they did not change significantly in contrast to previous steps. In the first step, we only included patient demographics in the model. In the second step, we added pain catastrophizing and psychological distress into the model. In the third step, we added belief that the treatment will help. In the fourth step, we also incorporated illness perceptions in the model. In the final set, we added baseline MHQ scores. We calculated the explained variance (R^2) for each group of variables to assess the additive explained variance attributed to a step. This procedure was performed twice, once for the MHQ pain subscale and once for the MHQ general function subscale. Due to violation of the homoscedastic assumption, standard errors could not be interpreted. We used robust sandwich variance estimators for linear regression analyses to obtain reliable standard errors in the linear regression models.

Table 1. Baseline patient and psychosocial characteristics of the study population (n = 353)

	Value
n	353
Age, mean(SD)	61 (8)
Gender, Male (%)	21
Occupational intentensity (%)	
No payed labor	43.4
Light physical labor	18.4
Average physical labor	23.7
Heavy physical labor	14.5
Duration of complains, median (IQR)	24 (12 - 48)
Dominant side treated, yes (%)	47.6
BMI, mean(SD)	27 (4)
Smoking status, Non smoker (%)	83
MHQ - baseline pain, mean (SD)	37 (14)
MHQ - baseline hand function, mean (SD)	54 (19)
PCS - catastrophizing, median(IQR)	11.5 (6 - 19)
PHQ - psychological distress, median(IQR)	0 (0 - 2)

	Value
EQ5D - index score, mean (SD)	0.67 (0.20)
CEQ - expectations, mean (SD)	23 (3)
CEQ - credibility, median (IQR)	24 (22 - 26)
IPQ - consequences, median(IQR)	78(7 - 8)
IPQ - timeline, median(IQR)	7 (5 - 8)
IPQ - personal control, median(IQR)	5 (2 - 6)
IPQ - identity, median(IQR)	8 (6 - 8)
IPQ - concern, median(IQR)	7 (5 - 8)
IPQ - illness comprehensibility, median(IQR)	9 (8 - 10)
IPQ - emotional concequences, mean(SD)	5 (2 - 7)

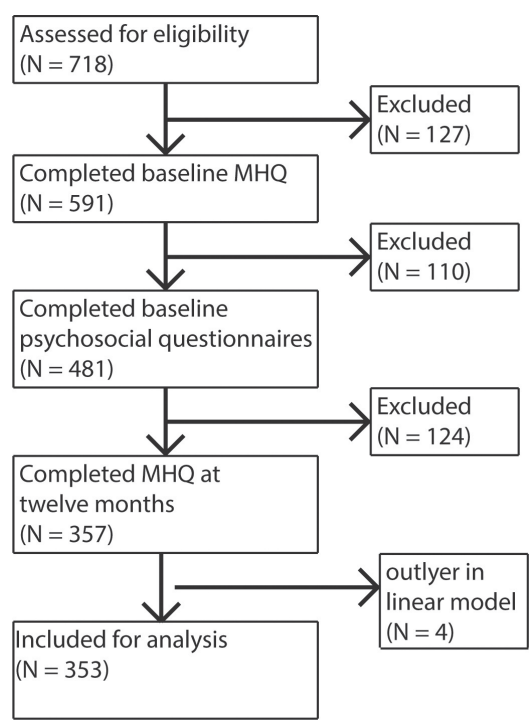


Figure 1. flow diagram of included patients

Results

Michigan Hand Questionnaire (MHQ) Pain Intensity One Year After Surgery

Accounting for potential confounding using stepwise multivariable analysis, in the first step (patient demographics), no factors were associated with pain 1 year after surgery. In the second step, psychological distress was significant ($B = -2.39$) while controlling for patient demographics and catastrophic thinking and the full model accounted for 7% of the variation in pain 1 year after surgery. In the third step, belief that the treatment will help did not explain any additional variation and psychological distress remained significant with a similar coefficient. In the fourth step, psychological distress remained significant, and perceptions of the expected duration ($B = -1.44$) and a sense of control ($B = -1.89$) were also significant, while controlling for demographics, catastrophic thinking and belief that the treatment will help, with the full model accounting for 14% of the variation. In the final step, baseline pain was added to the model and was also significant ($B = 0.25$), controlling for all other factors. The step-five model explained 15% of the variation in pain 1 year after surgery (Figure 2). The final model of factors associated with higher pain intensity 1 year after surgery included greater psychological distress ($B = -2.03$, $P = 0.015$), greater concern about the illness ($B = -1.92$, $p = 0.002$), greater expected duration of the illness ($B = -1.47$, $p = 0.008$), and greater baseline pain intensity ($B = 0.25$, $P = 0.028$). Observed coefficients and standard deviations were stable across all models (Supplementary Table 1).

Table 2. Multivariable linear regression model for pain at twelve months. 95% confidence intervals were estimated using robust sandwich variance estimators. Bold denotes significant variables.

	Beta	95% CI	p-value
Dominant side treated, yes	2.614	[-2.69 ; 7.92]	0.334
BMI	-0.162	[-0.85 ; 0.53]	0.644
Duration of complains, months	0.016	[-0.05 ; 0.09]	0.639
Occupational intentensity (ref: No payed labor)			
Light physical labor	-3.839	[-12.18 ; 4.5]	0.367
Average physical labor	-5.864	[-13.59 ; 1.86]	0.137
Heavy physical labor	-3.281	[-12.65 ; 6.09]	0.492
Age	-0.03	[-0.5 ; 0.44]	0.898
Gender, Male	0.313	[-6.46 ; 7.08]	0.928
Smoking status, non smoker	2.448	[-5.38 ; 10.27]	0.54
PHQ - psychological distress	-2.03	[-3.66 ; -0.4]	0.015
PCS - catastrophizing	0.186	[-0.12 ; 0.49]	0.234
CEQ - expectations	-0.232	[-1.41 ; 0.95]	0.701
CEQ - credibility	0.494	[-0.85 ; 1.84]	0.472
IPQ - consequences	0.588	[-1.01 ; 2.19]	0.472
IPQ - timeline	-1.469	[-2.56 ; -0.38]	0.008
IPQ - personal control	-0.052	[-1.17 ; 1.07]	0.927
IPQ - identity	-0.095	[-1.26 ; 1.07]	0.872
IPQ - concern	-1.915	[-3.13 ; -0.7]	0.002
IPQ - illness comprehensibility	0.096	[-1.55 ; 1.75]	0.909
IPQ - emotional concequences	0.913	[-0.13 ; 1.96]	0.086
MHQ - baseline pain	0.249	[0.03 ; 0.47]	0.028

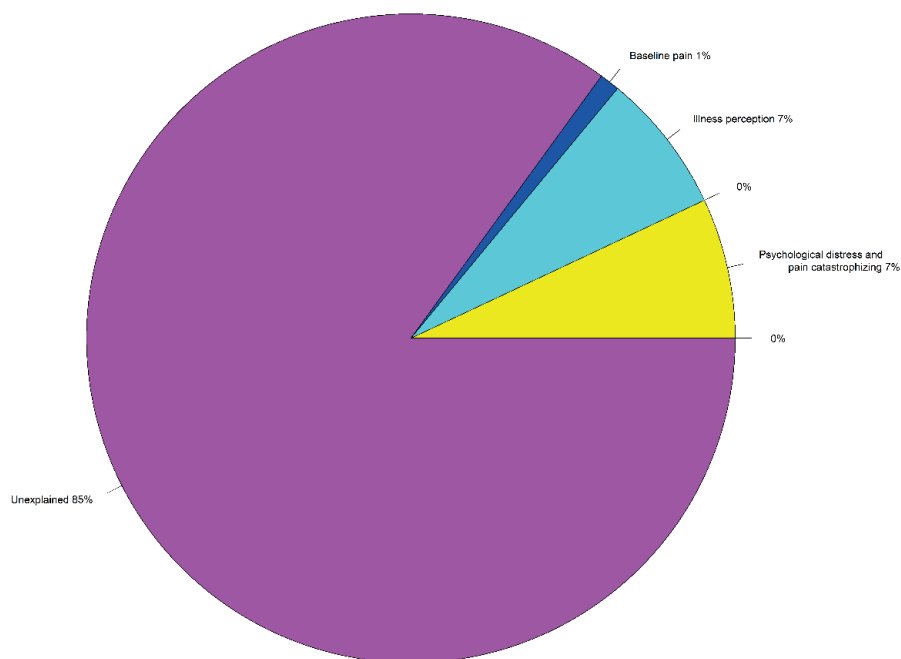


Figure 2. The relative contribution of variable groups to pain at twelve months.

Michigan Hand Questionnaire (MHQ) Hand Function at One-year After Surgery

Accounting for potential confounding using stepwise multivariable analysis, in the first step (patient demographics), moderate physical labor ($B = -6.21$) was associated with patient reported hand function 1 year after surgery, and the model accounted for 3% of the variation. In the second step, psychological distress and catastrophic thinking did not explain additional variation and moderate physical work remained significant. In the third step, belief that the treatment will help did not explain any additional variation and moderate physical work remained significant with a similar coefficient. In the fourth step, moderate physical work remained significant, and lower preoperative rating of the impact of the illness on life ($B = 1.44$) and less sense of control ($B = -1.57$) were also significant, while controlling for demographics, catastrophic thinking and belief that the treatment will help, with the model accounting for 12% of the variation. In the final step, baseline hand function was added to the model and was also significant

($B = 0.22$), controlling for all other factors. The step-five model explained 17% of the variation in patient reported hand function 1 year after surgery (Figure 3). In the final model, greater capability 1 year after surgery was associated with moderate physical work ($B = -6.11$, $p = 0.023$), lower pre-operative rating of the impact of the illness on life ($B = 1.69$, $p = 0.01$), greater concern about the illness ($B = -1.46$, $p = 0.007$), and greater baseline hand function ($B = 0.22$, $p < 0.001$). Observed coefficients and standard deviations were stable across all models (Supplementary Table 2).

Table 3. Multivariable linear regression model for self-reported hand function at twelve months. 95% confidence intervals were estimated using robust sandwich variance estimators. Bold denotes significant variables.

	Beta	95% CI	p-value
Dominant side treated, yes	-1.306	[-5.32 ; 2.7]	0.523
BMI	-0.279	[-0.79 ; 0.24]	0.287
Duration of complains, months	-0.028	[-0.08 ; 0.03]	0.295
Occupational intentensity (ref: No payed labor)			
Light physical labor	-4.036	[-10.01 ; 1.94]	0.185
Average physical labor	-6.107	[-11.36 ; -0.86]	0.023
Heavy physical labor	-4.718	[-11.96 ; 2.52]	0.202
Age	-0.052	[-0.39 ; 0.29]	0.767
Gender, Male	0.912	[-4.03 ; 5.85]	0.718
Smoking status, non smoker	-0.51	[-5.58 ; 4.56]	0.844
PHQ - psychological distress	-0.846	[-2.07 ; 0.38]	0.175
PCS - catastrophizing	0.155	[-0.08 ; 0.39]	0.195
CEQ - expectations	0.492	[-0.41 ; 1.39]	0.284
CEQ - credibility	-0.04	[-1.05 ; 0.98]	0.939
IPQ - consequences	1.692	[0.4 ; 2.99]	0.01
IPQ - timeline	-0.893	[-1.74 ; -0.04]	0.04
IPQ - personal control	-0.036	[-0.87 ; 0.8]	0.933
IPQ - identity	0.076	[-0.83 ; 0.99]	0.869
IPQ - concern	-1.459	[-2.53 ; -0.39]	0.007
IPQ - illness comprehensibility	-0.466	[-1.76 ; 0.83]	0.481
IPQ - emotional consequences	0.041	[-0.76 ; 0.84]	0.92
MHQ - baseline hand function	0.215	[0.1 ; 0.33]	0

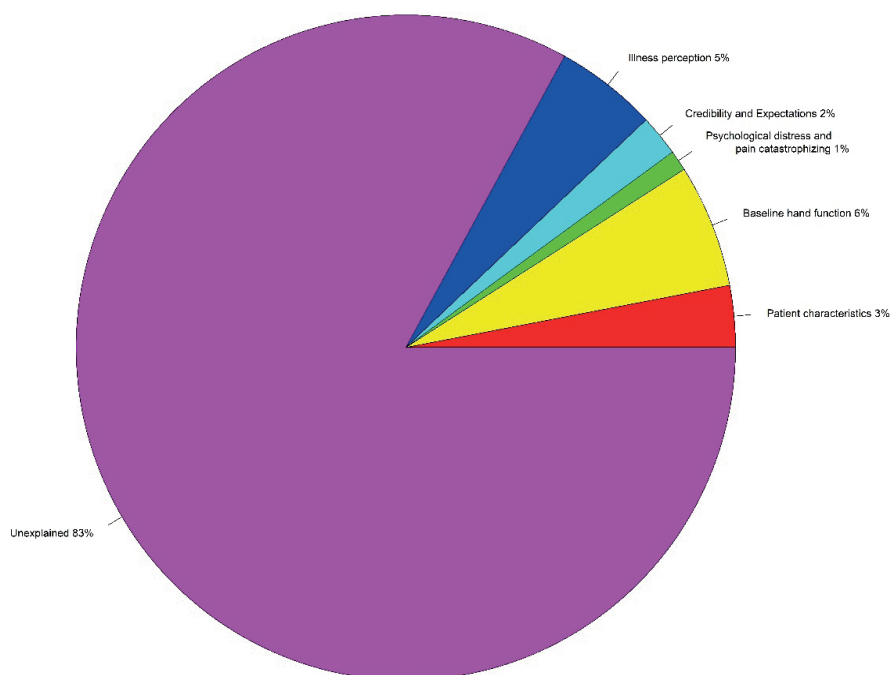


Figure 3. The relative contribution of variable groups to self-reported hand function at twelve months.

DISCUSSION

Previous studies addressing factors associated with comfort and capability among people with TMC OA, either as a presenting symptom or an incidental finding, suggest that mental health measures (symptoms of depression and catastrophic thinking) have comparable or greater influence than severity of pathophysiology³. The influence of personal (mental and social health) factors on patient reported outcomes after surgery are less studied. We found that negative thoughts and emotions prior to surgery are associated with both less comfort and less capability 1 year after surgery .

This study has some limitations. First, patients completed several questionnaires with similar sounding items and there may have been some priming and questionnaire fatigue.^{36,37} The existence of ample spread in the scores and the alignment with prior results suggest there was limited influence of fatigue and priming on the results. Second, a relatively large proportion of the variation in

outcomes remains unexplained. This might be related to the observation that the influence of mental health is greater earlier in the recovery trajectory^{38–40}. Third, the percentage of nonresponse in this study is substantial, but representative for routine, non-research administration of patient reported outcome measures. The similarities between responders and non-responders suggest the findings may be generalizable, although the findings are interesting even if they only apply to the subset of people willing to complete questionnaires for a full year after surgery.

Our finding that greater pain intensity one year after surgery is associated with greater preoperative psychological distress, greater preoperative concerns regarding the illness, greater preoperative expected illness duration, and greater baseline pain intensity is consistent with previous research and adds to the existing body of evidence stressing the notable influence of thoughts and emotions (mental health) on human illness and treatment outcomes^{12,13,21,41–51}. It is important to consider that baseline pain intensity has notable correlations with psychological distress and cognitive biases regarding pain (catastrophic thinking, fear of painful movement, and intolerance of uncertainty) in cross-sectional studies. The association of baseline and one-year postoperative comfort supports the important role of mental health and is consistent in other anatomical areas. A prospective longitudinal study of 78 patients undergoing total knee arthroplasty found greater preoperative pain intensity was associated with troublesome persistent postoperative pain⁴⁹. A 1-year prospective study of 725 workers doing repeated manual tasks demonstrated that greater psychological stress was associated with increased reporting of musculoskeletal symptoms on a questionnaire during periodic planned evaluations.⁵² Several studies demonstrate an association of early post-injury thoughts and emotions and recovery trajectory after fracture^{38,40,46}.

Our finding that greater capability 1 year after surgery was associated with moderate physical work, greater concern regarding the illness, and greater preoperative capability is consistent with previous studies demonstrating that preoperative employment status and more vigorous activities of daily living are associated with a better postoperative recovery trajectory^{49,50}. It is counterintuitive (and contrary to other studies from our group) that lower consequences for daily activities prior to surgery was associated with less

capability one year after surgery—a finding that we cannot explain. Sensitivity analyses demonstrate that greater concern and less preoperative capability are reliable associations with 1-year postoperative capability.

In conclusion, our study adds additional evidence to the importance of the biopsychosocial paradigm in the treatment of human illness and disease perception, and points to the importance of helping people presenting for care with TMC arthrosis develop healthy thoughts and emotions. Treatment strategies that promptly and accurately diagnose and address important misconceptions about symptoms, unhealthy symptoms of despair or worry, and stressful life situations hold promise for helping people considering surgery decide to accommodate arthritis in some cases, and helping those that choose surgery to achieve better comfort and capability.

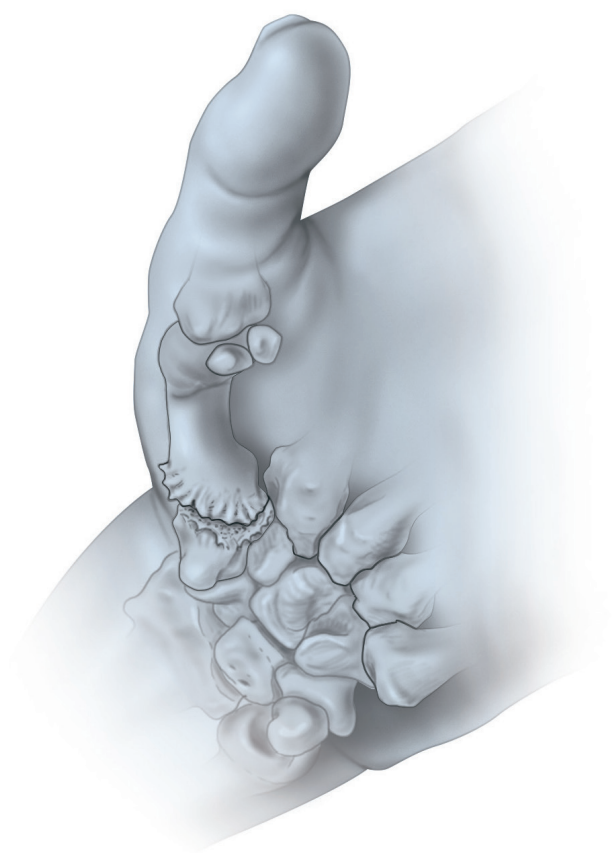
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CHAPTER 16

FACTORS SIGNIFICANTLY AFFECTING RETURN TO WORK AFTER SURGICAL TREATMENT OF TRAPEZIOMETACARPAL JOINT OSTEOARTHRITIS

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ABSTRACT

This study aimed to identify factors contributing to the timing of return to work after surgical treatment of trapeziometacarpal joint osteoarthritis and to calculate the costs of lost productivity. We included 627 patients with paid employment who underwent trapeziectomy and ligament reconstruction with tendon interposition. Time to return to work was measured through filling online questionnaires and analysed using survival analysis at six weeks and three, six, and 12 months after the surgery. Patients also filled in the Michigan Hand Outcomes questionnaire. Costs of lost productivity were calculated using the human capital method. After one year, 78% of the patients returned to work. The median time to return to work was 12 weeks. Factors which significantly affected the time to return to work were occupational intensity (light, moderate, or heavy physical labor) and whether the dominant hand was treated, and the Michigan Hand Outcomes questionnaire work score and hand function score of the unoperated side at baseline. The costs of lost productivity were estimated at €11.175 on the patient level, resulting in €16,8 million on the Dutch population level per year.

INTRODUCTION

Osteoarthritis (OA) has a big impact on patients' ability to work and thus on costs of lost productivity. Little is known about the factors associated with the time to return to work after surgical treatment of trapeziometacarpal joint OA. Wolf et al.¹ reported that there were no effects of prior sick leave, sex, or age and concluded that "further evaluation of factors contributing to lengthy work absences is needed". In patients with carpal tunnel syndrome, Peters et al.² found an effect of several physical and psychosocial factors at work and functional limitations in work before surgery on delayed return to work.

Time to return to work translates directly into costs of productivity lost, but there is little insight into the costs beyond costs of the surgery itself. Marks et al.³ studied the economic aspects of surgical treatment and steroid injection in patients with trapeziometacarpal joint OA and estimated the healthcare and lost productivity costs due to sick leave in the first year to be €5770 for surgical treatment and €5548 for a steroid injection. However, Marks et al (2015) note that the indirect costs must be carefully extrapolated since monetary values are strongly dependent on the income, contractual weekly working hours, and ratio of the employed to non-working patients in the study population.

This study aims primarily to identify factors contributing to the time to return to work after surgical treatment of trapeziometacarpal joint OA and secondly to calculate the costs of lost productivity due to sickness absence.

METHODS

Consecutive patients who had a trapeziectomy at the Xpert Clinic in the Netherlands, a specialised centre for treatment of hand and wrist problems with 18 different locations, between 2011 and 2018 were included in this study. The 18 hand surgeons had experience levels two (2), three (5), four (4), and five (7)⁴. Depending on the surgeon's preference, a ligament reconstruction with tendon interposition was carried out according to Weilby⁵ or Burton-Pellegrini⁶.

Other inclusion criteria were that the patient had paid employment, provided information about return to work at least once, and had given written informed consent. Patients followed a standard post-operative regiment, consisting of a cast for up to 10 days, followed by a removable splint for up to 6 weeks. Patients had two sessions of hand therapy and all were advised to follow an

extensive program of hand exercises. A detailed description of the splinting and therapy protocol has been reported earlier ⁷. The study was approved by the local institutional review board.

Baseline demographics of the patients

The diagnosis of trapeziometacarpal joint osteoarthritis was made by a certified hand surgeon based on clinical examination such as a positive grind test. In most patients, a radiograph was taken and the trapeziometacarpal and scaphotrapeziotrapezoidal joints were assessed. Additionally, surgeons inspected both joints during the procedure. We only included patients who underwent trapeziectomy and ligament reconstruction with tendon interposition without additional procedures. Baseline characteristics of all patients, including age, sex, occupational intensity, duration of complaints, and hand dominance were collected. Three levels of occupational intensity were defined: light physical work (e.g., an office job), medium physical work (e.g., working in a shop), and heavy physical work (e.g., working at a construction site). This was documented by a hand therapist after the diagnosis was made during the first consultation.

Data collection

Patients were asked to complete an online questionnaire on return to work at six weeks and three, six, and 12 months after the surgery. The maximal length of the data collection was 12 months after surgery. The questionnaire consisted of 5 questions: (1) whether the patient was able to work and, if not, whether this was due to the hand disorder, (2) for how many hours a week the patient used to work, (3) how many hours a week the patient currently works, (4) whether the patient performs the original work or has adjusted work, (5) how many weeks after the treatment the patient returned to performing the original work (if applicable). The patients were also asked to fill in the Dutch translation of the Michigan Hand Outcomes Questionnaire (MHQ) ^{8,9}. Study data were collected and managed using a secure web-based application for the distribution of questionnaires and forms during medical research and quality registrations.

Return to work was defined as the first time a patient-reported to have returned to performing the original work for a minimum of 50% of the original hours a week as stated in the patient's contract. We chose 50% return to work as our primary outcome since Dutch labour laws require patients to perform less than 50% of their original work to be allowed any form of compensation. If

the patients are working more than 50% of their original work, but perform adjusted work activities, they are legally still on sick leave in the Netherlands. The time to return to work was defined as the time in weeks between surgery and the return to work.

Costs of lost productivity

The costs of lost productivity can be defined as costs associated with production loss and replacement costs due to illness, disability, and death of productive persons, both paid and unpaid ¹⁰. These are the costs for the employer related to being less productive due to health problems. In this analysis, productivity loss is limited to sickness absence and does not include lower productivity due to functional limitations while being at work. We used the human capital method to calculate the costs of lost productivity: any hour that the patient does not work is considered as an hour of lost productivity. The human capital method multiplies the total of working hours lost due to health problems and rehabilitation treatment (like hand therapy) with the average costs of lost productivity per hour. The total working hours lost due to health problems and treatment were calculated by multiplying the median time to return to work by the patient population's average working hours a week. The average costs of lost productivity per hour were calculated as a weighted value of the mean income per hour for women (€32) and men (€38) in the Netherlands in 2012 ¹¹⁻¹³, resulting in €33.26 per hour for our patients. As a formula: total costs of lost productivity per patient = median time to return to work (weeks) X average working hours per week X €33.26. To estimate the costs of lost productivity for patients with specific characteristics, additive costs for subgroups compared to the costs of the entire cohort were calculated. Median survival was estimated using Kaplan-Meier curves. Continuous variables were split at the mean to create categories for the Kaplan-Meier curves.

To calculate the annual costs of lost productivity for the Dutch population, we estimated the number of patients that are surgically treated for trapeziometacarpal joint OA every year. According to open data of the Dutch healthcare authority, over the past five years, approximately 1500 patients were surgically treated each year ¹⁴. We then calculated the annual costs of lost productivity for the Dutch population by multiplying it with the individual costs. As a formula: total annual costs of lost productivity on population level = 1500 X Total costs of lost productivity per patient.

Statistical analysis

Univariate survival was estimated with the Kaplan-Meier method and the survival curves were plotted. Multivariate survival analysis was performed using a Cox proportional hazard model. The dependent variable was time to return to work. As independent variables, we included age, sex, duration of complaints, dominant side, occupational intensity, and whether surgery was performed as part of a second opinion. We also included MHQ scores for the operated and unoperated side in the Cox model to control for symptoms on the unoperated side. The major advantage of this model is that patients who reached retirement or did not complete any additional questionnaires were censored, thus dealing with loss to follow-up and minimising bias. For all tests, we considered a p -value smaller than 0.05 as statistically significant.

RESULTS

We included 627 patients. Patient characteristics are shown in Table 1.

Table 1. Baseline characteristics and hand function scores of the study population (627 patients).

Characteristic	Value
Age, mean (SD)	55 (6) years
Female patients, n (%)	493 (79)
Weekly hours work, mean (SD)	28 (11)
Occupation-physical labour, n (%)	
Light, medium, heavy	217 (35), 264 (42), 146 (23)
Dominant side, n (%)	
Right, left, bimanual	530 (85), 69 (10), 28 (5)
Duration of complaints, median (IQR)	24 (36) months
MHQ, median (IQR)	
Pain, work	35 (15), 50 (40)
<i>Operated side</i>	
general hand function	50 (15)
ADL, esthetics, satisfaction	45 (35), 81 (38), 29 (25)
<i>Unoperated side</i>	
general hand function	70 (15)
ADL, esthetics, satisfaction	90 (25), 94 (25), 75 (50)

MHQ: Michigan Hand Outcome Questionnaire [Range: 0-100]

ADL: activities of daily life.

SD: standard deviation; IQR: interquartile range

Return to work

In the first year after surgery, 78% of the patients returned to work. The median time [Q1, Q3] to RTW 12 [6, 29] weeks and the survival analysis curve for return to work is shown in Figure 1. The curve shows that few additional patients go back to work from about 20 weeks onwards.

The overall return to work was 87% for light, 76% for medium, and 70% for heavy physical labour. Figure 2 shows the Kaplan-Meier curves by occupational intensity. Overall return to work was the same in males and females. Twenty-five percent of the patients performing light physical work returned to work within the first three weeks, compared to seven and five percent for medium and heavy physical work.

When corrected for other patient characteristics, the occupational intensity of the patient's work remained associated with return to work (online table 1). Compared with light physical labour, patients with medium physical labour had a Hazard ratio (HR) of 0.54 (95%CI[0.42 – 0.69], $P < 0.001$) and patients with heavy physical labour had an HR of 0.50 (95%CI[0.37 – 0.67], $P < 0.001$). This means that the return to work within the first year after surgery is 46% lower when performing medium physical labour and 50% lower when performing heavy physical labour compared with light physical labour. In addition, patients with a lower score on the MHQ work and MHQ hand function of the unoperated side also had a longer period until return to work. More specifically, an increase of 1 point on the MHQ work and MHQ hand function of the unoperated side was associated with an HR of 1.02 (95%CI[1.02-1.03], $P = 0.001$) and an HR of 1.01 (95%CI[1.00-1.02], $P = 0.034$), respectively (online table 1). Patients who were operated on the dominant hand also had a delayed return to work with an HR of 0.745 (95%CI[0.60-0.93], $P = 0.008$).

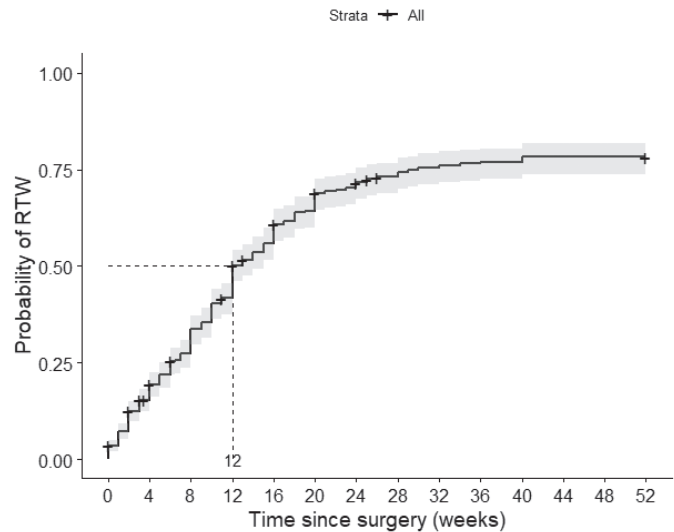


Figure 1. Kaplan-Meier plot of the overall return to work after surgery for trapeziometacarpal joint OA with a 95% confidence interval.

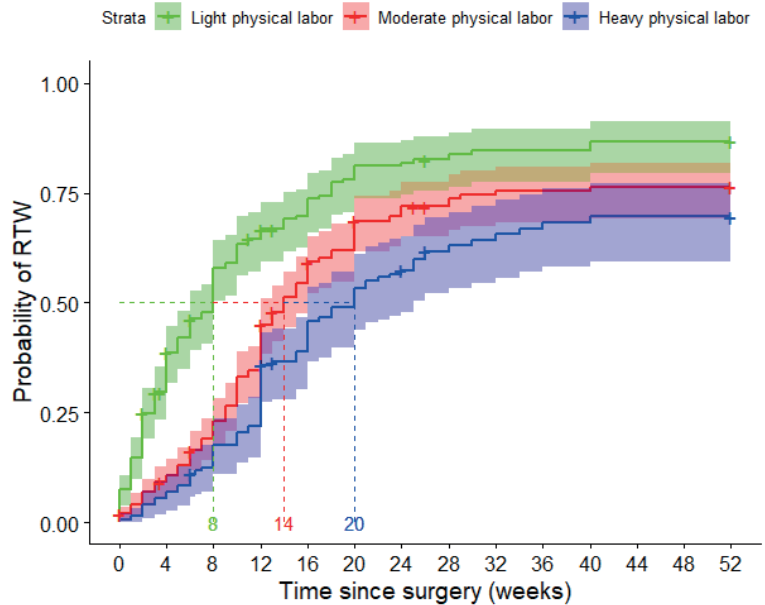


Figure 2. Kaplan-Meier plot of the return to work after surgery for trapeziometacarpal joint OA, stratified by different occupational intensities with corresponding 95% confidence intervals.

Costs of lost productivity

On a patient level, the total costs of lost productivity per patient in the first year after surgery were €11.175 (25%-75%; €5.588 – €27.007). The median costs of lost productivity increased from €7.450 in the light occupational intensity group to €18.626 in the heavy occupational intensity group (Online table 2). The costs of lost productivity were €2.794 higher in patients who were treated on their dominant side compared with the non-dominant hand.

Online table 1. COX-model for returning to work for 50% of the original contract hours, using patient characteristics and hand function scores in Michigan Hand Outcome Questionnaire (MHQ) [Range: 0-100] before surgery as covariates.

Variable	HR	CI	p-value
Age	0.987	[0.97 – 1.01]	0.198
Duration of complaints, years	1.000	[1.00 – 1.00]	0.557
Sex			
Male	Ref	Ref	ref
Female	0.835	[0.64 – 1.09]	0.191
Occupational intensity			
Light physical labour	Ref	Ref	ref
Medium physical labour	0.538	[0.42 – 0.69]	0.001
Heavy physical labour	0.499	[0.37 – 0.67]	0.001
Dominant side treated			
No	ref	Ref	ref
Yes	0.745	[0.60 – 0.93]	0.008
Second opinion			
No	ref	ref	ref
Yes	1.080	[0.81 – 1.43]	0.595
MHQ – Pain	1.000	[0.99 – 1.01]	0.985
MHQ – Work	1.021	[1.02 – 1.03]	0.001
MHQ - hand function (operated side)	1.001	[0.99 – 1.01]	0.745
MHQ - ADL (operated side)	0.995	[0.99 – 1.00]	0.104
MHQ - esthetics (operated side)	1.004	[1.00 – 1.01]	0.278
MHQ - satisfaction (operated side)	0.998	[0.99 – 1.01]	0.640
MHQ - hand function (unoperated side)	1.011	[1.00 – 1.02]	0.034
MHQ – ADL (unoperated side)	1.000	[0.99 – 1.01]	0.982
MHQ - esthetics (unoperated side)	1.000	[0.99 – 1.01]	0.964
MHQ - satisfaction (unoperated side)	0.997	[0.99 – 1.00]	0.428

Ref: Reference group

MHQ: Michigan Hand Outcome Questionnaire (MHQ) [Range: 0-100], assessed at baseline.

ADL: Activities of daily living

On a population level, the annual loss of productivity costs on the population level was €16,8 million. Since the costs of lost productivity are directly dependent on the median time to return to work, 50% of the total costs of lost productivity were made in the first 12 weeks after surgery.

Online table 2. Additional productivity costs for patient or disease characteristics, compared to the costs of the entire cohort.

	Median RTW (weeks)	Additive (€)	1y-costs (€)
Overall	12	-	11.175
Occupational intensity			
Light physical labour	8	-3.725	7.450
Medium physical labour	14	1.863	13.038
Heavy physical labour	20	7.451	18.626
Dominant side treated			
No	12	-	11.175
Yes	15	2.794	13.969
MHQ - Work, categorical			
Lower half (Mean = 29)	20	7.451	18.626
Upper half (Mean = 69)	10	-1.862	9.313
MHQ - hand function (unoperated side), categorical			
Lower half (Mean = 54)	15	2.794	13.969
Upper half (Mean = 82)	12	-	11.175

MHQ: Michigan Hand Outcome Questionnaire [Range 0 – 100], assessed at baseline.

DISCUSSION

In our patients, in the first year after trapeziectomy and ligament reconstruction with tendon interposition for trapeziometacarpal joint OA, 78% of the patients returned to work and 50% of the patients returned to work within 12 weeks. Factors associated with return to work were physical workload, whether the dominant hand was treated or not, the MHQ work, and hand function score of the unoperated side at baseline.

Our results show a quicker return to work than previous studies on return to work after surgery for trapeziometacarpal joint OA than reported by other authors. Wolf et al (2018) found a median time to return to work of 18 weeks (124 days) for women and 20 weeks (138 days) for men and Marks et al (2015)

reported an average of 10 weeks of fulltime sick leave. These differences in time to return to work may be explained by different definitions of return to work since there is a lack of consistency and comprehensiveness of return to work¹⁵. In addition to these methodological differences, differences in surgical procedures, post-operative treatment and rehabilitation may explain these different results. Tsehaie et al. (2019) found that a shorter immobilisation period of three to five days of plaster after trapeziometacarpal joint OA surgery may lead to quicker recovery.

Other studies have identified several identical factors associated with return to work. Neutel et al. (2018) reported the type of work as an important predictor for return to work in patients with a traumatic wrist injury. However, they also found that being a female increased the duration to return to work, which we were not able to corroborate in our patient population. Opsteegh et al. (2009) reported baseline pain to be a determinant of return to work in patients with hand disorders and hand injuries. Our findings do not support this result, but show that work impairments before surgery are more important than pain.

We found higher costs and economic burden than Marks et al.³ after trapeziectomy with LRTI or arthrodesis for trapeziometacarpal joint OA. The mean age of their population (64 years) was nine years older than our population (55 years). The difference in costs between both studies could be explained by lower productivity costs per hour, as Marks used values ranging between €16 and €24 whereas the weighted average in our study was €33. This difference partly stems from the fact that we used the total cost for the employer rather than the income of individuals. Also, our study was only performed in patients who had paid employment before surgery, whereas 63% of their population was unemployed. Other cohorts of trapeziometacarpal joint OA surgery patients reported that roughly 50% was unemployed before surgery³.

The indirect costs of trapeziometacarpal joint OA are high compared to the indirect costs of other types of surgery. For example, the cost of lost productivity of hernia surgery and total knee arthroplasty (Ruiz et al., 2013;¹⁶ €6451, and €3612, respectively, are almost two to three times lower than our reported costs. This difference is most likely because hand function is crucial for performing nearly all jobs.

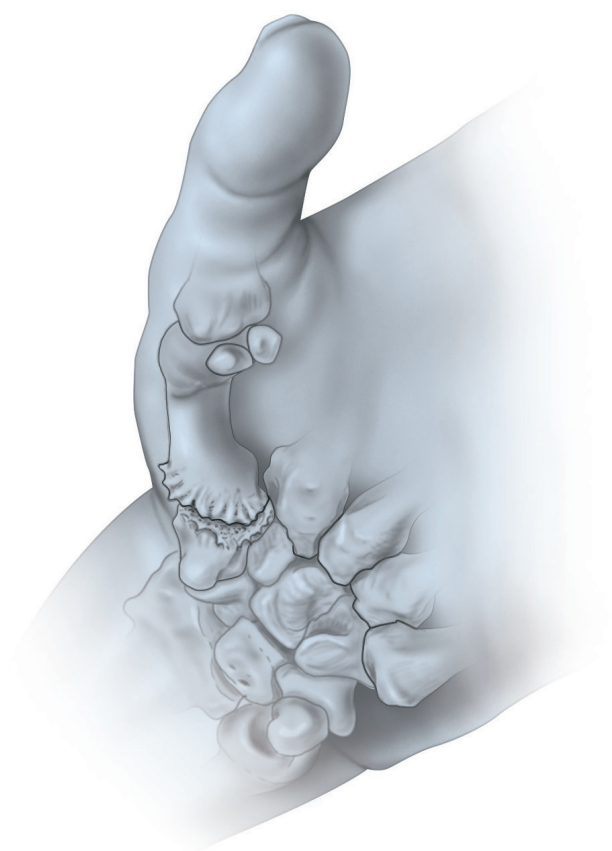
We were not able to make subgroups for different surgical procedures as the database does not provide reliable information on which LRTI was used. Also, we did not have any information on the recommendation of sick leave from the surgeon and on additional hand pathology such as scapholunate dissociations, which may have influenced the results. Furthermore, we estimated the time to return to work with subjective questionnaires. Databases with information from public services could have provided a clearer picture, but these were not accessible for us. Time to return to work in days or hours instead of weeks would make the economic evaluation more precise. Moreover, we did not have any information on whether patients returned to work quickly and stopped again due to complaints. The estimated costs in this study may be an absolute underestimation of the actual economic burden because we only included not attending work and did not take diminished functioning while attending work into account.

The factors that influence the return to work in the present study only partially explain the variance in return to work. Neutel et al. (2018) reported for return to work in patients with a traumatic wrist injury that having complications and blaming someone else for the injury also are predictors for a delayed return to work. Opsteegh et al. (2009) reported accident location, job autonomy, and symptoms of post-traumatic stress disorders to be determinants of return to work in patients with hand disorders and hand injuries. Work-related factors such as working relationships, accommodations, practical and physical limitations are known to influence return to work outcomes in patients with musculoskeletal conditions¹⁷. In other illnesses, psychosocial factors are also associated with return to work^{2, 18}, e.g. in patients with chronic back pain, more anxiety and depression were associated with later return to work. Psychosocial interventions might reduce the indirect costs of surgery for trapeziometacarpal joint OA due to a longer time to return to work. The influence of prior sick leave before the treatment should be investigated as studies in lower back pain, musculoskeletal illnesses or respiratory diseases¹⁹⁻²¹ found that sick leave pattern before the current episode was associated with longer sick leave during follow-up. Determining the optimal timing for treatment might reduce the length of sick leave after surgery.

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CHAPTER 17

THUMB CARPOMETACARPAL OSTEOARTHRITIS: POSITIVE EXPERIENCE WITH TREATMENT IS ASSOCIATED WITH BETTER SURGICAL OUTCOME

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ABSTRACT

Introduction: Although patients' experiences with the delivered care can influence treatment outcome, this relationship has not been examined for surgical treatment of thumb carpometacarpal joint (CMC) osteoarthritis. Therefore, the aim of the study was to investigate the association between patients' experiences with CMC arthroplasty and treatment outcomes in terms of patient-reported outcome measures (PROMS).

Methods: Included were eligible patients who received a Weilby procedure for CMC osteoarthritis in 17 outpatient clinics between 2011 and 2017. Before surgery and 12 months postsurgery, patients completed a PROM and the Michigan Hand Outcomes Questionnaire (MHQ) (0-100), and their therapists recorded strength measurements. In addition, at three months post-surgery, a patient-reported experience measure (PREM) (0-10) was completed. Regression analysis was used to examine associations between the different subscales of the PREM and the MHQ change scores, while adjusting for confounders.

Results: A total of 233 patients were included in the analysis. A significant positive association was found between the PROM (the MHQ) and the PREM, with the strongest associations for patients' experiences with i) information provision ($B = 4.8$, 95% CI 2.5-7.0, $p < 0.05$), ii) communication skills of the physician ($B = 4.0$, 95% CI 1.6-6.4, $p < 0.05$), and iii) postoperative care ($B = 3.7$, 95% CI 1.5 - 5.9, $p < 0.05$). No significant associations were found between patient experience and strength measurements. The PREM explained 3.2-8.4% of the variation between patients in the MHQ outcomes.

Conclusion: This study shows a positive association between experiences with healthcare delivery and PROMs in the surgical treatment of CMC osteoarthritis. The results highlight the potential importance of positive experience with the treatment process to improve treatment outcomes in patients undergoing surgery for CMC osteoarthritis.

INTRODUCTION

The context in which healthcare is delivered is an important part of a treatment, since the experience with healthcare delivery can contribute to treatment outcomes.¹ Treatment context can be broadly defined as all aspects of the therapeutic context (e.g., treatment rationale, response to treatment) or the healthcare environment (e.g., quality of facilities, hygiene) that may affect patient perceptions across the continuum of care.²⁻⁴ When these aspects have an effect on treatment outcomes which cannot be attributed to the treatment itself, they are called 'contextual effects'.^{5,6} In many conditions, influencing the treatment context, e.g. by improving the communication between patient and clinician, can improve patient-reported health status.⁷

To measure these contextual aspects of a treatment, questionnaires are available that can reliably record the patient's experience with the delivered healthcare: such questionnaires are called patient-reported experience measures (PREMs).⁸ These questionnaires often focus on different domains of healthcare experience, such as communication with the physician or other healthcare providers, involvement of the patient in the decision-making, delivery of postoperative care, and hygiene of the healthcare facilities. Together with patient-reported outcome measures (PROMs) and therapist-reported outcome measures (TROMs), which are measurements of clinical outcome, PREMs are increasingly used as a measure of quality of care.⁹⁻¹¹

Observational studies have shown an association between healthcare experience (measured with PREMs) and PROMs in emergency surgery and elective surgery.^{12,13} For example, in hip replacement surgery, better experience with the healthcare process was associated with better outcome as measured with the Oxford Hip Score.¹⁴ Another study showed that general practitioners (GPs) who received training in communication and pain evaluation prior to the treatment for osteoarthritis had significantly better outcomes, i.e. their patients experienced significantly less pain compared with patients whose GPs did not receive this training.¹⁵ Moreover, in hand surgery, empathy of the physician was the strongest driver of patient satisfaction, with 66% of the variation in patients satisfaction explained by the empathy of the physician.¹⁶

Currently, it is unknown why some patients have good outcome after surgery for CMC osteoarthritis, while others have less than optimal outcome and/or residual pain after surgery. Although a relation has been shown between expectations of treatment outcome and patient-reported outcome after treatment of CMC osteoarthritis¹⁷, to our knowledge no study has investigated the effect of the experience of the delivered healthcare on outcome after treatment of CMC osteoarthritis. To elucidate why some patients have good outcomes after CMC arthroplasty while others do not, it is important to take into account the effect of patient-reported healthcare experiences on postoperative outcome of patients treated for carpometacarpal osteoarthritis of the thumb.

Therefore, this study aimed to investigate which aspects of the experienced healthcare delivery are associated with better treatment outcome after surgery for CMC osteoarthritis in terms of both patient-reported outcomes and therapist-reported outcomes.

METHODS

Study design and setting

This cohort study was performed between February 2011 and April 2017 at Xpert clinic in the Netherlands. Xpert clinic is a specialized treatment center for hand and wrist problems. Xpert clinic has 17 different locations, with 16 European Board certified (FESSH) hand surgeons and over 50 hand therapists. The study was approved by the local institutional review board and written informed consent was obtained from all patients.

Included were patients who underwent surgery for their symptomatic CMC osteoarthritis. During the study period, no non-certified hand surgeons or fellows performed the surgical procedure. Patients were invited to fill in a PROM questionnaire prior to surgery and 12 months postoperatively. In addition, 3 months postoperatively, patients were also asked to fill in a PREM questionnaire to rate their experience with the delivered healthcare. To include a homogenous group, patients who underwent a surgical treatment other than the Weilby procedure were excluded from the analysis. Also excluded were patients who did not fill in either the PROM questionnaires or the PREM questionnaires.

Treatment

In the Weilby technique¹⁸, after a Wagner incision, first the trapezium was removed (while preserving the superficial nerve of the radial nerve). Then, the flexor carpi radialis distal pedicled tendon strip was intertwined in a figure of eight reconstruction round the abductor pollicis longus and distal flexor carpi radialis insertion. Lastly, the excessive tendon split was placed in the trapezial cavity as a spacer. Postoperatively, patients received plaster cast immobilization for 3-14 days. Thereafter, the cast was replaced by a custom-made removable splint. Hand therapists provided hand therapy, divided into two phases of six weeks. Phase one included instructions to wear the splint during heavy activities; this consisted of hand therapy to optimize the position of the thumb and to use a full thumb range of motion. In phase two, the splint was slowly phased out; the patient practiced the learned stability during daily activities and also improved thenar muscle strength.¹⁹ Patients performed home exercises 4-6 times a day. The number of prescribed home exercises ranged from 3-6 exercises, with 10-15 repetitions each.

Baseline demographics

Baseline characteristics of all patients (including age, gender, occupational status and hand dominance) were collected before start of treatment.

Patient-reported outcome measures (PROMS)

To evaluate treatment outcome, patients were invited to fill in the Michigan Hand Questionnaire²⁰⁻²² (MHQ, Dutch Language Version, MHQ; 0 = poorest function, 100 = ideal function) before surgery and at 12 months postoperatively. The MHQ is a self-reported questionnaire with six domains (pain, esthetics, hand function, performance of activities of daily living, work performance and satisfaction) and 37 items. For non-traumatic hand conditions, minimal clinically important difference (MCID) for the total MHQ ranges from 9-13 points.²³ Furthermore, all subdomains have excellent internal consistency, with Cronbach's alpha ranging from 0.86-0.97 for the subscales.²⁰

Patient-reported experience measures (PREMS)

To rate patients' perceived experience with the provided healthcare, patients completed a PREM questionnaire that is widely used in private practice clinics

in the Netherlands.²⁴ The PREM questionnaire consists of 25 items divided into six subscales to rate patients' perceived experience. The six subscales were: quality of facilities (6 items), physician communication and competence (6 items), perioperative care (4 items), postoperative care (4 items), treatment information (3 items), and general information (2 items). Each item was graded on a 10-point scale, where 1 represents 'very poor experience', and 10 'excellent experience'. The full questionnaire is published in the study of Poelstra et al.²⁴

Therapist-reported outcome measures (TROMS)

Using a Jamar-type hydraulic hand dynamometer, tip pinch and key pinch were measured by the hand therapist at baseline and at 12 months postoperatively. All strength measurements were recorded as the mean of three consecutive measurements²⁵ in accordance with the Dutch treatment guideline for CMC osteoarthritis.¹⁹ The MCID was 0.33 kg for tip pinch and 0.84 kg for key pinch.²⁶

Statistical methods

Data for this study was collected during daily clinical practice, which led to some attrition at follow-up (Fig. 1). Because of this non-response, a thorough non-responder analysis was performed to compare patients that did and those that did not fill in the questionnaires at 3 months, using Chi-square statistics or t-tests for all variables measured at baseline based on the response at 3 months.

Paired t-tests were performed to investigate whether the change in outcome measured in both PROMS and TROMS at 12 months post-surgery was significant. Linear regression analysis was used to examine the univariable relationship between PREMS and the change in outcome after surgery (PROMS + TROMS) and were reported as beta coefficients.

To examine the extent to which the variation in treatment outcomes between patients could be explained by the experience of the delivered healthcare, explained variance (R^2) was calculated for treatment outcomes when all PREM subscales were entered simultaneously in a multiple linear regression model. All analyses were done using R statistical computing, version 3.3.3. For all tests, a p-value ≤ 0.05 was considered statistically significant.

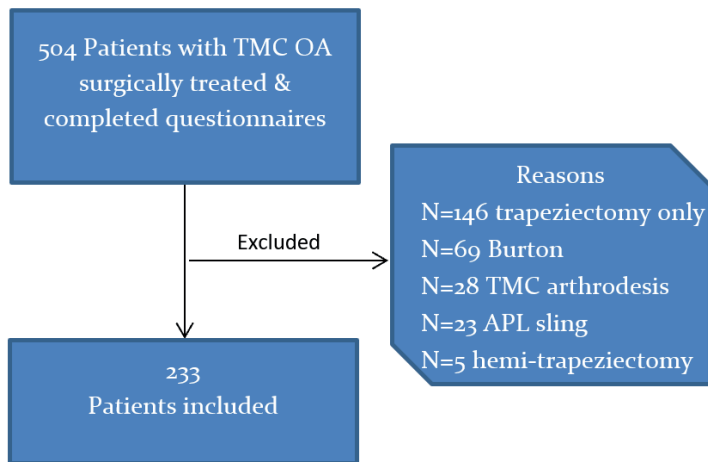


Figure 1. Flowchart showing the selection of patients and the reasons for exclusion. Of the 504 identified patients, 233 were included for the analyses.

Abbreviations: CMC OA = Carpometacarpal osteoarthritis; APL = Abductor Pollicis longus; PROM = Patient- Reported Outcome Measure; PREM = Patient-Reported Experience Measure.

RESULTS

Between 2011 and 2017, a total of 504 patients with CMC osteoarthritis were operated. After applying the exclusion criteria, 233 patients were included for a complete case analysis (Fig. 1). At baseline, no significant differences were found between patients that filled in all the questionnaires and those that did not fill in all the questionnaires at follow-up, except for a small but significant difference in MHQ work (see Supplementary Table 2). The mean age of the patients was 59.3 (SD ± 7.9) years, and 82% of the patients were female. Furthermore, 48% was either unemployed or retired, and 48% had surgery on their dominant hand. At 12 months post-surgery, all improvements in MHQ total and MHQ subscales were significant and clinically important (i.e. they exceeded the MCID described in Methods), except for the MHQ subscale 'esthetics' (Table 1). Change in the therapist-reported outcomes key pinch strength at 12 months post-surgery was not significant, whereas the improvement in tip pinch strength was significant and clinically important (Table 1). Lastly, on average, patients had very high satisfaction with the whole treatment experience, with all subscales of the PREMS scoring ≥ 8.0 on a 1-10 scale.

Table 1. Preoperative and postoperative outcome scores.

	Preoperative	Postoperative
PREM scores: median (IQR)		
Physician: communication & competence		8.3 (7.8-9.0)
Perioperative care		8.5 (8.0-9.0)
Postoperative care		8.4 (8.0-9.0)
General information		8.2 (8.0-9.0)
Treatment information		8.3 (7.7-9.0)
Quality of facilities		8.4 (7.8-9.0)
PROM scores: mean (SD)		
Total	48 (13)	69 (19)*
General function	47 (16)	63 (18)*
ADL	49 (21)	76 (22)*
Pain	33 (13)	60 (23)*
Esthetics	79 (21)	85 (20)*
Satisfaction	28 (17)	65 (28)*
Work	44 (23)	64 (28)*
Objective outcome scores (SD)		
Key pinch	4.4 (2)	4.8 (2)
Tip pinch	18.9 (9)	24.8 (9)*

* $p < 0.05$. Abbreviations: IQR = Interquartile range, ADL = Activity of daily living

Regression analysis showed a positive association between PREM subscales and PROM subscales, with the ‘general information’ subscale of the PREM having the highest association with the change in PROM subscales (Table 2). Beta coefficients of the regression analysis are presented in Table 2 and show, for instance, that each 1-point improvement in PREM subscale general information (1-10) resulted in an 8.1-point increase on the MHQ satisfaction subscale (0-100). In contrast to the PROMS, no significant association was found between the PREM subscales and change in key pinch or tip pinch strength.

Multiple regression analysis showed that, when combining all the individual PREM subscales into one model to match the PROM, the PREM subscales explained 3-8% of the variation in patient-reported outcome between patients (Table 2, bottom row). The PREM subscales had the strongest association with the total score of the MHQ, with 8.4% of the variance explained by the subscales of the PREM. Again, no associations were found between PREM subscales and change in key pinch or tip pinch strength.

PREM	Total	Change in PROM					Change in TROM	
		General function	ADL	Pain	Esthetics	Satisfaction	Work	Key pinch
Physician communication	4.0	1.2	4.7	5.5	3.5	5.9	5.4 (0.1
& competence	(1.6 - 6.4)*	(-1.7 - 4.0)	(1.1 - 8.2)*	(2.3 - 8.7)*	(-0.1 - 7.0)	(1.8 - 9.9)*	1.5 - 9.3)*	(-0.3 - 0.6)
Perioperative care	2.5	1.0	2.8	3.1	0.9	5.3	3.4	0.2
	(0.0 - 5.0)*	(-1.9 - 3.9)	(-0.8 - 6.5)	(-0.3 - 6.4)	(-2.6 - 4.6)	(1.1 - 9.4)*	(-0.6 - 7.4)	(-0.2 - 0.6)
Postoperative care	3.7	1.7	4.6	4.1	3.0	5.0	5.0	-0.2
	(1.5 - 5.9)*	(-0.8 - 4.3)	(1.4 - 7.8)*	(1.1 - 7.0)*	(-0.2 - 6.3)	(1.3 - 8.7)*	(1.4 - 8.5)*	(-0.5 - 0.2)
General information	4.8	3.2	5.7	5.3	4.0	8.1	4.4	0.1
	(2.5 - 7.0)*	(0.5 - 5.9)*	(2.3 - 9.0)*	(2.2 - 8.3)*	(0.6 - 7.3)*	(4.3 - 11.8)*	(0.7 - 8.1)*	(-0.3 - 0.6)
Treatment information	3.6	0.7	3.0	3.9	4.7	6.2	3.8	0.0
	(1.3 - 5.9)*	(-2.0 - 3.3)	(-0.3 - 6.4)	(0.8 - 6.9)*	(1.4 - 8.0)*	(2.4 - 10.0)*	(0.1 - 7.5)*	(-0.4 - 0.4)
Quality of facilities	4.5	1.9	3.6	5.8	5.0	6.1	6.5	0.2
	(1.7 - 7.3)*	(-1.3 - 5.2)	(-0.5 - 7.7)	(2.1 - 9.5)*	(0.9 - 9.1)*	(1.4 - 10.8) *	(2.0 - 11.0)*	(-0.3 - 0.7)
Explained variance (R ²)	8.4 %*	3.2 %	6.7 %*	7.1 %*	4.7 %	7.8 %*	5.0 %	4.4 %
								0.0 %

Table 2. Univariable regression analysis of the association between experience with the delivered healthcare (PREM) and outcome after surgery (PROM + TROM), displayed as beta-coefficients (with 95% confidence interval). Bottom row presents the results of the multiple regression analysis and shows how much of the variation in the subscales of the PROMS are explained by the PREM, when the PREM subscales are combined in one model to reflect the different subscales of the PROM and TROM.

DISCUSSION

The main objective of this study was to investigate which aspects of experienced healthcare delivery are associated with treatment outcomes after surgery for carpometacarpal osteoarthritis of the thumb. It was found that patients who reported a more positive experience with the delivered healthcare had better self-reported outcomes in terms of pain and function. Patient experiences with i) general information provided to patients and ii) better postoperative care delivery, were most strongly associated with a positive change in treatment outcomes. In contrast, no association was found between the experience of the delivered care and therapist-reported outcomes of hand strength. Lastly, PREMs explained 3-8% of the variance in the change in therapist-reported outcome.

Our findings are in line with similar studies, but with different patient populations. For example, in patients undergoing knee or hip replacement, Black et al.¹⁴ found that communication and trust in their doctor had the highest association with patient-reported outcome. We found similar results, with strong univariate associations between physician's communication and patient-reported outcome in terms of pain and satisfaction.

Since the role of treatment context on outcomes in hand surgery has not yet been thoroughly studied, it is difficult to compare our results with other studies. However, Poelstra et al.²⁴ who examined the association between treatment context and treatment outcome after Dupuytren's disease, showed that treatment context was also positively associated with PROMS. More specifically, they found that the subscales 'physician communication', 'postoperative care' and 'treatment information' were most strongly associated with outcome. We found very similar results, with a strong association between the subscales 'physician communication' and 'general information' and patient-reported outcomes.

In addition, Menendez et al.¹⁶ showed that one aspect of treatment context, i.e. the perceived empathy of their physician, was correlated with higher overall satisfaction with their provider. Our study showed that also other aspects of treatment context, e.g. perioperative and postoperative care, are associated with treatment outcomes in terms of pain, function and satisfaction.

Although our study had an observational design, an intervention study by Basch et al.²⁷, examining the effects of symptom monitoring during routine cancer

care, showed that patients who received symptom monitoring during their cancer treatment had less decline in quality of life compared to patients who received usual care (1.4-point v 7.1-point drop; $p < 0.001$). More interventional research is required to assess whether improving various aspects of healthcare delivery in surgical treatments for CMC osteoarthritis leads to better treatment outcomes.

There are many reasons why the experience of healthcare delivery is associated with patient-reported outcomes. For example, we found that the general information provided on the website and the brochure had the highest association with outcomes after surgical treatment for CMC1 osteoarthritis. As we designed and produced a video for our website showing which steps are performed during surgery and what the entire treatment will consist of (including the postoperative rehabilitation process), patients may have felt they knew what to expect, which may have resulted in better postoperative exercise adherence, which may have led to better treatment outcomes.

Another explanation is that providing adequate information on general treatment, and good communication with the patient, may lead to altered expectations of outcome. It is becoming clearer that treatment expectations are a cornerstone in context effects²⁸ and can be adjusted by either discussing treatment beliefs²⁹, using an empathetic communication style³⁰, or by performing short psychological interventions in forms of therapy.^{12,31} In addition, a trustful caregiver-caretaker relationship where patients feel understood and taken seriously may lead to better postoperative rehabilitation treatment adherence which may lead to better patient-reported treatment outcome.³² The present study did not find a positive association between treatment context and strength measurements, possibly because no marked improvements were seen in strength post-surgery.

Our study has a several strengths and limitations. The main strength is the large sample population and the observational study design. Another strength is the relatively high level of generalizability, since our data were collected in daily clinical practice instead of the more controlled setting of a randomized controlled trial. In addition, the collection of data took place in 17 outpatient clinics throughout the Netherlands, providing a representative sample of the population of patients with CMC osteoarthritis. Furthermore, the well-validated and tested MHQ was used to measure the PROMs.

A limitation of the study is that the PREM questionnaire has not yet been thoroughly tested and may have omitted other important aspects of treatment context. For example, the validated OAS-CAHPS questionnaire includes questions on the recovery period after surgery, which our PREM questionnaire did not include.³³

Furthermore, an important part of contextual effects is the expectations of the patient regarding the treatment. Patients who have more positive or optimistic expectations may have reported more positive experiences with the delivered healthcare, irrespective of the actual delivered care; this may be a confounder and warrants more research.

A critical note is that it is impossible to know whether the associations found are causal, i.e. it remains unclear whether patients have a better outcome because of the better experience, or whether they have better experience because of a better outcome. Future studies with an appropriate design should further investigate this topic.

Finally, we could only include 233 of the initial 504 patients in our complete case analysis. However, our analysis of the patients who did not complete all questionnaires showed only a slight significant difference on the work subscale of the MHQ.

In conclusion, the present study shows that experience with the delivered care of patients with CMC osteoarthritis is positively associated with patient-reported outcomes, whereas no association was found between experience with the delivered care and therapist-reported outcomes. This study highlights the potential importance of positive experiences with the treatment process for improving treatment outcomes in patients treated for CMC osteoarthritis. Educating surgeons and other healthcare providers about such contextual effects may be a valuable addition to their skillset.

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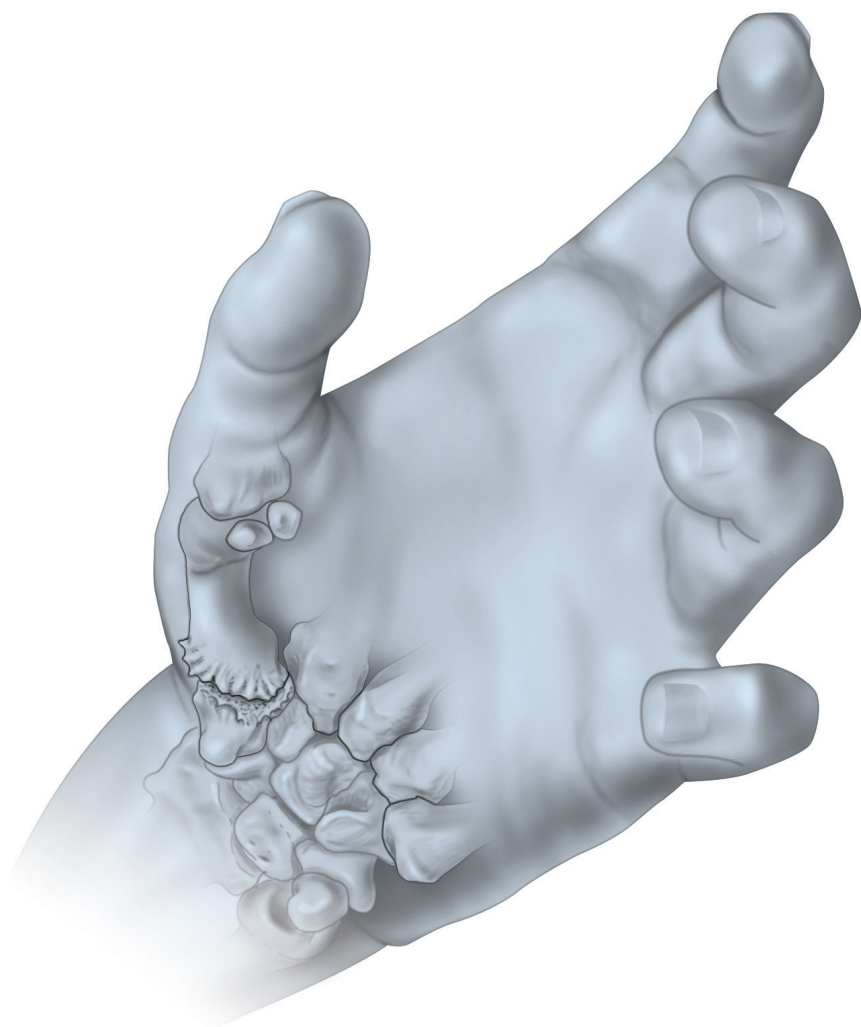
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APPENDIX

Supplementary Table 1. Baseline characteristics of not included and included patients

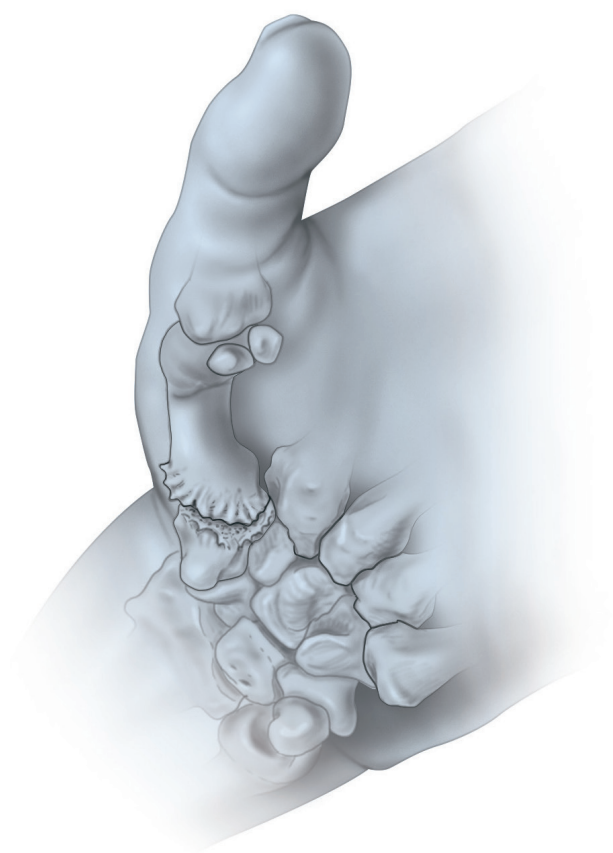
Variables	Not included patients (n=271)	Included patients (n=233)	p-value
Mean age: years (SD)	60 ± 9	59 ± 8	0.11
Sex (% female)	77.9	82.0	0.24
Occupational intensity (%)			0.40
Unemployed/retired	48.4	42.5	
Light	18.3	21.5	
Moderate	21.4	23.6	
Heavy	12.0	12.4	
Surgery on dominant hand (% yes)	48.3	44.8	0.29
MHQ Total	49 ± 14	48 ± 13	0.23
MHQ General hand function	48 ± 17	47 ± 16	0.15
MHQ ADL	52 ± 22	49 ± 21	0.12
MHQ Pain	34 ± 15	33 ± 13	0.81
MHQ Esthetics	76 ± 22	79 ± 21	0.10
MHQ Work	47 ± 25	44 ± 23	0.02
MHQ Satisfaction	29 ± 19	28 ± 17	0.21

Abbreviations: MHQ = Michigan Hand questionnaire, ADL = Activity of daily living



PART 4

DISCUSSION AND SUMMARY



CHAPTER 18

GENERAL DISCUSSION

GENERAL DISCUSSION

This thesis addresses how psychosocial factors are associated with outcomes of treatment for thumb base osteoarthritis (OA). The discussion follows the structure of the thesis: 1) the introduction to the cohort and innovation in data collection, 2) psychosocial effects in patients who receive nonsurgical treatment for thumb base OA, and 3) psychosocial and occupation effects in patients who receive surgical treatment for thumb base OA. Conclusions, limitations, and future perspectives will be discussed separately for each part.

Part 1 – Introduction to the cohort and innovation in data collection

The aims of this part were: 1) to describe the prevalence of thumb base osteoarthritis, 2) to describe the observational health data collected as part of routine outcome measurements used in this thesis, 3) to find ways to optimize observational health data collection, and 4) to describe how much patients contribute their complaints to their illness (i.e., their illness perception).

In Chapter 2, we found that the prevalence of radiological thumb base OA doubles every 11 years and is higher in women than in men. Furthermore, in Chapter 3, we showed the successful design and implementation of a routine outcome measurement system, made feasible using a highly automated data collection infrastructure. In Chapter 4 we explained how the routine outcome measurements of Chapter 3 are used in daily clinical care. We showed that routine outcome measurements are used to facilitate shared decision making, evaluate care and ultimately, improve care. We demonstrate in Chapters 5 and 6 that two common hand-specific patient-reported outcome measurements can be shortened without loss of data quality to facilitate faster and more efficient data collection in routine outcomes. Our shortened questionnaires use machine learning to reduce the number of questions to a maximum of six while maintaining an ICC of 0.94 with the Boston Carpal Tunnel Questionnaire and .97 with the Patient Rated Wrist Evaluation. Finally, in Chapter 7, we found that patients with thumb base OA have a more negative perception of their illness than patients with other common hand conditions (e.g., Dupuytren's disease or trigger finger) before the treatment. Most of all, these patients experience more symptoms and are more concerned about their illness. This could be as a result of the amount of pain and functional problems patients experience.

This information can provide hand surgeons with more insight into the patients' mindset and the differences between patient groups.

Limitations

The studies in Part 1 have several limitations.

First of all, in our systematic review in Chapter 2, we were only able to study the prevalence of radiographic thumb base OA, while clinically symptomatic thumb base OA might be more interesting. While our meta-analysis shows that up to 72% of the general population has thumb base OA on an x-ray, this does not correspond with the number of patients presenting with symptomatic thumb base OA. This discrepancy is remarkable, and understanding what drives this discrepancy will help us understand how we can treat patients. To understand this process, we could focus on two areas; which factors determine which patients develop symptoms and which factors determine when patients with symptoms report to a doctor to be treated? Answers to the first question may help explain the underlying biological process. For the second question, one hypothesis is that patients with a more negative psychosocial profile are more likely to report symptoms. If this is indeed the case, a psychosocial intervention alongside the biological treatment might improve outcomes.

The major limitation of our routine outcome measurement system, described in Chapter 3, is that it did not use a standardized set of outcome measures. However, at the time of implementation, no such set was available. Therefore, recently, an international standard set for hand and wrist conditions was developed. When implemented internationally, this will allow (inter)national benchmarking for outcomes and provide even more value to the routine outcome measurement system.

A limitation of both shortened (decision tree) questionnaires in Chapter 5 and 6 is that they were developed with data from the complete questionnaire. This did not allow us to validate the short questionnaire but only show its potential. By changing the order of questions, the answers might change due to anchoring[ref]. To use the short questionnaire, we will need to make sure that changing the order of the questions does not alter the results of the questionnaire.

Implications

Routine outcome measurements are an important step towards improving patient-centered care and value-based healthcare. In Chapter 3, we showed that incorporating routine outcome measurements into daily practice is feasible when everyone in the clinic contributes. For example, we found that data collection stalled when hand therapists were not aware of their important role in the routine outcome measurement system.

While important, implementing an outcome measurement system is only the first step towards more patient-centered care. In Chapter 4, we showed the first steps that have been taken to implement routine outcomes in daily clinical care and how they changed daily care. Doctors and therapists, preferably in cooperation with epidemiologists and statisticians, can use the collected data to collectively optimize care even further. For example, by making and validating prediction models, doctors and therapists have more insight into the expected results and could use this information during shared decision-making. In order to work optimally, clinicians need to be in constant communication with scientists about their needs for such models and how they want these models to work. The future of routine outcome measurements incorporates this practice of ‘closing the loop’ and uses this to optimize care for patients even further than what we showed in Chapter 4. For example, routinely collected data can be used to compare different approaches to care (e.g., surgical techniques, patient-doctor interactions) and choose the optimal approach. A practical example is a study by Tschäpe et al., in which surgeons collectively shortened patients’ immobilization after surgical treatment for thumb base OA. The study evaluates this change and shows that shorter immobilization was as safe and effective but offers more comfort for patients. For clinicians without easy access to scientists, these last steps of value-based healthcare are harder to incorporate. A solution could be to develop systems that can autonomously collect data and evaluate treatments based on those data. Future research could focus on two aspects of such systems.

First, the systems need to be able to collect data without too much manual input. To date, our outcome measurement system only distributes Patients Reported Outcome Measures (PROMs) after a hand therapist has assigned them to a patient. This can be improved when the PROMs are collected seamlessly based on information in an Electronic Healthcare Records (EHR). When this can be

done with all different EHRs, any clinician can start collecting data. Second, these systems should automatically be able to return data to the clinician. Clinicians would need to see the collected data themselves, preferably readily available in the EHR. If this is the case, they can make treatment decisions based on this data. If such systems are developed, value-based healthcare becomes available for every clinician.

To optimize these routine outcome systems and their impact on care, completeness of data is important but also a challenge. To achieve this, patients need to be incentivized to complete questionnaires. One of the ways to do so is to offer shorter questionnaires that provide the same data. Decision trees, as presented in Chapters 5 and 6, contribute to this. However, they need to be validated to make sure they offer the same information. Future studies could randomly assign a normal or a decision tree questionnaire to patients and the extent to which they provide the same scores.

If these decision trees prove useful, more parts of the data collection might be made more efficient by using decision trees. For example, instead of offering all mindset questionnaires to patients, we might only ask them to complete a decision tree based screener and only ask them to complete more questions if the screener shows patients have a negative mindset. Especially for PROMS in the field of hand surgery, this seems to be redundancy in current questionnaires. Currently, we use only five questions to ask patients about their quality of life, while we use more than 50 questions to gain insight into their hand specific quality of life. Shorter, more efficient questionnaires for all data we collect could be important to learn as much as possible from our patients without burdening them too much with lengthy questionnaires. How missing data influences outcomes and how this can be minimized will be discussed later in this discussion.

Part 2 - Psychosocial effects in patients who receive nonsurgical treatment for thumb base osteoarthritis

In Part 2, we examined the effect of the patients' mindset on nonsurgical treatment outcomes for thumb base OA. First, in Chapter 8 we showed that the patients' mindset explains a large portion of the variance in patient-reported pain before the nonsurgical treatment for thumb base OA. More specifically,

42% of the variance in pain before treatment was explained by the patients' psychological distress, pain catastrophizing, and their perception of the illness. In contrast, patient characteristics only explained 6% of the variance in pain and radiographic findings were not associated with pain before the treatment. Second, in Chapter 9 and 10 we found that patients with higher outcome expectations have less pain, better hand function, and are more satisfied with the result of the nonsurgical treatment. Moreover, patients with a good understanding of their illness had worse hand function. These findings suggest that actively changing the patients' mindset might improve outcomes. Therefore, in Chapter 11, we observed the extent to which patients' mindset changes during nonsurgical treatment – without an active psychological intervention – and whether this change is associated with change in pain. We found that patients who reported a reduction in psychological distress, who become more optimistic, and who perceive fewer consequences from their illness, have more decrease in pain during the first three months of nonsurgical treatment for thumb base OA. These results suggest that when surgeons and therapists are actively changing the patients' mindset, outcomes of nonsurgical treatment will improve.

Part 3 - Psychosocial and occupation effects in patients who receive surgical treatment for thumb base osteoarthritis

In Part 3, we examined the effect of the patients' mindset on the outcomes of surgical treatment for thumb base OA. First, we found in Chapter 12 that at the start of surgical treatment – after unsuccessful hand therapy treatment – patients have a more negative mindset than the general patient population at the start of hand therapy treatment. Second, in Chapter 13 we showed that at the start of surgical treatment for thumb base OA, patients with a more negative mindset also report more pain and less hand function. These findings support the hypothesis that patient-reported pain and hand function at the start of treatment might improve by positively influencing the patients' mindset. Third, we studied the relationship between psychosocial factors and outcomes of surgical treatment. We studied outcomes of surgical patients 24 hours after surgery (Chapter 14) and at one year follow-up (Chapter 15) and found that patients with a more negative mindset have worse outcomes. This suggests that even during the rehabilitation after surgery, changing the patients' mindset might improve outcomes. Moreover, in Chapter 16 we found that patients with heavier

physical jobs return to work later. Patients with light physical labor return to work in 8 weeks, moderate physical labor in 14 weeks, and patients with heavy physical labor in 20 weeks. Surgeons can use this information to inform their patients regarding sick leave and promote an earlier return to work. Finally, in Chapter 17 we found that a higher appraisal of the delivered care (i.e., doctor competence, provided information) was associated with better outcomes (i.e., better hand function and less pain). When surgeons and therapists spend more time to improve the patients' mindset, this might also improve the patients' experience of the treatment and thus the outcomes of the treatment.

Limitations

The studies in Part 2 and 3 have similar limitations. We will discuss five major limitations.

First, all studies used a complete case analysis, which included only data from patients who completed all questionnaires. The disadvantage of this method is that it can lead to selection bias. If patients with worse outcomes feel less inclined to complete questionnaires, the results will not reflect this and thus be biased. Without specific studies, we are never able to show that this is not the case. However, we can provide circumstantial evidence that would suggest that no selection bias has occurred. We found that missing data was not dependent on any patient, disease, or baseline characteristics. This suggests that the data is not missing not at random (MNAR). Next to increasing compliance, described earlier in this discussion, statistical methods can provide solutions to this problem. Using multiple imputations, the missing data can still be used and might provide even less biased results than complete case analyses. While these techniques are widespread in current literature, they are not widely adopted in orthopedic and (hand)surgical literature. As a result, reviewers in orthopedic and (hand)surgical literature are skeptical to accept papers that utilize multiple imputations. Therefore, we chose to use complete case analyses. Future research should make efforts to publish papers that use multiple imputations and thereby minimize the bias that can be caused due to missing data.

Second, all studies utilize PROMs. While PROMs provide a more personal perspective to the disease, they have some limitations. All measurements, including PROMs, have some measurement error; if patients complete the same

questionnaire within a week, they will not answer precisely the same. Therefore, we cannot distinguish the true change in any outcome measurements from measurement error due to this error. Several concepts have been developed to deal with this, for example, the minimal detectable change or the minimal clinical important difference (MCID). If change on a PROM exceeds this MCID threshold, we know that those patients often are more satisfied with their health, and thus, the change is most likely not due to measurement error. Comparing change in PROMs with MCID levels is therefore essential. Furthermore, PROMs were introduced to gain insight into the patients' perspective of the disease. While many support these changes, some are still skeptical, especially for thumb base OA. While we, and others, showed that the radiographic stage of OA does not correlate with the pain that patients report, some still believe that pain in patients with thumb base OA is only a result of changes in bone morphology and that staging drives treatment choice¹. Meanwhile, numerous studies have shown that by measuring and using PROMs, doctors can gain insight into the patients' perspective, which results in more shared decision making and better outcomes²⁻⁵.

Third, most of the studies were conducted in a privately-owned clinic that offers public services. Due to the lack of an ICU, the clinic is not allowed to perform surgery on patients with an ASA classification of three or higher. This indication might result in a patient population that is not representative and thus not generalizable. However, the results of this thesis are comparable with results acquired in a tertiary hospital in the United States⁶⁻⁹. While they report a more negative mindset than, for example, the patients described in Chapters 9 and 15, the relationship between the patients' mindset and outcomes has the same direction and magnitude as the associations found in our studies in these chapters. This suggests that we measured the same underlying linear trend, but in a population with a slightly more positive mindset.

Fourth, specifically in Part 3, our studies describe a select population, namely, only patients who failed to reach a satisfactory result during hand therapy treatment and choose to convert to surgical treatment for thumb base OA. Approximately 15% of all patients who start hand therapy treatment for thumb base OA end up converting to surgical treatment. By selecting only these patients who opt into surgery, we might select a specific group. Results from

this group cannot be extrapolated to the entire group (hand therapy and surgical treatment). While this tiered approach in the treatment for thumb base OA is standard in the Netherlands, it might be different for other countries. If patients are scheduled for surgery without receiving hand therapy first (e.g., in countries without a strictly tiered treatment guideline), this might alter the association between the patients' mindset and outcomes. If we can find a cohort of patients who receive surgery without receiving hand therapy first, we could examine if this is indeed the case.

Finally, and most importantly, due to the research's observational nature, all results in Chapters 8 through 17 are associations. Therefore we cannot conclude there is a causal relationship between the patients' mindset and outcomes. This thesis is written based on the hypothesis that a more negative mindset causes worse outcomes. While it is essential to formulate a hypothesis, observational research can never confirm them. Without this confirmation, it is still possible that all the associations we have found in this thesis do not have the opposite direction (i.e., high pain causes patients to have a negative mindset).

Implications

We showed that psychosocial factors are associated with outcomes in patients with thumb base OA, but we have not proven a causal relationship. This section will discuss what could be done to make a causal relationship more plausible and recommends several steps towards using the biopsychosocial model to improve the outcomes of patients with thumb base OA. The criteria formulated by Bradford Hill¹⁰ will be used to illustrate which criteria are fulfilled with research in this thesis and which criteria need to be fulfilled using future research.

In 1965, Hill formulated nine criteria that would suggest a causal effect¹⁰. We will address the five most important criteria for our population to illustrate the extent to which we can assume that the associations between patients' mindset and pain and hand function, that we found in this thesis, are in fact causal relationships. First, Hill states that only *strong* associations can potentially be causal. Hill stresses that the relative effect size is even more important than the absolute effect size. In the case of the patients' mindset, our study in Chapter 9 shows that more positive patients (8% lower psychological distress, 2% lower pain catastrophizing, 4% lower outcome expectations, and 10% higher illness

perceptions) reported 50% less pain three months after nonsurgical treatment for thumb base osteoarthritis as compared to average patients. This relatively strong effect supports this causal relation criterion. Second, Hill proposed that *consistency* in the findings is key. This criterion means that different studies in different settings should find the same results. Throughout this thesis, we find that illness perceptions and outcome expectations are associated with patient-reported outcomes. This is consistent with findings in other orthopedic illnesses. For example, studies with total knee arthroplasties also found that the patients' mindset is associated with outcomes¹¹. This supports the consistency criterion, both within this thesis and even within similar conditions. Third, Hill states that a *biological gradient* or dose-response relationship should be present. For example, the rate of lung cancer is associated with the number of cigarettes a patient smokes. Our use of linear regression models allows us to identify such gradients. In Chapters 9 and 15, we found that the pre-operative or pre-therapy patients' mindset is associated with the amount of complaints at follow-up. This suggests that a dose-response relationship is present between the patients' mindset and outcomes of thumb base OA. Fourth, the criterion of *plausibility*. About this criterion, Hill states the following: "It will be helpful if the causation we suspect is biologically plausible. But this is a feature I am convinced we cannot demand. What is biologically plausible depends upon the biological knowledge of the day." While placebo treatments' biological effect has been proven extensively¹²,¹³, no biological pathway has been found that explains the associations between patients' mindset and outcome in elective (hand) surgery. One study showed changes on a biological level from an intervention on outcome expectations¹⁴. While this is remarkable, it does not provide an entire pathway to explain these differences. We do not have direct evidence that a plausible, biological pathway exists, but circumstantial evidence suggests that this will be found in the future. Finally, the *Experiment* criterion needs to be considered. Hill states, "Here the strongest support for the causation hypothesis may be revealed." If actively changing the environment leads to the expected outcomes, this proves a causal effect. Currently, only controlled (and randomized) experiments provide sufficient evidence to speak of a causal relationship. For the relationship between the patients' mindset and outcomes of hand surgery or hand therapy, such a study has not been performed.

Future research

As obvious from the Hill model, an experimental study showing that improving mindset leads to better outcome would be the strongest proof of a causal relation. An intervention might be to allocate additional consultations with a psychologist to intervene in the patients' mindset. We could then evaluate if these additional consultations change the patients' mindset and whether patients with these additional consultations have better outcomes than patients who did not receive the additional consultations. While the study seems simple, it would have several limitations. First of all, to prevent selection bias and confounding, the consultations need to be randomly assigned. Second, it is hard to determine if the effect comes from the psychologist (and the change in mindset) or just the additional consultations. If this intervention does prove effective, it remains to be seen if this intervention is cost-effective, since this intervention requires allocation of resources to all patients. However, not all patients might benefit from this expensive intervention and therefore this intervention is most likely not cost-effective and might therefore never be used in daily care.

To prevent interventions that are not cost-effective, we could think about ways to incorporate a mindset intervention into routine care. We could investigate if it is possible to incorporate it into the standard consultations by hand therapists and hand surgeons. An extensive (online) training program that empowers hand therapists and hand surgeons to discuss and optimize the patients' mindset might be cost-effective. This online program could teach surgeons and therapists to optimize patients outcome expectations. The general strategy of outcome optimization is to maximize the placebo response and minimize the nocebo response. The nocebo response is "a negative symptom induced by the patients' own negative expectations and/or by negative suggestions from clinical staff in the absence of any treatment"¹⁵ (e.g., patients reported more side-effects when national media covered it). There are several ways the nocebo effect can be introduced. However, most likely, they are introduced during the informed consent process. Clinicians have to explain side effects but can thereby introduce a negative treatment context^{16, 17}. Teaching clinicians to provide this necessary information without invoking nocebo responses could reduce side effects and increase patients' overall outcome. Maximizing the placebo effect could prove to be more difficult and requires a more active intervention from clinicians. One way to do so would be to promote the sense of personal control

over the disease. Suppose patients feel they are in control of the outcome of their illness. In that case, they will most likely have a better outcome. Patients with more personal control will also adhere better to treatment regimens (e.g., hand therapy visits). Additionally, it might be possible to increase the general expectations of patients. For example, research has shown that patients who generally believe all things in their life have a good outcome have a stronger placebo response to analgesia¹⁸. A systematic review has shown that programs that utilize the previously mentioned methods to optimize outcomes (i.e., maximize placebo responses and minimize nocebo responses) have higher effects than other types of expectation manipulations¹⁹.

Furthermore, only providing physicians and therapists information about the patients' mindset before starting treatment might change the outcome itself. If we can show physicians a (reliable) estimate of the patients' mindset before a consultation, physicians might be more inclined to intervene in the patients' mindset. This comes with two challenges; how can we reliably estimate the patients' mindset and communicate this to physicians effectively. The first part will always be a tradeoff between gathering as much data as possible and the least burden for the patient. Like the decision trees described in Chapters 5 and 6, an ultra-short screener could be developed to screen the patients' mindset, using only a few questions. To have reliable results, we need to investigate if this ultra-short screener captures the patients' mindset sufficiently. As for the second challenge, integrated dashboards in the electronic patient records system might be a solution. In these dashboards, physicians should be able to see the patients' mindset in the blink of an eye and instinctively know if an intervention is needed. If IT specialists work closely with physicians, this might be possible to achieve. Finally, to make this system work, physicians need to know how to act to different stages of the patients' mindset. The previously mentioned (online) education system might be able to do so.

A small proportion of patients might benefit from more extensive psychological interventions than hand therapists and hand surgeons can offer. For these patients, additional consultations with a psychologist could be an option. Identifying these patients is a challenge. Regular and short

screening questions could monitor the patients' mindset, just as routine outcome measurements monitor patients' symptoms. The system could identify two types of patients that could have better outcomes if their mindset is optimized: 1) Patients with an extremely negative mindset and 2) patients whose mindset does not change by interventions from a hand therapist or physician. These patients could be flagged by the routine mindset measurement system and offered additional psychological consultations. In other cases, this system might help prevent unnecessary treatments for patients who will never react to this treatment. In specific cases, we might even see that patients benefit more from immediate surgery. This could further improve the outcomes of hand therapy or hand surgery for these patients.

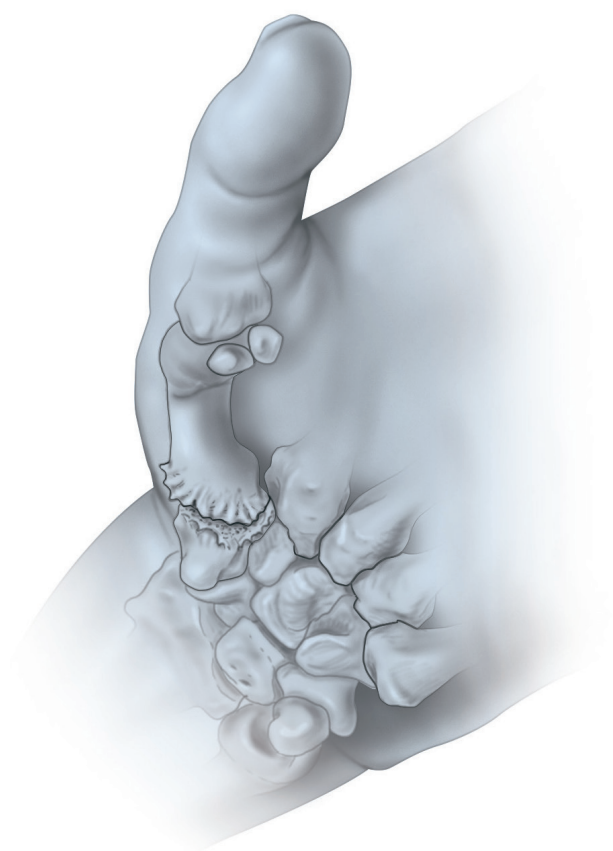
Specifically for patients who will have surgical treatment for thumb base OA, a higher tendency towards depression and anxiety showed a substantial association with worse pain and hand function 1 year after postoperative. Incorporating interventions for these patients could prove challenging, and therefore, we recommend that these patients are offered an additional consultation with a psychologist. For this specific patient population, these consultations could be cost-effective. A randomized trial could be conducted to study this. In this study, half of the patients will be offered additional consultation(s) with a psychologist. We hypothesize that these patients will have less pain and more hand function 1 year after surgery.

To conclude, this thesis suggests that a causal relationship between the patients' mindset and outcomes of treatments for thumb base OA is plausible. However, numerous future steps are needed to provide more compelling evidence that this relationship is causal. We would then need to study if actively changing the patients' mindset in daily care will improve outcomes. If that is the case, we have described several interventions that could be designed to use this relationship to improve the outcomes of patients with thumb base OA.

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CHAPTER 19

SUMMARY

SUMMARY

In this thesis, we set out to uncover to what extent the patient mindset influences patient-reported outcomes in patients with thumb base osteoarthritis (OA). Patients with low expectations, a negative perception of their illness, or patients who catastrophize their pain might not achieve a successful outcome. It could also imply that interventions on the patient mindset result in better outcomes.

To do so, this thesis was structured in three parts: 1) the introduction to the prevalence of thumb base OA, the patient cohort used in this thesis, and innovation in data collection, 2) psychosocial effects in patients who receive nonsurgical treatment for thumb base OA, and 3) psychosocial and occupation effects in patients who receive surgical treatment for thumb base OA.

Part 1 - the introduction to the cohort and innovation in data collection

While the radiographic prevalence is widely reported, there is no consensus on the exact prevalence of thumb base OA. Therefore, in **Chapter 2**, we conducted a meta-analysis on the age and sex-specific prevalence of radiographic thumb base OA. We found that females and older participants had significantly more radiographic thumb base OA. The prevalence of radiographic OA for the 50-year-old male and female participants was 5.8% and 7.3%, respectively, while the respective prevalence for 80-year-old male and female participants was 33.1% and 39.0%.

Chapter 3 describes how we created and implemented a routine outcome measurement cohort of patients with hand and wrist conditions and how these data are used to improve the quality of care and facilitate scientific research. Implementing such a system was feasible using a highly automated data collection infrastructure tightly linked to the patient journey and the workflow of healthcare professionals. The system serves as a tool to improve care and as a basis for scientific research. **Chapter 4** describes how these routine outcome measurements are used in daily clinical care to optimize care and strive for better outcomes. For instance, extreme value detection helps identify patients that report extreme pain postoperatively and historical outcome data help surgeons choose the best available treatment and facilitate shared decision making.

Shorter patient-reported outcome questionnaires are preferred because they lead to compliance. **Chapters 5 and 6** describe a machine-learning method to shorten the Boston Carpal Tunnel Questionnaire (BCTQ) and Patient Rated Wrist Evaluation (PRWE). We could reduce both questionnaires from 15 to six questions in the case of the PRWE and from 19 to six in case of the BCTQ, while retaining excellent agreement with the original questionnaire.

In **Chapter 7**, we were specifically interested in how patients perceive their illness. We found that patients with thumb base OA and carpal tunnel syndrome perceive their illness to be more negative than patients with trigger finger syndrome or Dupuytren's disease.

Part 2 - Psychosocial effects in patients who receive nonsurgical treatment for thumb base osteoarthritis

Previous research indicated that psychosocial factors influence outcomes of musculoskeletal diseases. We set out to study the influence of the patients' mindset on outcomes at different time points during the nonsurgical treatment of thumb base OA. In **Chapter 8**, we studied the extent to which the patients' mindset could explain baseline pain. We found that the patients' mindset explains 41% of the variance in pain before the start of nonsurgical treatment while the presence of scaphotrapeziotrapezoid OA only explained 1%.

Chapter 9 aimed to find if the patients' mindset at baseline is associated with nonsurgical treatment outcomes for thumb base OA. We found that more positive outcome expectations and better illness understanding were associated with less pain and more hand function three months after treatment. The finding that more positive (higher) outcome expectations are associated with less pain contradicts most surgeons' beliefs. In **Chapter 10**, we tested the hypothesis that patients with too high expectations will most likely be less satisfied. We found the reverse effect; patients with higher expectations of the outcome of nonsurgical treatment are more likely to be satisfied, even when the expectations were as high as could be measured. This effect can partially be attributed to the findings that higher expectations are associated with less pain, described in Chapter 9.

These prior studies suggest that changing the patients' mindset could improve the outcomes of nonsurgical treatment of thumb base OA. In **Chapter 11**,

we studied whether the patients' mindset changes during standard nonsurgical treatment and the extent to which this change is associated with the change in pain during the first three months of treatment. We found that an increase in outcome expectations and gaining a more positive perception of the illness was associated with more pain reduction. Our findings emphasize the need for randomized intervention studies to assess if actively changing the patients' mindset, for example by optimizing their outcome expectations, can cause an additional decrease in pain.

Part 3 - Psychosocial and occupation effects in patients who receive surgical treatment for thumb base osteoarthritis

While the previous part shows that the patients' mindset is important for patients who received nonsurgical treatment, we do not know if this was the same for patients who receive surgical treatment. In **Chapter 12**, we compared patients at the start of surgical or nonsurgical treatment for thumb base OA. We compared them on patient characteristics, baseline pain and hand function, and mindset. We found that patients scheduled to undergo surgery for thumb base OA have a more negative mindset than those scheduled for nonsurgical treatment. More specifically, they are more prone to depression and anxiety and tend to catastrophize their pain more.

In **Chapter 13**, we studied the extent to which the patients' mindset was associated with pain and hand function in patients scheduled for surgical treatment for thumb base OA. We found that the patients' mindset could explain 31% of baseline pain, while this was only 12% for hand function. This 31% was less than their nonsurgical counterparts, described in Chapter 8.

Chapter 14 aimed to find which factors are associated with postoperative pain after surgical treatment for thumb base OA. We found that female sex, opioid usage, higher preoperative satisfaction with hand, and higher self-reported consequences and coherence were associated with more postoperative pain. Future studies could investigate sex-based approaches and patient education for reducing acute postoperative pain.

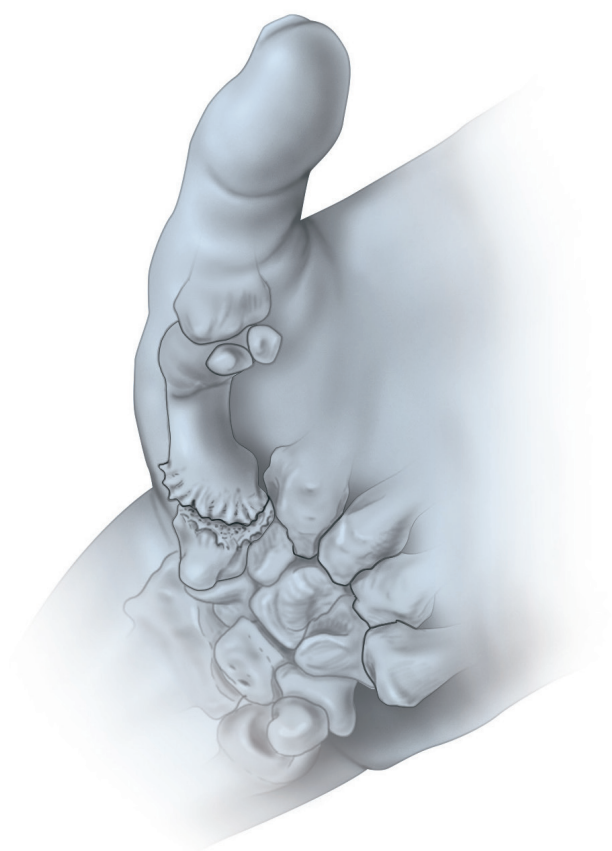
We hypothesized that the patients' mindset would also be associated with outcomes of surgical treatments. Therefore, in **Chapter 15**, we studied the

extent to which patients' mindset was associated with pain and hand function one year after surgical treatment for thumb base OA. We found that more psychological distress, longer expected duration and greater concern were associated with more pain one year after surgery. Furthermore, more concern was associated with less hand function. These findings indicate that surgeons could anticipate psychological distress and greater concern about the illness as opportunities for improved comfort and capability, develop care strategies to address them.

Many patients will ask surgeons the same question: "doctor, when can I work again?". For surgical treatment for thumb base OA, this answer was always based on experience from the surgeon. In **Chapter 16**, we evaluated how long it takes patients to return to work and which factors are associated with return to work. The median time to return to work was 12 weeks; this costs the employer €11.175 on average. However, the type of work greatly influenced this. Patients who had an office job returned to work after 8 weeks, patients who had a moderate physical job (e.g., work in a shop) returned after 14 weeks, and patients who performed heavy physical labor (e.g., carpenter) returned to work after 20 weeks.

Finally, in **Chapter 17**, we studied how the experience with the treatment influences outcomes. We found that the information provision, communication skills of the physician, and postoperative care had the strongest association with outcomes. The results highlight the potential importance of positive experience with the treatment process to improve treatment outcomes in patients undergoing surgery for thumb base OA.

Chapter 18 discusses these findings, their limitations and their implications in more detail.



CHAPTER 20

NEDERLANDSE SAMENVATTING

NEDERLANDSE SAMENVATTING

In dit proefschrift hebben we onderzocht in hoeverre de mindset van de patiënt van invloed is op de door de patiënt gerapporteerde uitkomsten bij patiënten met duimbasis artrose. Patiënten met lage verwachtingen, een negatieve perceptie van hun ziekte of patiënten die hun pijn catastroferen halen mogelijk niet het optimale resultaat van hun behandeling. Dit zou impliceren dat interventies op de mindset van de patiënt zullen resulteren in betere uitkomsten.

Om hier meer inzicht in te krijgen is dit proefschrift ingedeeld in drie delen: 1) de introductie van het cohort en innovaties in dataverzameling, 2) psychosociale effecten bij patiënten die een niet-chirurgische behandeling voor duimbasis artrose krijgen, en 3) psychosociale en beroepseffecten bij patiënten die een chirurgische behandeling voor duimbasis artrose krijgen.

Deel 1 – introductie van het cohort en innovaties in dataverzameling

Hoewel de radiografische prevalentie op grote schaal wordt gerapporteerd, is er geen consensus over de exacte prevalentie van duimbasis artrose. Daarom hebben wij in **hoofdstuk 2** een meta-analyse uitgevoerd naar de leeftijd- en geslacht specifieke prevalentie van radiografische duimbasis OA. Wij vonden dat vrouwen en oudere deelnemers significant meer radiografische duimbasis artrose hadden.

Hoofdstuk 3 beschrijft hoe wij een cohort hebben opgezet en geïmplementeerd met de routinematige verzamelde uitkomsten van patiënten met hand- en polsaandoeningen, en hoe deze gegevens worden gebruikt om de kwaliteit van de zorg te verbeteren en wetenschappelijk onderzoek te vergemakkelijken. Het implementeren van een dergelijk systeem was haalbaar door gebruik te maken van sterk geautomatiseerde elektronische infrastructuur die nauw gekoppeld is aan het traject van de patiënt en de workflow van zorgverleners. Het systeem dient als instrument om de zorg te verbeteren en als basis voor wetenschappelijk onderzoek. **Hoofdstuk 4** beschrijft hoe deze routinematige uitkomstmetingen worden gebruikt in de dagelijkse klinische zorg, helpen om de zorg te optimaliseren en leiden tot betere uitkomsten. Detectie van extreme waarden helpt bijvoorbeeld bij het identificeren van patiënten die postoperatief extreme pijn rapporteren en de historische gegevens helpen chirurgen bij het kiezen van de beste beschikbare behandeling en het vergemakkelijken daarmee de shared decision making.

Kortere vragenlijsten genieten de voorkeur omdat patiënten de voorkeur hebben kortere vragenlijsten in te vullen. **Hoofdstuk 5 en 6** beschrijven een machine-learning methode om de Boston Carpal Tunnel Questionnaire en de Patient Rated Wrist Evaluation vragenlijsten in te korten. We konden beide vragenlijsten terugbrengen tot zes vragen zonder daarbij de kwaliteit van de data te verminderen.

In **hoofdstuk 7** waren we specifiek geïnteresseerd in hoe patiënten hun ziekte ervaren. We vonden dat patiënten met duimbasis artrose en carpaal tunnel syndroom hun ziekte negatiever ervaren dan patiënten met trigger vinger syndroom of de ziekte van Dupuytren.

Deel 2 - Psychosociale effecten bij patiënten die een niet-chirurgische behandeling voor duimbasisartrose ondergaan

Eerder onderzoek wees uit dat psychosociale factoren belangrijke factoren zijn bij uitkomsten van aandoeningen van het bewegingsapparaat. Wij onderzochten de invloed van de mindset van de patiënt op de uitkomsten op verschillende tijdstippen tijdens de niet-chirurgische behandeling van duimbasis artrose. In **hoofdstuk 8** onderzochten we de mate waarin de mindset van de patiënt de pijn voorafgaand aan de behandeling kon verklaren. We vonden dat de mindset van de patiënt 41% van de variantie in pijn voor aanvang van de niet-chirurgische behandeling kan verklaren. De aanwezigheid van scaphotrapeziotrapezoïde artrose verklaarde slechts 1%.

Hoofdstuk 9 had als doel te onderzoeken of de mindset van de patiënt op baseline geassocieerd is met de niet-chirurgische behandelingsuitkomsten voor duimbasis artrose. We vonden dat positievere verwachtingen over de uitkomst en een beter ziekte-inzicht geassocieerd waren met minder pijn en meer handfunctie drie maanden na de behandeling. De bevinding dat positievere (hogere) uitkomstverwachtingen geassocieerd zijn met minder pijn is in tegenspraak met de mening van de meeste chirurgen. In **hoofdstuk 10** testten wij de populaire hypothese dat patiënten met hogere verwachtingen minder tevreden zullen zijn. Wij vonden juist het omgekeerde effect: patiënten die hogere verwachtingen hebben van het resultaat van een niet-chirurgische behandeling zijn vaker tevreden. Dit effect kan gedeeltelijk worden toegeschreven aan de bevindingen dat hogere verwachtingen samenhangen met minder pijn, beschreven in **hoofdstuk 9**.

Deze eerdere studies suggereren dat het veranderen van de instelling van de patiënt de uitkomsten van niet-chirurgische behandeling van duimbasis OA zou kunnen verbeteren. In Hoofdstuk 11 onderzochten wij of de mindset van de patiënt verandert tijdens de standaard niet-chirurgische behandeling en in hoeverre deze verandering geassocieerd is met de verandering in pijn gedurende de eerste drie maanden van de behandeling. Wij vonden dat een toename in uitkomstverwachtingen en een afname in hoe negatief een patiënt de ziekte ervaart, geassocieerd was met meer pijnvermindering. Onze bevindingen benadrukken de noodzaak van gerandomiseerde interventiestudies om te beoordelen of het actief veranderen van de mindset van de patiënt een extra afname van pijn kan veroorzaken.

Deel 3 - Psychosociale en beroepseffecten bij patiënten die chirurgisch behandeld worden voor duimbasis artrose

Terwijl uit het vorige deel blijkt dat de mindset van de patiënt belangrijk is voor patiënten die een niet-chirurgische behandeling kregen, wisten we niet of dit ook gold voor patiënten die een chirurgische behandeling kregen. In **hoofdstuk 12** vergeleken we patiënten bij aanvang van chirurgische of niet-chirurgische behandeling voor duimbasis artrose. We vergeleken ze op patiëntkenmerken, pijn en handfunctie voorafgaand aan de behandeling en mindset. We vonden dat patiënten die chirurgisch behandeld zouden worden voor duimbasis artrose een negatievere mindset hebben dan patiënten die niet-chirurgisch behandeld zouden worden.

In **hoofdstuk 13** onderzochten we in hoeverre de mindset van patiënten geassocieerd was met pijn en handfunctie bij patiënten die chirurgisch behandeld zouden worden voor duimbasis artrose. Wij vonden dat de mindset van de patiënt 31% van de pijn kon verklaren en 12% van de handfunctie voorafgaand aan de chirurgische behandeling. Dit was minder dan wat we eerder vonden bij patiënten die een non-chirurgische behandeling zouden ondergaan, zoals beschreven in hoofdstuk 8.

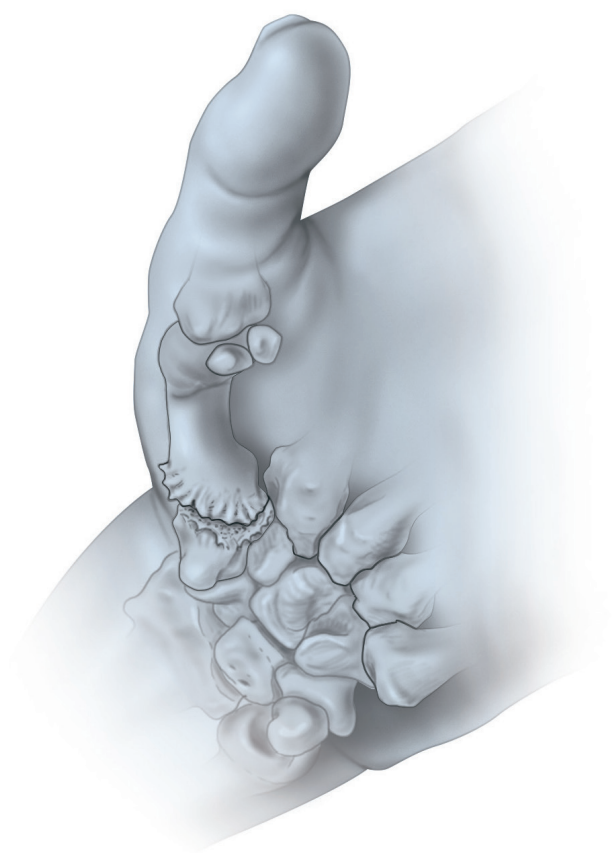
Hoofdstuk 14 had als doel te onderzoeken welke factoren geassocieerd zijn met postoperatieve pijn na chirurgische behandeling voor duimbasis artrose. Wij vonden dat vrouwelijk geslacht, opioïde gebruik, hogere preoperatieve tevredenheid met de hand, en hogere zelf gerapporteerde gevolgen en een begrip

van de ziekte geassocieerd waren met meer postoperatieve pijn. Toekomstige studies zouden geslachtsgebonden benaderingen en patiëntenvoorlichting voor het verminderen van acute postoperatieve pijn kunnen onderzoeken.

Wij stelden de hypothese dat de mindset van de patiënt ook geassocieerd zou zijn met de uitkomsten van chirurgische behandelingen. Daarom onderzochten wij in **hoofdstuk 15** de mate waarin de mindset van de patiënt geassocieerd was met pijn en handfunctie één jaar na chirurgische behandeling voor duimbasis artrose. We vonden dat meer psychologische belasting, langere verwachte duur van de aandoening en meer bezorgdheid geassocieerd waren met meer pijn één jaar na de operatie. Bovendien was meer bezorgdheid geassocieerd met minder handfunctie. Chirurgen zouden kunnen anticiperen op psychologische belasting en grotere bezorgdheid over de ziekte en zorgstrategieën ontwikkelen om deze aan te pakken. Toekomstige studies zouden de effectiviteit van deze strategieën kunnen meten.

Veel patiënten zullen chirurgen dezelfde vraag stellen: “dokter, wanneer kan ik weer werken?”. Voor de chirurgische behandeling van duimbasis artrose was dit antwoord altijd gebaseerd op de ervaring van de chirurg. In **hoofdstuk 16** evalueerden we hoelang het duurt voordat patiënten weer aan het werk kunnen en welke factoren samenhangen met terugkeer naar het werk. De mediane tijd om terug te keren naar het werk was 12 weken; dit kost de werkgever gemiddeld €11.175. Het soort werk had hier echter grote invloed op. Patiënten met een kantoorbaan gingen na 8 weken weer aan het werk, patiënten met een matig fysieke baan (bijv. werk in een winkel) gingen na 14 weken weer aan het werk, en patiënten met zware fysieke arbeid (bijv. timmerman) gingen na 20 weken weer aan het werk.

Tenslotte, in **hoofdstuk 17**, onderzochten we hoe de ervaring met de behandeling de uitkomsten beïnvloedt. We vonden dat de informatievoorziening, de communicatieve vaardigheden van de arts, en de postoperatieve zorg de sterkste associatie hadden met uitkomsten. De resultaten benadrukken het potentiële belang van positieve ervaring met het behandelingsproces voor het verbeteren van de behandeluitkomsten bij patiënten die een operatie ondergaan voor duimbasis OA.



APPENDICES

LIST OF PUBLICATIONS

Changes in mindset during treatment influences the outcomes of nonsurgical treatment for thumb OA; a cohort study Submitted: Arch Phys Med Rehabil

Van der Oest MJW, Wouters RM, Bakhshaie J, Hoogendam L, Souer JS, Vranceanu AM, Zuidam JM, the Hand-Wrist Study Group, Selles RW

The association between preoperative pain, dysfunction, and psychosocial profile in patients with ulnar-sided wrist disorders: a cross-sectional study. Submitted: Clin Orthop Relat Res

Teunissen JS, van der Oest MJW, van Groeninghen D, Feitz R, Hovius SER, van der Heijden EPA

Do psychosocial factors influence pain and hand function at intake in patients with carpometacarpal osteoarthritis of the thumb? Submitted: acta orthopaedia

Van der Oest MJW, Feitz R, Hoogendam L, Vermeulen G, Slijper HP, Zuidam JM, Vranceanu AM, Selles RW and the Hand-Wrist Study Group

Warm Weather And Surgical Site Infections: A Meta-Analysis Submitted: Plast Reconstr Surg

Sahtoe APH, Duraku LS, van der Oest MJW, Hundepool CA, de Kraker M, Bode LGM, Zuidam JM

Treatment expectations and illness perceptions influence the results of non-operative treatment of first carpometacarpal osteoarthritis: a cohort study Submitted: Disability & Rehabilitation

Van der Oest MJW, Hoogendam L, Wouters RM, Vermeulen GM, Slijper HP, Selles RW, Vranceanu AM, Porsius JT, the Hand-Wrist Study group

Prognostic patient, disease and surgical factors after open Triangular Fibrocartilage Complex (TFCC) reinsertion. Submitted: JHS am

Feitz R, Stip DR, van der Oest MJW, Souer JS, Hovius SER, Selles RW, and the Hand-Wrist Study Group

Denervation of the joints of hand and wrist: surgical techniques and a systematic review with meta-analysis accepted: Plast Reconstr Surg

Zuidam JM, Tieman TE, Duraku LS, van der Oest MJW, Hundepool CA, Selles RW

Return to work and associated costs after treatment for Dupuytren's disease.
Accepted Plast Reconstr Surg

Poelstra R, Blake SN, Andrinopoulou ER, Obdeijn MC, van der Oest MJW, Feitz R, Burdorf A, Selles RW

Are Patient Expectations and Illness Perception Associated with Patient-reported Outcomes from Surgical Decompression in de Quervain's Tenosynovitis? *Clin Orthop Relat Res.* 2021 May

Blackburn J, van der Oest MJW, Chen NC, Feitz R, Duraku LS, Zuidam JM, Vranceanu AM, Selles RW; and the Hand-Wrist Study Group.

Patient-reported outcomes and function after reinsertion of the triangular fibrocartilage complex by open surgery. *Bone Joint J.* 2021 Apr

Feitz R, van der Oest MJW, van der Heijden B, Slijper HP, Selles RW, Hovius SER, Hand-Wrist Study Group

Factors associated with return to work after open Fibrocartilage Complex (TFCC) reinsertion *Hand Surg Rehabil.* 2021 Apr

Feitz R, Van der Oest MJW, Hovius SER, Selles RW, the Hand-Wrist Study Group

The prevalence of radiographic thumb base osteoarthritis: a meta-analysis *Osteoarthritis Cartilage.* 2021 Mar

Van der Oest MJW, Duraku LS, Andrinopoulou ER, Wouters RM, Bierma-Zeinstra SMA, Selles RW, Zuidam JM

Patients with higher treatment outcome expectations are more satisfied with the results of non-operative treatment for thumb base osteoarthritis: a cohort study *Arch Phys Med Rehabil.* 2021 Feb

Hoogendam L, Van der Oest MJW, Andrinopoulou ER, Vermeulen G, Wouters RM, Slijper HP, Selles RW, Porsius JP

Factors associated with return to work after surgical treatment for carpometacarpal osteoarthritis of the thumb; a cohort study. *JHSeu, December 2020*

Van der Oest MJW, Teunissen JS, Poelstra R, Slijper HP, Feitz R, Porsius JT, Burdorf A, Selles RW, the Hand-Wrist Study group

Psychological Characteristics and Female Sex Predict Acute Postoperative Pain in Patients Surgically treated for Thumb Base Osteoarthritis – a Cohort Study, *Plast Reconstr Surg.* 2020 Dec

Wouters RM, Porsius JT, Van der Oest MJW, Slijper HP, Souer S, Selles RW, MacDermid JC, the Hand-Wrist Study group

Routine Health Outcome Measurement: Development, Design, and Implementation of the Hand and Wrist Cohort. *Plast Reconstr Surg.* 2020 Aug
Selles RW, Wouters RM, Poelstra R, van der Oest MJW, Porsius JT, Hovius SER, Moojen TM, van Kooij Y, Pennenhout PY, van Huis R, Vermeulen GM, Feitz R, Slijper HP; Hand-Wrist Study Group.

Wat kan je verwachten van handtherapie? [What to expect from hand therapy for thumb base osteoarthritis?] *Dutch journal for Hand Therapy* June 2020
van der Oest MJW, Hoogendam L, Wouters RM, Tschäpe J, Vermeulen GM, Slijper HP, Selles RW, the Hand-Wrist Study Group

Werkhervatting na chirurgische interventie voor duimbasis artrose. [Return to work after surgical intervention for thumb base osteoarthritis] *Quintesse (Dutch journal for occupational medicine)* Mar 2020
van der Oest MJW, Feitz R, van der Werff F

Patient's Satisfaction Beyond Hand Function in Dupuytren's Disease: Analysis of 1106 Patients *J Hand Surg Eur Vol.* 2020 Mar
Poelstra R, Van Kooij YE, Van der Oest MJW, Slijper HP, Hovius SER, Selles RW, the Hand Wrist study group

Item Reduction of the 39-item Rotterdam Diabetic Foot Study Test Battery Using Decision Tree Modelling *Diabetes Metab Res Rev.* 2020 Jan 19
Rinkel WD, Van der Oest MJW, Coert JH

Illness Perceptions of Patients With First Carpometacarpal Osteoarthritis, Carpal Tunnel Syndrome, Dupuytren Contracture, or Trigger Finger.
J Hand Surg Am. 2019 Dec 4
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Patients With Thumb-base Osteoarthritis Scheduled for Surgery Have More Symptoms, Worse Psychological Profile, and Higher Expectations Than Nonsurgical Counterparts: A Large Cohort Analysis.

Clin Orthop Relat Res. 2019 Dec .

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Item reduction of the Boston Carpal Tunnel Questionnaire using decision tree modelling. *Arch Phys Med Rehabil*, 100 (12), 2308-2313 Dec 2019

Jansen MC, Van der Oest MJW, Porsius JT, Slijper HP, Selles RW

Patient's satisfaction beyond hand function in Dupuytren's disease: analysis of 1106 patients. *J Hand Surg Eur Vol.* 2019 Nov 28.

Poelstra R, Van Kooij YE, Van der Oest MJW, Slijper HP, Hovius SER, Selles RW, Hand-Wrist Study Group.

Psychological Factors Are More Strongly Associated With Pain Than Radiographic Severity in Non-Invasively Treated First Carpometacarpal Osteoarthritis. *Disabil Rehabil*, 1-6 2019 Nov 8

Hoogendam L, Van der Oest MJW, Tsehaie J, Wouters RM, Vermeulen GM, Slijper HP, Selles RW, Porsius JT; Hand-Wrist Study Group

Three-ligament tenodesis for chronic scapholunate injuries: short-term outcomes in 203 patients. *J Hand Surg Eur Vol.* 2019 Nov 11.

Blackburn J, Van der Oest MJW, Poelstra R, Selles RW, Chen NC, Feitz R; Hand-Wrist Study Group.

Which Psychological Variables Are Associated With Pain and Function Before Surgery for de Quervain's Tenosynovitis? *Clin Orthop Relat Res* 2019 Oct 15

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Tschaie J, Van der Oest MJW, Poelstra R, Selles RW, Feitz R, Slijper HP, Hovius SER, Porsius JT, the Hand-Wrist Study Group

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PORTFOLIO

NIHES courses	year	ECTS
Study design	2017	4,3
Biostatistical methods I	2017	5,7
Biostatistical methods II	2017	4,3
Principles of Research in Medicine and Epidemiology	2017	0,7
Scientific Writing in English for Publication	2019	2
Clinical translation to Epidemiology	2017	2
Clinical Epidemiology	2017	3,7
Principles of causal inference	2018	1,4
Methods of public Health Research	2017	0,7
Clinical trials	2017	0,7
Health economics	2017	0,7
The practice of epidemiologic analysis	2017	0,7
Fundamentals of medical decision making	2017	0,7
Repeated measurements in clinical studies	2018	1,4
advanced clinical trials	2018	1,9
Advance analysis of prognosis studies	2019	0,7
Intermediate course in R	2018	1,4
Logistic regression	2018	1,4
Joint models for longitudinal and survival data	2018	0,7
Principles of epidemiologic data analysis	2019	0,7
Quality of life measurement	2019	0,9
Preventing failed psychological interventions in behavioural research	2019	1,4
Advances in clinical epidemiology	2018	0,7
Other NIHES credits	2017-2020	(75,8)
Other courses	year	workload
BROK	2018	30
Scientific integrity	2020	8
Microsurgery training	2017-2020	150

Oral Scientific presentations	year	workload
Item reduction of the patient-reported wrist evaluation using decision tree modelling. FESSH, Budapest	2017	15
Differences in illness perceptions between hand surgery patients. FESSH, Copenhagen	2018	15
Factors associated with return to work after surgical treatment for carpometacarpal osteoarthritis of the thumb; a cohort study NVPC, spring	2019	15
IFSSH, Berlin	2019	15
Plastic surgery - the meeting, San Diego	2019	15
Treatment expectations and illness perceptions influence the results of non-operative treatment of first carpometacarpal osteoarthritis: a cohort study IFSSH, Berlin	2019	15
How do patients psychosocial factors influence the preoperative pain and hand function in patients with CMC-1 OA? IFSSH, Berlin	2019	15
Conference attendance	year	workload
FESSH, Budapest	2017	30
ASSH, Boston	2018	30
FESSH, Copenhagen	2018	30
IFSSH, Berlin	2019	30
Plastic Surgery - The meeting, San Diego	2019	30
NVPC, spring	2019	8
NVPC, fall	2019	16
Conference and seminar organization	year	workload
Esser, local flaps	2018	30
Esser, fractures	2019	30
Esser, Osteoarthritis	2021	10
European Symposium on Pediatric Hand	2020	20
Datascience in a day	2020	20

Grants	year	
FESSH/Foundation for Hand Surgery Grant (€50.000)	2021	
Teaching - research	year	workload
Systematic review - Minor students	2017-2020	40
Systematic review - 'keuzeonderwijs' students	2017-2020	40
NIHES student - Lisa Hoogendam	2017-2019	90
NIHES student - Joris Teunissen	2017-2019	90
Master student - Daniel Stip	2019	30
Bachelor student - Romy Bosman	2019-2020	50
Master student - Sara Koshnaw	2020	30
Master student - Eva Tetteroo	2020	30
Master student - Stefanie Hakkersteegt	2020	30
Teaching - clinical	year	workload
3rd year bachelor anatomy	2017-2020	30
master student's anatomy	2018-2020	30
micro surgery - teaching	2018-2020	40

DANKWOORD

Prof Mathijssen, dank voor het begeleiden van mijn promotie. Ik heb een mooie tijd gehad en ik heb veel geleerd van alles en iedereen op de afdeling. Dat heeft ervoor gezorgd dat mijn wens om plastisch chirurg te worden alleen maar groter is geworden. Ik kijk nu al uit naar mijn oudste coschap op de afdeling!

Ruud, jij bent waarschijnlijk de eerste die mij doctor mag noemen. Bijna mag ik jou ook professor noemen, helaas ben ik waarschijnlijk niet de eerste. Na een lang traject is het voor jou eindelijk zover, geheel verdiend! Onze samenwerking begon ooit lang geleden met een ‘onmogelijk’ project met decision trees. Nog altijd is daar vanuit verschillende hoeken erg veel belangstelling voor! In de jaren daarna hebben we, samen met de groep, vele mooie studies gedaan. Met de beurs die we recent hebben gekregen, zal dat ook nog wel even doorgaan en daar kijk ik erg naar uit.

Michiel, het was voor mij heel erg verfrissend toen jij aan boord kwam. Jouw klinische blik op onderzoek plaatst alles in perspectief. Juist die klinische blik heeft mij geholpen om het onderzoek nog meer toepasbaar te maken. Juist de combinatie van kliniek en onderzoek is belangrijk, zonder elkaar kom je er niet. Ik vind het mooi om te zien hoe jij dit combineert, de afgelopen jaren hebt uitgebouwd en daarmee nu ook succesvol beurzen weet te krijgen. Hopelijk kan ik daar de komende jaren ook nog wat betekenen.

Prof. Bierma-Zeinstra, prof. Van Busschbach en prof. Van der Sluis, de verschillen in jullie achtergrond belichamen voor mij hoe multidisciplinaire mijn proefschrift is (geworden). Hopelijk kunnen we dat in de toekomst nog meer bevorderen. Dank voor het zitting nemen in mijn leescommissie en het kritisch lezen van mijn proefschrift.

Dear Ana-Maria, it was a great honor to come to your department in Boston to learn more about the patients' mindset and to experience how you approach it. You, and everyone in your lab, have shown me the importance of the patients' mindset even more. Specifically, the importance of interventions. I hope we will keep working together to incorporate the biopsychosocial model even more into daily clinical care.

Carin, altijd de rots in de branding, vooral als het even tegenzit met alle bureaucratie die gepaard gaat met dit boekje. Vooral door jouw contacten en volharding heb ik de mogelijkheid om dit boek nu al te verdedigen. Dank voor alles!

Drs. Feitz, Reinier, ik zal onze eerste kennismaking in Boedapest nooit vergeten. Zelfs na die verschrikkelijke eerste indruk is het goed gekomen. Eerst vele dagen samen op OK, maar nu ook een belangrijke factor tijdens jouw eigen promotie. Ik ben blij dat ik de wetenschapper in jou ook boven heb weten te krijgen, je lol hebt in het onderzoek en je nu na jaren toch die ‘s’ weg kan poetsen. Succes met de laatste loodjes!

Liron, baas! Wat is het toch heerlijk samenwerken met jou. Altijd 100 ideeën, waarvan we er steeds “slechts” een paar publiceren. Thanks voor de mooie tijd, gave cursussen en leuke discussies. Zelfs als die discussies, tegen de zin van mijn vriendin (en volgens mij ook jouw vrouw) ‘s avonds en in het weekend plaatsvinden.

Jarry, juist door de vele discussies die we samen hadden heeft mijn promotie deze richting gekregen. Helaas realiseer ik me dat nu pas en kan ik dat nu pas op waarde schatten. En dankzij jou heb ik een geweldige ervaring gehad in Boston. Ik vond het heel leerzaam om samen bij Ana-Maria te zijn en uiteraard de beroemde Ted Kaptchuk te ontmoeten. Dank voor de mooie herinneringen!

Harm, de man achter de schermen. Altijd bezig om Pulse weer verder te helpen, altijd net iets te druk, maar nooit te beroerd voor een goede discussie over MCID of iets anders. Het liefst ergens op een vrijdagmiddag op een terrasje. Het is prachtig om te zien hoe jij, samen met een heleboel anderen, Pulse naar een hoger, internationaal niveau trekt! Zonder al jouw inzet de afgelopen 15 jaar had dit boekje nooit zoveel hoofdstukken kunnen hebben.

Lisa, stille wateren hebben diepe gronden, voor niemand geldt dat meer dan voor jou. Al vanaf het moment dat jij tijdens jouw NIHE,S begon bleek dat jij een stuk slimmer was dan ik en ook nog eens veel handiger met R. Volgens mij hebben anderen dat inmiddels ook door en heb jij de traditie van zijprojectjes doorgezet. En dan vergeet ik bijna Berlijn (daar laat ik het voor nu bij). Hoe jij dit allemaal moeiteloos combineert met het opvoeden van een dochter vind ik echt heel knap! Dank voor de mooie tijd en op naar nog meer zijprojecten.

Dr. Poelstra, eindelijk mag ik het een keer opschrijven. Het was balen dat je eerder al de kans kreeg om als AIOS aan de slag te gaan in het hoge noorden. Hierdoor misten we een belangrijke gangmaker en de bedenker van de beruchte wetenschapslunch. Dit stukje is te kort om alle mooie avonturen samen weer te bespreken, maar het hoogtepunt was toch wel met de camper naar Zweden voor congres. Ook al was het niet jouw volle contract, ik heb ontzettend genoten van jouw aanwezigheid op de 15° en daarbuiten.

Jonna, kleine snelheidsduivel. Ik weet nog dat ik jou de eerste keren de heuvels op moest duwen (sorry, dat laat ik je nooit vergeten). Maar inmiddels fiets jij rondjes om me heen en die drive is aanstekelijk. Op de fiets of als collega. Als ik iets heb geleerd van jou is dat het altijd goed komt en dat je overal goed op je plek kan komen. Ik weet namelijk zeker dat jouw drive dat voor jou gaat doen.

Xavier, zonder jou was ik nooit het laatste jaar van mijn promotie doorgekomen. Dan had ik tijdens de lockdowns te veel thuis zitten netflixen en was mijn boekje nu niet af geweest. Gelukkig kwamen we erachter dat we dat beiden hadden en hebben we een mooie paar maanden gehad samen op de 15°. Dan hadden we beiden een klankbord voor als het weer even tegenzat met inclusies of schrijven. Geniet van jouw welverdiende opleidingsplek.

Robbert, het duurde even voordat we elkaar gevonden hadden, maar gelukkig zitten we inmiddels met veel dingen erg op een lijn. In al die jaren hebben we samen ook veel mooie dingen mee mogen maken. Leuke congressen, promoties en (vrijmi)borrels. Vaak gepaard met een goede discussie, die altijd resulteert in nog meer onderzoek. Juist dat is de kracht van onze samenwerking, ik kijk er naar uit om dat ook de komende jaren nog te doen.

Joris, al die jaren op de 15° en onze voorliefde voor de roeisport heeft tot een hoop mooie dingen geleid. Al vanaf de tijd dat jij NIHES student was kunnen we goed over het leven en de toekomst filosoferen al dan niet onder het genot van een alcoholische versnapering in de tuin. Een van de hoogtepunten blijft toch wel het congres in Berlijn, waar ik nog altijd met veel plezier aan terug denk. Succes met jouw laatste loodjes.

Alle anderen mensen op de 15°, voor niemand is promoveren makkelijk, maar ik denk dat we het op de 15° voor elkaar allemaal net een stukje makkelijker maken. Dat hebben jullie voor mij namelijk wel gedaan. De wetenschapslunch,

avonden in de vibes, vrijmibo bij Ari en alle koppen koffie zorgen voor een heerlijke, ontspannen, maar toch motiverende sfeer. Zonder jullie allemaal was het niet gelukt.

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Dora en Levi, het is altijd fijn om met ons vieren een avond te ontspannen. Vaak gaat het een uurtje over ons leven als promovendus, maar gaan we al snel over tot waar we eigenlijk voor komen: lekker eten en een avond spelletjes spelen. Of het nou codenames, clever of bonanza is, we hebben altijd een geweldige avond. Die avonden geven met altijd weer nieuwe energie om door te gaan. Geniet van jullie nieuwe huis en tot de volgende avond.

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Papa, Mama, Vera, Paul, “ja ik zit op de fiets naar huis” is waarschijnlijk de zin die jullie allemaal het vaakst van mij gehoord hebben. Dan was ik klaar met werken en belde ik even. Ondanks de afstand spreken we elkaar daarom vaak. We spreken elkaar moed in, katsen even over onze dag of bespreken juist de leuke dingen van die dag en dan gaan we weer door. Dank voor jullie steun al die jaren!

Lieve Im, nog 1 laatste keer. Het is patients’ mindset toch? Of was het nou patient mindset of toch patient’s mindset? Volgens mij zijn we er uiteindelijk samen uit gekomen en heb jij sindsdien geen enkele kans meer gegeven om het nog anders op te schrijven. Waar ik altijd alles gelijk wil doen en af wil hebben, ben jij degene dan nog de tijd neemt om alles secuur na te lezen (en er dan altijd nog iets uit haalt). Hoewel ik dit traject alleen in ben gegaan, komen we hier samen uit. Niet alleen stond jij altijd voor me klaar als er weer iets nagelezen moest worden, maar ik kon ook altijd mijn perikelen bij jou kwijt. Dit werd mij pas echt duidelijk toen we eindelijk samen gingen wonen. Al was dat een lang proces. Nadat we (lees jij) heel veel huizen hebben bezichtigd, eerst midden in de nacht video bellend vanuit Boston (nadat ik een iets te gezellige vrijdag avond had gehad) en later ook samen. Gelukkig hebben we nu een plek waar we samen van genieten en ik onbeperkt misbruik kan van jouw kwaliteiten. De afgelopen 4 jaar zijn veel meer geweest dan alleen dit boekje. Ze staan ook voor de periode waarin we samen zoveel leuke dingen hebben gedaan en fantastische reizen hebben gemaakt. Ik heb nu al zin in de volgende periode van ons leven samen!

ABOUT THE AUTHOR

Mark Johannes Willem van der Oest was born April 28, 1994 in Amsterdam. He had a nature and health profile at the Sint Oelbert Gymnasium in Oosterhout, after which he started studying medicine in Rotterdam in 2012. At the same time, Mark started rowing at the Rotterdam Student Rowing club Skadi. His love for rowing continues to this day. While not rowing anymore himself, Mark spends considerable time on his racing bike. Early on during his studies, he focused on surgical subjects, culminating in the minor



‘Head to hands’ of the plastic surgery department at Erasmus MC. In 2016, Mark started his master’s research at the same department. After successfully completing this, Mark started the Health Science research master in September 2017 and his PhD in November 2017. As part of this PhD, Mark spent five months with Professor Vranceanu of the Integrated Brain Health Clinical and Research Program of the Department of Psychiatry in Boston as a visiting researcher. After winning the award for best presentation at the NVPC spring 2019 conference, Mark was subsequently asked to give this presentation again at “Plastic Surgery, the Meeting” of the American Association for Plastic Surgery in San Diego. At the beginning of 2021, Mark, together with Michiel Zuidam and Ruud Selles, was awarded the FESSH clinical research grant to continue his PhD research as a post doc. Mark has started his internships since February 2021. He is expected to do his oldest internship at the Plastic, Reconstructive and Hand Surgery department of Erasmus MC in February 2023. Ultimately, his goal is to become a plastic surgeon.

