Traumatic Knee Disorders in General Practice

Diagnosis, Course and Prognosis

Harry Wagemakers

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Traumatic Knee Disorders in General Practice

Diagnosis, course and prognosis

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Diagnostiek, beloop en prognose

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Part One

Well, I can ease your pain,
get you on your feet again.
Relax, need some information first.
Just the basic facts.
Can you show me where is hurts?

Pink Floyd – Comfortably numb (David Gilmour/Roger Waters 1979)

1

General introduction

Introduction

Musculoskeletal disorders are common, affecting millions of people worldwide and causing short or long-term pain and physical disability, including sick leave [1, 2]. These musculoskeletal disorders represent a substantial burden on the demand for healthcare systems, resulting in the need for considerable financial budgets [3]. Knee disorders, from both traumatic and non-traumatic origin, make a substantial contribution to the total amount of musculoskeletal disorders [4].

Knee injuries are often associated with heavy physical activities during sport and work [5, 6]. These injuries are frequently encountered in both general practice and secondary care. The annual incidence of these injuries (excluding fractures) reported in the Dutch general practice is about 5.3 per 1000 registered patients [4]. In the Dutch healthcare system the general practitioner functions as a gatekeeper to secondary care. In Dutch general practice about 25% of patients with knee injuries are referred to secondary care [7], resulting in medical attention including diagnostic procedures, e.g. X-ray or magnetic resonance imaging (MRI), sometimes followed by surgical interventions such as meniscectomy and anterior cruciate ligament reconstruction followed by a period of rehabilitation. Long-term disease burden might be caused by the possible relation between knee injuries and the development and progression of osteoarthritis [8, 9], again leading to medical consumption including total knee arthroplasty [10].

The stability of the knee is considered as a synergistic function in which joint capsules, ligaments, muscles and tendons act together (Figure 1) [11, 12].The ligaments of the knee are the major restraints to external forces and provide joint stability together with the muscles around the knee [13]. They are the passive viscoelastic structures whereas the muscles are dynamic viscoelastic structures [14]. The anterior cruciate ligament plays an important role in controlling anterior displacement and rotational stability of the knee [15]. The medial collateral ligament is a primary restraint for valgus laxity [16]. The meniscus plays a role in shock absorption and protects articular cartilage from wear and tear [17, 18].

Anterior cruciate ligament lesions result in a clinically significant increase of anterior translation of the tibae relative to the femur, and axial rotation within the knee joint [19, 20]. A medial collateral ligament lesion results in a significant increase of valgus laxity of the knee joint [16]. Whether or not increased laxity due to these ligament lesions alone induces an increased risk for cartilage deterioration and osteoarthritis in the long term is still a matter of debate [21]. Especially meniscal injury or menisectomy is widely recognized as being associated with the development of knee osteoarthritis, causing long-term pain and physical disabilities [22]. Apart from intra-articular mechanical alterations in the knee due to these lesions, it is suggested that the biology of the knee is changed already in the first weeks after acute injury; inflammatory processes in the initial phase of recovery are suggested to induce proteoglycan loss followed by subsequent collagen loss [21]. Both pathways might be involved in the initiation of post-traumatic osteoarthritis [21].

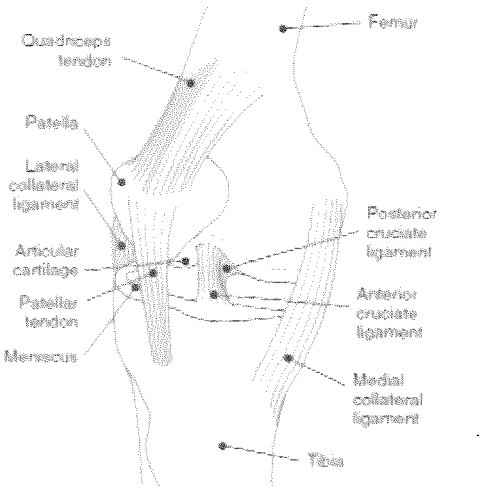

Figure 1: Basic anatomy of the knee, reproduced from [11].

The diagnostic accuracy of history taking and physical examination in traumatic knee disorders is often questioned by physicians [23, 24]. MRI has become a standard procedure in secondary care settings to establish the nature and severity of traumatic knee disorders (Figure 2) [25]. MRI can accurately show the presence, nature and severity of meniscal tears or collateral ligament lesions [26, 27]. For cruciate ligament lesions, MRI shows a somewhat lower sensitivity [28]. Currently, although MRI is utilized in some general practices, it is not recommended in primary care because there is insufficient evidence that the use of MRI in general practice has diagnostic value and/or is a cost-effective strategy [29].

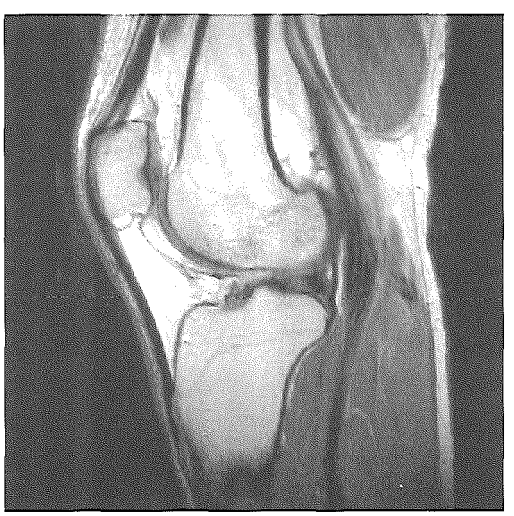

Figure 2: Sagittal view of the knee, reproduced from [25].

Once a diagnosis is established, treatment options related to functional outcome and the prognosis of persistent complaints become of interest. Based on the initial diagnosis and corresponding prognosis the general practitioner can decide on a 'wait-and-see' policy. Alternatives for this policy are conservative treatment (e.g. physical therapy), referral to secondary care for diagnostic imaging, or consultation with an orthopaedic surgeon.

Around the year 2000, several systematic reviews on the diagnostic value of physical examination in traumatic knee disorders were performed [30-32]. However, these reviews are based on secondary care populations only [30-32]. Thus, the question rises whether these results can be generalized to a primary care setting [33]. In primary care the distribution of traumatic knee disorders probably differs from that in secondary care; in primary care patients with distortion without lesions might be over-represented while in secondary care this might be the case for more serious lesions. This implies differences in the diagnostic value of history taking and physical examination and, in many cases, differences in prognosis. Therefore, the generalization of results from studies in one setting (primary, secondary or tertiary) to other care settings requires considerable caution [34-36]. In another systematic review the course of cruciate ligament lesions was reported to be favorable [37].

Careful history taking and physical examination should help the general practitioner to establish a clinical diagnosis in knee injuries [38]. In 1998 the Dutch College of General Practitioners (NHG) developed a clinical guideline 'Traumatic knee disorders'. This guideline reports only a limited diagnostic value of history taking and physical examination and advocates a wait-and-see policy [39]. In 2010 this guideline was revised, but contained more-or-less the same recommendations [29].

The gaps in our knowledge on the diagnostic value of history taking and physical examination, together with the outcome and prognosis in traumatic knee disorders in primary care, were the basis of the aims of the present study.

The department of General Practice of Erasmus MC, University Medical Center Rotterdam, conducted a large prospective cohort study on knee disorders [40]. In this study, 40 general practitioners from 5 municipalities in the southwest of the Netherlands participated, representing a total patient population of about 84,000 patients [40]. Inclusion of patients took place between October 2001 and October 2003. The inclusion criteria for eligible patients entering the cohort study were: age 12 years or older, and consulting their general practitioner for a new episode of knee complaints [40]. New complaints were defined as complaints that were presented to the general practitioner for the first time [40]. Recurrent complaints for which the general practitioner was not consulted within the last three months were also considered new complaints [40]. Patients with malignancies, neurological disorders, systematic musculoskeletal diseases and complaints that required urgent medical attention (such as fractures or infections) were excluded [40]. During the recruitment period a total of 1,068 patients were included.

Because of the widespread range of diagnosis within the general cohort, three subgroups were identified [40]. Group 1 consisted of patients with non-traumatic complaints aged 12-35 years (n=192), group 2 consisted of patients with non-traumatic complaints aged over 35 years (n=549), and group 3 consisted of patients with traumatic knee disorders (n=327). Within this last group we further defined specific criteria for the study aims that are investigated and described in the present thesis. These specific inclusion criteria were: aged 18-65 years, knee complaints caused by a sudden impact or wrong movement, consulting the general practitioner within 5 weeks after the initial injury, and providing consent for an additional MRI of the knee [41].

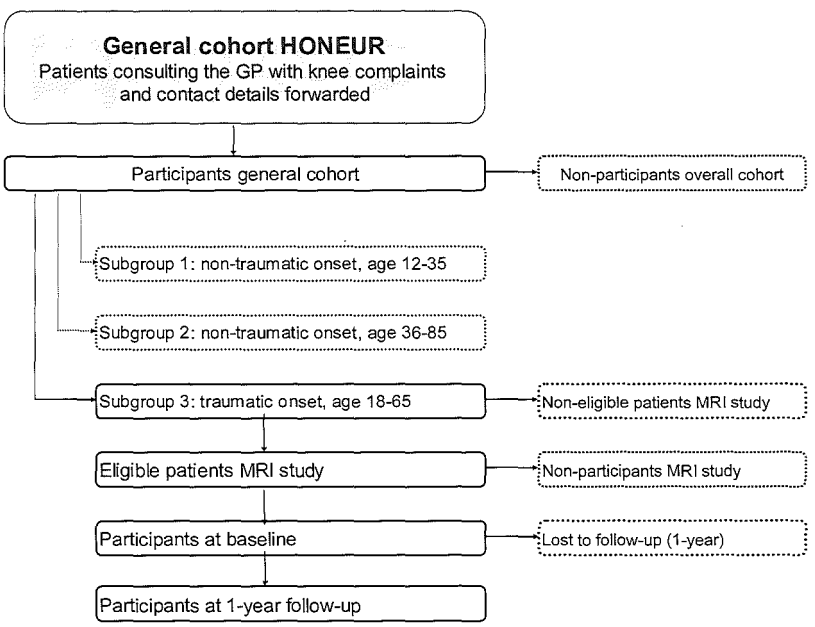

Figure 3: Flow chart of the general cohort and MRI study.

Objectives and outline

This thesis describes the diagnostic process with the aid of history taking, physical examination and MRI in patients with knee injuries in primary care. In addition, subsequent to the therapeutic management initiated by the general practitioner, we describe the outcome and prognosis in these patients over a follow-up period of one year.

Our objectives are:

- to determine the nature and prevalence of meniscal tears, and to determine the diagnostic value of isolated determinants as well as combinations of determinants from history taking and physical examination, in assessing meniscal tears (Chapter 2),
- to determine the prevalence and nature of (anterior) cruciate ligament lesions. Also, the diagnostic value of isolated and combinations of determinants from history taking and physical examination in assessing (anterior) cruciate ligament lesions (Chapter 3),
- to determine the prevalence and nature of collateral ligament lesions and to determine the diagnostic value of isolated determinants as well as combinations of determinants from history taking and physical examination, in assessing collateral ligament lesions (Chapter 4),
- to describe the outcome and management by the general practitioner of knee disorders with a traumatic onset over a period of one year (Chapter 5),
- to investigate whether specific determinants from history taking and physical examination have predictive value for the prognosis of persistent complaints, one year after an acute knee injury (Chapter 6),
- to assess the course of self-reported and tested instability during one year of follow-up and assess how this instability is related to persistent complaints (Chapter 7)

In Chapter 8 we discuss the general conclusions, study limitations, clinical implications for daily practice, and present recommendations for further research. Finally, Chapter 9 presents a summary of our study and its main findings.

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Part Two

Appearances to the mind are of four kinds.
Things either are what they appear to be;
or they neither are, nor appear to be;
or they are, and do not appear to be;
or they are not, yet appear to be.
Rightly to aim in all these cases is the wise man's task.

Epictetus (c. 55 – c. 135 AD))

2

Diagnostic Value of History Taking and Physical Examination for Assessing Meniscal Tears of the Knee in General Practice

H.P.A. Wagemakers, E.M. Heintjes, S.S. Boks, M.Y. Berger, J.A.N. Verhaar, B.W. Koes, S.M.A. Bierma-Zeinstra

Clin J Sport Med, 2008. 18(1): p. 24-30.

Abstract

Objective

To assess the diagnostic value of history taking and physical examination of meniscal tears in general practice.

Design

An observational study determining the diagnostic values (sensitivity, specificity, predictive value and likelihood ratios).

Setting

General practice

Patients

Consecutive patients aged 18 to 65 years with a traumatic knee injury who consulted their general practitioner within 5 weeks after trauma.

Assessment

Participating patients filled out a questionnaire (history taking) followed by a standardized physical examination.

Main outcome

Assessment of meniscal tears was determined by means of MR imaging, and was performed blinded for the results of physical examination and history taking.

Results

Of the 134 patients included in this study, 47 had a meniscal tear. From history taking the determinants "age over 40 years", "continuation of activity impossible" and "weight bearing during trauma" indicated an association with a meniscal tear after multivariate logistic regression analysis, whereas from physical examination only "pain at passive flexion" indicated an association. These associated determinants from history taking showed some diagnostic value; the positive likelihood ratio (LR+) reached up to 2.0 for "age over 40 years", while the isolated test "pain at passive flexion" from physical examination has less diagnostic value with an LR+ of 1.3. Combining determinants from history taking and physical examination improved the diagnostic value with a maximum LR+ of 5.8. However this combination only applied to a limited number of patients.

Conclusion

History taking has some diagnostic value whereas physical examination did not add any diagnostic value for detecting meniscal tears in general practice.

Introduction

General practitioners (GPs) are regularly consulted by patients who have sustained a traumatic knee injury. The incidence of these injuries (excluding fractures) reported in Dutch general practice is about 5.3 per 1000 patients yearly [1].

In the Netherlands, the GP plays a key role in the diagnostic process after a knee injury being the first clinician to see the patient. After clinical examination the GP decides on a wait-and-see policy, initiates conservative treatment or considers referral for further diagnostic imaging or secondary care. About 25% of all patients with traumatic knee injuries in the Netherlands is referred to secondary care [2].

Based on results of clinical examination and arthroscopic surgery in patients attending first aid clinics, it is estimated that about two-third of all knee injuries results in distortions or contusions [3]. In one third more serious lesions such as meniscal tears, cruciate ligament lesions, collateral ligament lesions, fractures and patella luxations are involved [3].

Patients with complaints and limitations after a knee injury who consult secondary care physicians are frequently diagnosed with meniscal tears [4]. The issue of non-operative operative treatment of meniscal tears, or meniscal tear repair versus excision remains inconclusive because of the lack of randomised clinical trials [5].

Careful history taking and physical examination should help the GP to establish a clinical diagnosis [6-7] in knee pain. However, the diagnostic accuracy of history taking and physical examination in knee examination is often questioned by physicians [8-9]. Three systematic reviews summarized available knowledge on this issue [10-12]. Jackson et al. concluded that physical examination should be sufficient in general practice to decide whether or not to refer patients with potential meniscal tears to specialty care, whereas history taking may be less accurate for this purpose [10]. Scholten et al. reported that the assessment of joint line tenderness, the McMurray test and joint effusion are of little diagnostic value (based on sensitivity and specificity) in the diagnosis of meniscal lesions; only the predictive value of a positive McMurray test seemed useful in detecting meniscal tears [11]. Solomon et al. stated that composite examination for meniscal tears might increase the diagnostic value compared to specific, isolated physical diagnostic tests or determinants from history taking [12]. The conclusions drawn from these three systematic reviews were based on studies investigating patients in the secondary care setting [10-12]. No study has yet investigated the usefulness of history taking and physical examination with meniscal tears in a primary care setting. Moreover the patients included in the studies in the above-mentioned reviews were selected because of their referral to secondary care, and arthroscopy was already warranted [10-12]. The predictive value of diagnostic tests in general practice is expected to be lower than suggested in these three reviews, because false negative test results will occur far more often [13].

The first objective of the present study is to determine the prevalence and the nature of meniscal tears in patients consulting the GP for traumatic knee complaints. The second objective is to determine the diagnostic value of history taking and physical examination for detection of meniscal tears in primary care.

Methods

Design

The present study was part of a prospective, observational cohort study in patients with new knee complaints in general practice [14]. New complaints were defined as episodes of complaints presented to the GP for the first time. Patients were recruited by 40 GPs participating in the research network HONEUR established by the department of General Practice of Erasmus Medical Center Rotterdam; follow-up of patients in the general cohort was one year [14].

Patients were eligible for the present study if they were aged 18 to 65 years and had consulted their GP for a traumatic knee complaint within 5 weeks after the initial trauma. In addition to their participation in the general cohort study, these patients were asked for informed consent for an additional MR imaging. Patients with MR imaging contraindications (pacemaker, pregnancy or metal implants) were excluded.

The study protocol was approved by the Medical Ethics committees of the Erasmus Medical Center Rotterdam and of the Medical Center Rijnmond Zuid.

Data collection

Patients filled out a self-report questionnaire and an appointment was made for the MR imaging. A physical examination was carried out immediately after the MR imaging by a trained physical therapist (HPAW) with over 10 years of experience in both physiotherapy and research. The physical therapist was blinded for the MR imaging results, as was the radiologist for the results of the physical examination and questionnaire.
Neither the patient nor the GPs were informed about the outcome of the MR imaging or physical examination; this as to avoid influencing on the behavior of the patient, or the management by the GP during follow-up.

The baseline questionnaire [14] collected data including age, gender, socio-economic status, history of previous knee injuries and/or operations, present symptoms, mechanism of injury, level of activity in work, household, study, sports, and the Lysholm knee score [15]. Physical examination [14] in both knees consisted of inspection (color, alignment and joint effusion [16]), palpation (temperature, collateral ligaments and joint line tenderness [16-17]), assessment of hydrops [16-17], passive range of motion in flexion and extension [16-17], and the McMurray [18], Steinmann II [19] and Apley [19-20] meniscal tests.

MR imaging was selected as the reference test because it is a highly accurate diagnostic tool for detecting meniscal tears [21-22]. MR imaging is non-invasive and less costly than diagnostic arthroscopy. In general hospitals MR imaging has shown additional diagnostic value compared to history taking and physical examination [23-24]. In the present study MR imaging was scheduled 3 to 6 weeks after the initial trauma using a 1.0 Tesla General Electric device; acute symptoms (such as hydrops or hemarthros) will likely be reduced while meniscal tears are still present [25]. Detailed information about the MR imaging procedure is reported elsewhere [26].

The patient outcome was defined as the presence or absence of a medial or lateral meniscal tear as seen on MR imaging. The MR imaging scans were classified by two radiologists independently. Meniscal tears were classified as horizontal, vertical or complex [26]. Degenerative meniscal lesions are not considered relevant for the present study even though these lesions are seen on MR imaging [27]. The relationship between these degenerative lesions and complaints remains uncertain [28-29], and one study has shown that physical examination can not accurately detect these lesions [30].

Statistical analysis

Descriptive statistics were used to present the MR imaging results. To determine the association between determinants from history taking and physical examination, and meniscal tears, expressed as odds ratio's (OR), univariate logistic regression analysis (SPSS, version 11.0) was used. Determinants showing a univariate association ($p<0.15$) with meniscal tears were analysed in a multivariate logistic regression analysis (Backward Wald method, entry 0.10, removal 0.20) to eliminate redundant variables. Separate analyses were performed for history taking and physical examination. Finally the remaining determinants ($p<0.15$) were analysed together (using the Enter method) to identify the independently associated variables from history taking and physical examination for meniscal tears`(composed diagnostic model).

The diagnostic value of the isolated determinants that indicated an independent relationship with meniscal tears ($p<0.15$) was determined by calculating the sensitivity (Se), specificity (Sp), predictive value-positive [31] (PVP) and predictive value-negative [31] (PVN). We also determined the likelihood ratio (LR) for positive (LR+) and negative (LR-) examination [31]. In general, an LR of 1 to 2 or between 0.5 and 1 changes the probability of the presence or absence of a meniscal tear by a small degree [32]. An LR of 2 to 10 or between 0.5 and 0.1 may occasionally be clinically important [32]. LRs greater than 10 or less than 0.1 may have substantial impact on the probability of a meniscal tear [32]. Finally, we combined determinants from the composed diagnostic model for meniscal tears ($p<0.15$) and determined the diagnostic value of these combinations.

Results

Study population

During the inclusion period (March 2002 to October 2003) 184 patients were eligible for inclusion (Figure 1). Of these, 134 patients (72.8%) were included. The remaining 50 patients did not participate for the following reasons: 14 were unable to make an appointment for the MR imaging, 7 reported that they had a minor injury, 8 patients withdraw their informed consent because of withhold of the results from MR imaging to the patient and the GP, and 21 patients were unwilling for unknown reasons or missed their appointments. No patient had to be excluded because of the MR imaging exclusion criterion.

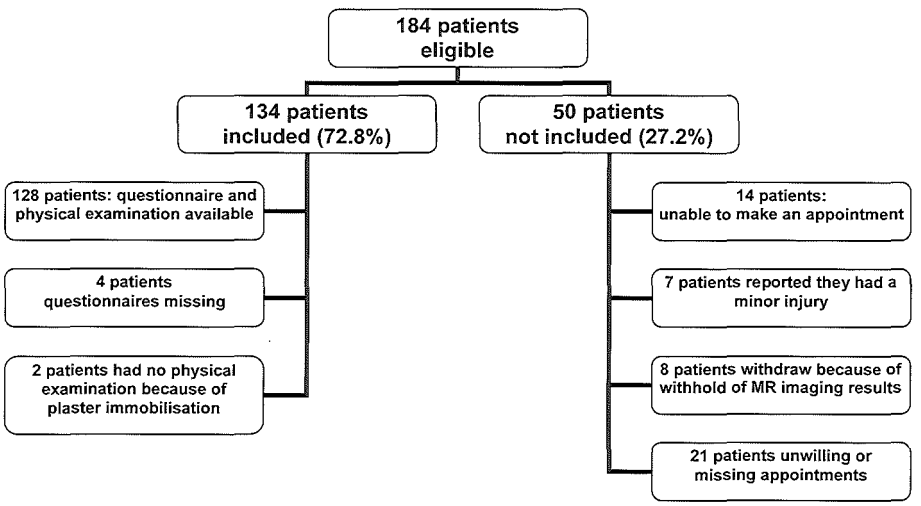

Figure 1. Flow chart of eligible patients

Table 1 shows that there were no clear differences between the baseline characteristics of the participants and non-participants. Mean age of the participants was 40 years (range 18-64 years) and a small majority is male (55.2%). Sixty-one patients (45.5%) sustained a knee trauma during sports activities. At baseline the mean pain severity on a numerical rating scale was 4.7 (0 = no pain to 10 = unbearable pain) and the mean Lysholm knee score was 63.7 (0 = worse to 100 = best).

Table 1. Comparison of baseline characteristics of the participants and non-participants

Characteristic	Participants (n=134)	Non-participants (n=50)
Age, years (mean ± sd)	40.2 ± 12.2	40.4 ± 11.3
Gender male n,(%)	74 (55.2)	32 (66.7)
Onset during sports activity n,(%)	61 (45.5)	16 (33.5)
Symptom side right n, (%)	70 (52.2)	19 (39.6)
Pain severity [0-10] (mean ± sd)	4.7 ± 2.4	4.2 ± 2.5
Lysholm knee function score [0-100] (mean ± sd)	63.7 ± 18.9	66.5 ± 23.3

MR imaging results

The results of MR imaging are presented in Table 2. The average time period between trauma and MR imaging was 38 days (range 9-81 days); 70% of all patients had their MR imaging within 6 weeks after the initial trauma. In total, 14 patients (10.4%) showed no effusion, meniscal tears or ligamentous lesions on the MR imaging and 38 patients (28.4%) showed only effusion without detectable meniscal tears or ligamentous lesions. Thus, 52 patients (38.8%) had no reported meniscal tears or ligamentous lesions. Meniscal tears detected by MR imaging were seen in 47 cases (35.1%), excluding degenerative lesions. When these degenerative lesions were included, 108 patients (80.6%) had positive MR imaging findings. In total, 28 anterior cruciate ligament lesions (20.9%) and 6 posterior cruciate ligament lesions (4.5%) were found. Of all 134 patients, 64 (47.8%) had either a mensical tear or a cruciate ligament lesion and 15 of these patients (11.2%) had a combination of both.

Table 2. Results of MR imaging (n=134)

Characteristic	
Days between trauma and MR imaging (mean ± sd)	38.1 ± 14.5
Diagnosis as seen on MR imaging	
No lesion or hydrops n (%)	14 (10.4)
Hydrops without ligament lesion or meniscal tear n (%)	38 (28.4)
Meniscal tear n (%)	47 (35.1)
Meniscal degenerative lesion n (%)	61 (46.7)
Degenerative meniscal lesion or tear or combination of both n (%)	108 (80.6)
Anterior cruciate ligament lesion (partial or complete) n (%)	28 (20.9)
Posterior cruciate ligament (partial or complete) n (%)	6 (4.5)
Meniscal tear or cruciate ligament lesion n (%)	64 (47.8)
Meniscal tear and anterior cruciate ligament lesion n (%)	15 (11.2)

History taking and physical examination

In 128 patients (95.5%) both history taking and physical examination was available. The questionnaire was available for 130 patients (97%) (Figure 1). Of the 4 missing questionnaires, 2 were not returned to the examiner at the appointment for the physical examination, and 2 were not returned to the research center. Physical examination was performed in 132 patients (98.5%); 2 patients had plaster immobilization at the time of the MR imaging.

Table 3 shows the frequencies of determinants from history taking and physical examination related to the presence or absence of a meniscal tear, as well as their association (OR) with a meniscal tear. "Age over 40 years", "painscore ≥ 6", "popping sensation during trauma", "continuation of activity impossible", "weight bearing during trauma", "rotational trauma" and "pain at passive flexion" all indicated an association with a meniscal tear ($p<0.15$).

Table 3. Univariate association (Odds Ratios and 95% confidence intervals) of variables from history taking and physical examination with detected meniscal tears on MR imaging

Variables[reference]	Subjects available (%)	Meniscal tear present (n=47)	Meniscal tear absent (n=87)	OR*	95% CI
History taking					
Age over 40 years	100	33	31	4.3***	2.0-9.1
Gender (male/female)	100	29/18	45/42	0.7	0.3-1.4
Mechanism of injury					
Trauma during sport	94	22	39	1.1	0.5-2.3
90° or more flexion at trauma	94	10	18	1.0	0.4-2.4
Fall on the knee	94	8	23	0.6	0.2-1.4
Trauma by external force to leg	94	5	12	0.8	0.3-2.3
Trauma while landing on leg	93	16	26	1.2	0.6-2.6
Trauma by forceful rising	94	5	7	1.4	0.4-4.8
Trauma during push off	94	13	17	1.6	0.7-3.8
Weight bearing during trauma	84	35	47	3.1***	1.2-8.4
Rotational trauma	69	19	21	2.1**	0.9-4.9
Foot/lower leg blocked	80	15	28	1.1	0.5-2.5
Signs at trauma					
Continuation of activity impossible	95	28	37	2.1***	1.0-4.6
Immediate pain at trauma	94	7	17	0.8	0.3-2.0
Immediate effusion after trauma	93	18	33	1.0	0.5-2.1
Painscore ≥ 6 (0-10 NRS#)	94	23	29	1.9**	0.9-4.0
Popping sensation during trauma	94	22	22	2.9***	1.3-6.3
Present symptoms					
Effusion	96	16	23	1.4	0.7-3.1
Warm knee	96	5	9	1.0	0.3-3.3
Crepitation knee	96	7	23	0.5	0.2-1.3
Lysholm knee score < 80[15]	97	38	63	1.9	0.7-4.9
Locked knee (Lysholm)[15]	97	9	11	1.7	0.6-4.4
Physical examination					
Genu flexum16	98	15	19	1.6	0.7-3.6
Increased temperature[16]	98	19	37	0.9	0.4-1.8
Ballottement test[16]	98	27	51	0.9	0.4-1.9
Fluctuation test/Minor effusion test[16]	96	6	7	1.5	0.5-4.9
Pain bursa infrapatellaris[17]	97	12	24	0.9	0.4-2.0
Effusion bursa infrapatellaris[17]	96	23	38	1.2	0.6-2.4
Pain medial joint line palpation[16]	98	29	46	1.2	0.9-1.8

After multivariate modelling only "age over 40 years", "continuation of activity impossible" "weight bearing during trauma" and "pain at passive flexion" indicated an independent association ($p<0.15$) with the presence of a meniscal tear (Table 4).

Table 4. Multivariate association (Odds Ratios and 95% confidence intervals) of variables from history taking and physical examination with meniscal tears on MR imaging

Variable from history taking or physical examination	OR* (95% CI)
History taking	
Age over 40 years	4.1*** (1.7-9.9)
Continuation of activity impossible	2.2** (0.9-5.4)
Weight bearing during trauma	3.4*** (1.1-9.9)
Physical examination	
Pain at passive flexion	2.7*** (1.0-6.9)
Explained variance (%)	23%

*p < 0.15, **p < 0.1, ***p < 0.05

Diagnostic value of history taking and physical examination

The prevalence of meniscal tears (prior probability) in this study population was 0.35. The sensitivity (Se), specificity (Sp), predictive value (positive and negative) and the likelihood ratio (LR+ and LR-) are presented in Table 5.

Table 5. Diagnostic values (with 95% confidence intervals) of isolated determinants and combinations of determinants with meniscal tears (prevalence = 0.35)

Variable	TP*	SE$^{\Phi}$	SP$^{\Phi}$	PVP$^{\Phi}$	PVN$^{\Phi}$	LR+$^{\Phi}$	LR-$^{\Phi}$
History							
Age over 40 years	33	0.70 (0.57-0.83)	0.64 (0.54-0.74)	0.52 (0.39-0.64)	0.80 (0.71-0.89)	2.0 (1.4-2.8)	0.5 (0.3-0.7)
Continuation of activity impossible	28	0.64 (0.49-0.78)	0.55 (0.45-0.66	0.43 (0.31-0.55)	0.74 (0.63-0.85)	1.4 (1.0-2.0)	0.7 (0.4-1.0)
Weight bearing during trauma	35	0.85 (0.75-0.96)	0.35 (0.24-0.46)	0.43 (0.32-0.53)	0.80 (0.67-0.95)	1.3 (1.1-1.6)	0.4 (0.2-0.9)
Physical examination							
Pain at passive flexion	36	0.77 (0.64-0.89)	0.41 (0.31-0.52)	0.41 (0.31-0.52)	0.77 (0.64-0.89)	1.3 (1.0-1.7)	0.6 (0.3-1.0)
Combinations of determinants							
History ≥ 1 out of 3 determinants positive	45	0.96 (0.90-1.00)	0.14 (0.06-0.21)	0.39 (0.30-0.48)	0.81 (0.65-1.00)	1.1 (1.0-1.2)	0.3 (0.1-1.4)
History ≥ 2 out of 3 determinants positive	30	0.64 (0.50-0.78)	0.46 (0.35-0.57)	0.41 (0.30-0.52)	0.69 (0.56-0.81)	1.2 (0.9-1.6)	0.8 (0.5-1.2)
History = 3 out of 3 determinants positive	9	0.19 (0.08-0.30)	0.93 0.87-0.98)	0.60 (0.35-0.85)	0.66 (0.57-0.75)	2.6 (1.0-6.7)	0.9 (0.8-1.0)
History ≥ 1 + physical examination positive	34	0.72 (0.60-0.85)	0.47 (0.36-0.58)	0.45 (0.34-0.56)	0.74 (0.62-0.86)	1.4 (1.0-1.8)	0.6 (0.4-1.0)
History ≥ 2+ physical examination positive	21	0.45 (0.30-0.59)	0.68 (0.58-0.78)	0.46 (0.31-0.60)	0.67 (0.57-0.77)	1.4 (0.9-2.2)	0.8 (0.6-1.1)
History = 3 + physical examination positive	7	0.15 (0.05-0.25)	0.97 (0.94-1.00)	0.78 (0.51-1.00)	0.66 (0.57-0.74)	5.8 (1.3-26.8)	0.9 (0.8-1.0)

TP = true positive Φ Se = sensitivity, SP = specificity, PVP = predictive value-positive, PVN = predictive value-negative, LR+ = positive likelihood ratio, LR- = negative likelihood ratio

After the diagnostic work-up the post-test probability or predictive value-positive (PVP) of a meniscal tear increased from 0.35 to 0.41 with a positive "pain at passive flexion", and to 0.43 for both continuation of activity impossible and weight bearing during trauma. With "age over 40 years" the PVP increased to 0.52. Combining the determinants from history taking increased the PVP to 0.41 with at least two out of three determinants positive and to 0.60 with all three determinants positive. However this last combination only has a limited number of cases involved (9). Adding "pain at passive flexion" from physical examination to the combinations of determinants from history taking increased the PVP to 0.46 and 0.78 respectively.

The probability of the absence of a meniscal tear (PVN) increased from 0.65 to 0.74 for both negative "popping sign during trauma" and "continuation of activity impossible". For "age over 40 years" and negative "pain at passive flexion" the PVN increased to 0.80. Combining determinants of history taking did not increase the PVN. Adding the "pain at passive flexion" from physical examination also did not increase the PVN.

A positive "age over 40 years" resulted in the highest LR+ in isolated determinants (2.0). Combination of variables from history taking resulted in a LR+ of 2.6 when all three variables were positive. This is only the case in a limited number of patients (9). When adding "pain at passive flexion" to this latter combination the LR+ increase to 5.8 (1.3-26.8) again with only a small number of cases (7). The LR- 0.4 (0.2-0.9) was with a negative "weight bearing during trauma". The combinations did not alter the LR- much.

Discussion

The present study is the first study to investigate in a primary care setting the diagnostic value of history taking and physical examination in patients with traumatic knee disorders. Lesions types in patients consulting the GP range from no effusion and no meniscal tears to horizontal, vertical or complex meniscal tears at the time of the MR imaging.

In this study, a meniscal tear was seen on MR imaging in 35% of the patients and their average age was 46.5 years; patients without meniscal tears are about 10 years younger. Additionally, degenerative meniscal lesions are frequently found among the patients in the present study. Recent studies [4, 27, 33-35] in secondary care settings have reported similar results. These degenerative lesions are probably the incipient sign of osteoarthritis in the knee [36].

In the present study the diagnostic value of history taking in detecting meniscal tears after a knee injury in general practice is small. "Age over 40 years" is of some use in clinical practice (LR+ = 2.0) [32]. These (poor) overall results are in agreement with recent systematic reviews [11-12] performed in secondary care settings. In contrast, Jackson et al. [10] suggested that physical examination is specific and moderately sensitive to decide which patients should be referred to secondary care after a knee trauma. Strangely enough they based their results on studies in secondary care where the prevalence of meniscal tears is expected to be higher and clinicians may be more experienced in examining the knee. In our study the prevalence for meniscal tears was 0.35, compared to 0.57 and 0.61 [4, 37] reported in studies in secondary care settings. Therefore the generalizability of the results of these latter studies to primary care is questioned.

Solomon et al. [12] suggested that composite examination will increase the diagnostic value. Because only a few determinants in the present study showed an association with meniscal tears after multivariate analyses, we were not able to make many combinations. After combining isolated determinants from history taking and physical examination the diagnostic value for a positive result increased (LR+ = 5.8) but this combination is only seen in seven patients and still has limited diagnostic value in detecting meniscal tears [32]. The LR- was hardly affected by creating combinations [32].

Horizontal meniscal tears are frequently encountered in both asymptomatic and symptomatic knees and may not always be related to symptoms [4]. Vertical or complex meniscal tears appear to be related to the symptomatic knee and seem clinically more meaningful [4]. The prognosis of these types of meniscal tears appears to be worse than other types of meniscal tears and operative treatment is often recommended [38]. We analysed a subset of patients with vertical or complex meniscal tears (n=23) for association of collected determinants. Univariate analysis showed no substantial difference in association (OR) compared with the results obtained from all patients with meniscal tears (n=47). Because of the smaller number of patients, 95% CI were wider and therefore less informative.

In the present study only meniscal tears are considered, even though some patients may suffer from a combination of a meniscal tear with other lesions, in particular cruciate ligament lesions [39]. These combinations might influence the outcome of determinants and thereby the diagnostic value. In our study 15 patients (11%) had a combined meniscal tear and anterior cruciate ligament lesion. Some studies have reported that the accuracy of clinical examination in patients with combined meniscal tears and cruciate ligament lesions is reduced compared to isolated injuries [40-42].

In our univariate analysis we used a rather strict p-value of 0.15 as cut-off point for initial inclusion in the multivariate model. The determinants "Lysholm knee score below 80 points", "locked knee" and "genu flexum" showed an univariate association (p-value < 0.2) with meniscal tears; in other study populations these variables can become of interest in the diagnostic process.

All our patients were examined by one physical therapist (HPAW). Previous studies [9, 30, 43] have shown that reproducibility is rather poor, even among experienced clinicians. Although in our study the examiner was highly experienced and performed the physical examination according to a written standardised protocol, one has to take into account that in daily general practice there is some variation in the performance and interpretation of physical tests by clinicians. However, although experienced, none of the physical examination tests in our study, reported to be of value before, were of diagnostic value in the univariate and multivariate analysis. As example the McMurray meniscal test showed in our study no relationship at all with meniscal tears. Moreover in our study this test could not be performed in 64 patients of the total group of 132 because pain hindered the required full flexion during the test. Even when we defined those patients also as test positives, no relation was found.

Finally we have to emphasize that, although it is a valid tool to diagnose meniscal tears, MRI is not the gold standard method. Maybe the predictive values of history-taking and physical examination would have been slightly better when compared to the gold standard arthroscopy. It would, however, not be ethical to examine all patients with arthroscopy. When arthroscopy was applied only in the subgroup with positive tests, verification bias would have been introduced.

There is lack of information on the natural course of meniscal tears. Follow-up of the patients in our study for several years in order to report on the functional recovery (pain and function) and natural repair (MR imaging) could provide more information. There is evidence that meniscal tears lead to accelerated osteoarthritis of the knee in 10 to 15 years after a knee injury [44-45] but whether operative treatment delays the process of osteoarthritis remains indistinct [5]. Alternatively, conservative treatment or refraining from operative treatment may also reinforce the osteoarthritic process and of course can cause patients complaints such as pain and functional limitations. More evidence-based data (both long-term and short-term) on surgical interventions in meniscal tears are needed to decide whether patients with meniscal tears should be referred to the orthopedic surgeon [5].

Based on our results it seems that the GP has hardly any diagnostic tools available to help in the decision whether or not to refer patients for further diagnostic imaging or specialty care. Future studies should address the question whether the decision to refer is beneficial or harmful for patients. Therefore more prospective observational and experimental studies on diagnostic procedures, treatment and prognosis of meniscal tears (including cost-effectiveness analysis) is recommended.

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3

Diagnostic Accuracy of History Taking and Physical Examination for Assessing Anterior Cruciate Ligament Lesions of the Knee in Primary Care

H.P.A. Wagemakers, P.A.J. Luijsterburg, S.S. Boks, E.M. Heintjes, M.Y. Berger, J.A.N. Verhaar, B.W. Koes, S.M.A. Bierma-Zeinstra

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Abstract

Objective

To assess diagnostic accuracy of history taking and physical examination for assessing anterior cruciate ligament lesions in primary care.

Design and setting

Cross-sectional diagnostic study in a primary care setting.

Participants

Patients were aged 18 to 65 years and consulted their general practitioner within 5 weeks after injury.

Main Outcome Measure(s)

Index tests were obtained with a questionnaire and physical examination. Magnetic Resonance (MR) imaging was used as the reference test. Logistic regression analysis was used to determine associations with ACL lesions. The diagnostic accuracy was determined by calculating sensitivity, specificity, predictive value and likelihood ratio.

Results

MR imaging showed an anterior cruciate ligament lesion in 28 of the 134 included patients. "Effusion", "popping sensation", "giving way" and "anterior drawer test" showed association with an anterior cruciate ligament lesion ($p<0.05$). "Popping sensation" showed a sensitivity, specificity, predictive value positive and a positive likelihood ratio of 0.63, 0.73, 0.39 and 2.3, respectively. Combining determinants from history taking (2 out of 3 positive regarding effusion, popping sensation and giving way) improved the diagnostic accuracy (sensitivity of 0.71, specificity of 0.71, predictive value positive of 0.42 and a positive likelihood ratio of 2.5). The "anterior drawer test" added diagnostic accuracy to these combinations (sensitivity of 0.63, specificity of 0.85, predictive value positive of 0.52 and a positive likelihood ratio of 4.2).

Conclusions

Anterior cruciate ligament lesions are frequently seen. Based on history taking (effusion, popping sensation and/or giving way) and physical examination (anterior drawer test) the general practitioner can screen for anterior cruciate ligament lesions in primary care.

Key Words

Anterior cruciate ligament, diagnostics, knee injury, primary care.

Introduction

A rupture of the anterior cruciate ligament (ACL) of the knee is a serious problem because of its role in controlling joint stability of the knee [1]. An ACL-deficient knee may result in complaints such as pain, effusion, instability and functional limitations in daily living, work or sport [2-3]. Furthermore, ACL-deficient knees because of injury, are considered to be an important risk factor for the development of osteoarthritis [4-5]. The incidence of knee injuries (excluding fractures) reported in Dutch primary care is about 5.3 per 1000 patients per year.[6] The prevalence of ACL injuries in the general population in the USA is estimated at 1 per 3500 persons [7].

In patients consulting the general practitioner (GP) for knee disorders caused by a knee injury, the GP uses history taking and physical examination to assess an initial diagnosis [8-9]. However, no studies on the diagnostic accuracy of history taking or physical examination in primary care patients are available. Three recent systematic reviews summarized available knowledge concerning physical examination in diagnosing ACL lesions [10-12]. Scholten et al. (2003) reported that the pivot shift test has favourable positive predictive value compared with the anterior drawer test and the Lachman test [10]. The Lachman test has good negative predictive value while the anterior drawer test seems of unproven value [10]. Jackson et al. (2003) concluded that the Lachman test is more sensitive and specific than the anterior drawer test [11]. Based on three studies [13-15], Solomon et al. (2001) stated that composite examination from history taking or physical examination for ACL lesions might increase the diagnostic value compared to specific items from history taking and physical examination [12]. The conclusions from these three systematic reviews are based on studies concerning patients in the secondary care setting. Jackson et al. (2003) suggest a primary care setting in the title of their review however the review only deals with secondary care studies [11]. In secondary care studies, arthroscopy is often used as the reference standard.
However, these studies carry the risk of verification bias, implying that only patients highly suspected for ACL lesions are diagnosed with arthroscopy. For assessing the diagnostic value, the reference standard should be performed in all patients with a knee injury and not only in those with highly suspected ACL lesions. Also, blinding between the index test and the reference test was not performed in these studies [16]. The likelihood of actual lesions in a secondary care setting is expected to be higher because the selection of patients has already taken place [16]. In primary care, because selection has yet to take place lower predictive values are expected.

Based on the initial diagnosis the GP can decide on a 'wait-and-see' policy, conservative treatment (e.g. physical therapy), referral to secondary care for diagnostic imaging or consultation with an orthopaedic surgeon. About 25% of all patients with traumatic knee disorders who visit their GP are referred to secondary care [17]. Furthermore, the initial diagnosis can serve to inform or reassure the patient. Because of the clinical decision making by the GP an accurate diagnosis is important.

The purpose of this study is to determine the diagnostic value of history taking and physical examination for detecting ACL lesions in primary care. The study specifically aims to determine the diagnostic value of isolated tests and combinations of tests from history taking or physical examination in patients with ACL lesions. Our hypothesis is that combinations of tests have a higher diagnostic value compared to isolated tests. Also we hypothesise that in patients with a complete ACL lesion, the diagnostic value is higher compared to a partial ACL lesion. Because of the lack of knowledge on this issue in primary care settings this study is of relevance to GPs.

Methods

Design

The present cross-sectional diagnostic study was part of a large prospective observational cohort study on traumatic and non-traumatic knee complaints in general practice [18]. Over forty GPs from five municipalities in the southwest region of The Netherlands, participating in the ErasmusMC GP research network HONEUR, asked patients with new knee complaints to participate in the general cohort study. This network represents a total patient population of around 84.000 patients. Detailed information about the study design has been published elsewhere [18].

From the general cohort study patients were eligible for the diagnostic study if they were aged 18 to 65 years and had consulted their GP for knee complaints within 5 weeks after an knee injury. In addition to their participation in the general cohort study, these patients were asked for informed consent for an additional MR imaging scan. Patients with MR imaging contraindications (pregnancy, metal implants or a pacemaker) or suspected for a fracture were excluded from the present study. Finally, 134 patients participated in the present study.

The Medical Ethics committees of the Erasmus Medical Center Rotterdam and of the Medical Center Rijnmond Zuid approved the study protocol.

Data collection

During the initial consult with the GP the patients were informed about the diagnostic study. Patients who were willing to participate received a self-report questionnaire and an appointment was made for the MR imaging. This baseline questionnaire collected data on age, gender, socio-economic status, history of previous knee injuries and/or operations, mechanism of injury, level of activity in work, household, sports, the Lysholm knee score [19] and pain severity [20]. Detailed information concerning the specific items asked for in the questionnaire and categories of possible answers is given in Appendix 1.

The physical examination was carried out immediately after the MR imaging, according to a standarized protocol by a physical therapist (HPAW) with over 15 years experience in performing physical examination in patients with knee injuries and with over 10 years experience in diagnostic research [18]. Physical examination of both knees consisted of inspection of alignment and joint effusion [21], palpation

of temperature [21], collateral ligaments [21] and joint line tenderness [21], assessment of effusion [21-22] and passive range of motion in flexion and extension [21-22]. Cruciate and collateral ligament integrity were assessed by means of the anterior and posterior drawer tests [23], the Lachman test [24], the pivot shift [25], and the valgus and varus stress tests [26]. Detailed information about the test performances and the definition of a positive test result is given in Appendix 2.

There was no interference from the GP, or the physical therapist who performed the examination, with regard to the answers given by the patient in the questionnaire. The physical therapist was blinded for the MR imaging results as was the radiologist for the results of the physical examination and the questionnaire. Neither the patient nor the GP were informed about the outcome of the imaging or physical examination; this was to avoid influencing the behaviour of the patient, or the management by the GP during follow-up.

MR imaging was selected as the reference test because it is a highly accurate diagnostic tool for detecting ACL lesions, especially complete lesions [27-28]. Partial lesions might be less accurately diagnosed by imaging [29-30]. In the present study MR imaging was scheduled 2 to 6 weeks after the initial trauma using a 1.0 Tesla General Electric device; using this time frame acute symptoms such as effusion or haemarthrosis will likely be reduced while ACL lesions are still present [31]. Detailed information about the MR imaging procedure is reported elsewhere [32].

The patient outcome was defined as the presence or absence of a complete or partial ACL lesion as seen on MR imaging. Two radiologists classified the MR imaging scans independently of each other [32].

Statistical analysis

Descriptive statistics were used to present the results of the MR imaging. Binary logistic regression analysis (SPSS, version 11.0) was used to determine the association of separate determinants from history taking and physical examination with ACL lesions, expressed as odds ratios (OR). Determinants showing a bivariate association with an ACL lesion ($p<0.15$) were analysed in a multivariate logistic regression analysis (Backward Wald method, entry p-value of 0.10, removal p-value of 0.20) to eliminate redundant variables. Separate analyses were performed for history taking and physical examination. We used a p-value of 0.15 as cut-off point (arbitrarily) for initial inclusion in the multivariate model because this cut-off point is favourable when analysing dichotomized determinants [33]. Finally, the remaining determinants were analysed together (using the Enter method) to compose a diagnostic model for ACL lesions ($p<0.05$).

It is reported that complete ACL lesions are accurately diagnosed with MR imaging [27-28] while partial ACL lesions might be less accurately diagnosed with MR imaging [29-30]. As the GP sees patients representing both partial and complete ACL lesions and a management decision might differ depending

on the nature of the involved lesion, we performed an analysis including patients with a partial or complete ACL lesion and a subgroup analysis including only patients with complete ACL lesions.

The diagnostic value of the determinants from the diagnostic model for ACL lesions was determined by calculating the sensitivity (Se), specificity (Sp), predictive value-positive (PVP) and predictive value-negative (PVN) [34]. We also determined the likelihood ratio (LR) for positive (LR+) and negative (LR-) examination.[34] In general, an LR+ of 1 to 2 or an LR- between 0.5 and 1 alters the probability of the presence or absence an ACL lesion by only a small degree [35]. An LR+ of 2 to 10 or an LR- between 0.5 and 0.1 may be considered clinically important [35]. An LR+ greater than 10 or an LR- less than 0.1 may have substantial impact on the probability of the diagnosis [34].
We also determined the diagnostic value for combinations of specific determinants from the diagnostic model. We first combined determinants from history taking and then added the determinant(s) from physical examination in the diagnostic model.

Results

Study population

A total 184 patients were referred for the present diagnostic study during the inclusion period of 18 months. Of these patients, 134 (73%) were actually included (Figure 1). Reasons for non-participation of the other 50 patients were: unwillingness after extended information about the research protocol or missing appointments for the MR imaging (n=21), inability by the patient to find time for the MR imaging appointment (n=14), too minor injury according to the patient (n=7), and no informed consent because of withholding the results of the MR imaging from the patient and the GP (n=8). No patient was excluded because of the MR imaging exclusion criteria or because of a diagnosed fracture.

No clinical or demographic significant differences were found between the baseline characteristics of the participants and non-participants. Table 1 shows the baseline characteristics of the participants. Mean age of the participants was 40 (range 18-64) years and a small majority were male (55.2%). A total of 61 patients (45.5%) reported that sport activities were the cause of the sustained knee injury. At baseline, the mean pain severity (measured with a numerical rating scale) was 4.7 (0 = no pain to 10 = unbearable pain) and the mean Lysholm knee score was 62.0 (0 = worse to 100 = best).

MR imaging results

The results of the MR imaging are presented in Table 1. The average time period between trauma and MR imaging was 38 (range 9-81) days; 70% of all patients had their MR imaging within 6 weeks after the initial trauma. A total of 14 patients (10.4%) showed no effusion, ligamentous lesions or meniscal tears on the MR imaging, and 38 patients (28.4%) showed only effusion without detectable ligamentous lesions or meniscal tears. Thus, 52 patients (38.8%) had no signs of meniscal tears or ligamentous lesions.

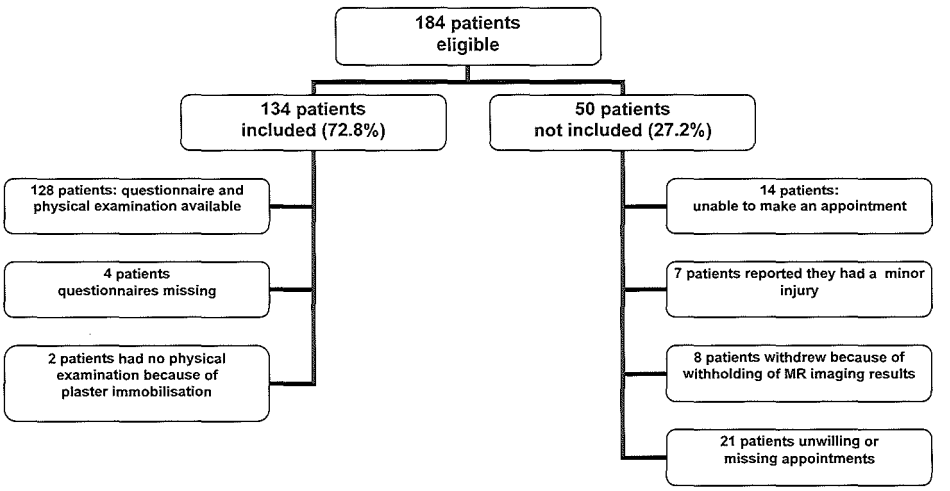

Figure 1. Flow chart of eligible patients

Table 1. Patient characteristics and findings on MR imaging

Patient characteristics		
Age in years, mean ± sd	40.2 ± 12.2	
Gender male, n (%)	74 (55)	
Onset during sports activity, n (%)	61 (45)	
Symptom side right, n (%)	70 (52)	
Pain severity {0-10}, mean ± sd	4.7 ± 2.4	
Lysholm knee function score {0-100}, mean ± sd	62 ± 19	
Diagnosis as seen on MR imaging		
No lesion or effusion, n (%)	14 (10)	
Contusion (effusion, no ligament or meniscal lesion), n (%)	38 (28)	
Anterior cruciate ligament lesion, n (%)	28 (21)	
partial lesion		*11 (8)*
complete lesion		*17 (13)*
Posterior cruciate ligament lesion, n (%)	6 (4)	
Meniscal tear, n (%)	47 (35)	
Medial collateral ligament lesion, n (%)	35 (26)	
Lateral collateral ligament lesion, n (%)	8 (6)	
Anterior cruciate ligament lesion and meniscal tear, n (%)	15 (11)	

ACL lesions detected by MR imaging were seen in 28 of the 134 included patients (21%); 11 lesions were partial and 17 lesions were complete.

History taking and physical examination

In 128 patients (95.5%) both the history taking and the physical examination were available. The questionnaires were available for 130 patients (97.0%). Four questionnaires were not returned by the patient (Figure 1). Physical examination was performed in 132 patients (98.5%); 2 patients had plaster immobilization at the time of the MR imaging.

Table 2. Bivariate association (OR (95% confidence interval)) with ACL lesions

Variables[reference]	Patients available (n)	Partial and complete ACL lesions‡ (n=28) OR (95% CI)	P-value	Complete ACL lesions‡ (n=17) OR (95% CI)	P-value
History taking					
Signs at injury					
Popping" sensation	126	4.5 (1.8-11.1)	0.001*	4.2 (1.4-12.4)	0.009*
Continuation activity impossible	126	3.8 (1.5-9.6)	0.006*	3.6 (1.1-11.8)	0.033*
Immediate pain at trauma	126	8.2 (1.0-63.8)	0.043*	4.3 (0.5-33.9)	0.169
Present symptoms					
Effusion (continuous)	127	2.0 (0.9-4.8)	0.111	3.0 (1.1-8.6)	0.036*
Lysholm knee score < 80	130	2.9 (0.8-10.2)	0.108	1.4 (0.4-5.2)	0.622
Giving way (Lysholm) [19]	130	2.6 (1.1-6.1)	0.029*	2.9 (1.0-8.3)	0.031*
Physical examination					
Pain palpation MCL	130	1.9 (0.8-4.8)	0.136	2.3 (0.8-6.9)	0.052
Pain at passive flexion	130	3.0 (1.1-8.6)	0.038*	2.8 (0.8-10.3)	0.144
Pain passive extension	130	2.0 (0.9-4.8)	0.111	2.8 (0.8-10.3)	0.119
Laxity valgus stress test 0^0	120	3.1 (1.2-8.1)	0.019*	1.4 (0.5-4.1)	0.478
Laxity valgus stress test 30^0	127	3.3 (1.2-9.5)	0.025*	1.4 (0.4-4.6)	0.553
Laxity anterior drawer test	127	6.7 (2.1-21.0)	0.001*	8.5 (1.8-39.4)	0.006*
Laxity Lachman test	127	3.6 (1.3-10.4)	0.016*	2.9 (0.9-8.7)	0.104
Effusion fossa poplitea	130	3.3 (1.1-10.3)	0.040*	2.6 (0.7-9.4)	0.159

‡ As detected on MR imaging / *p < 0.05

After bivariate analysis, 10 determinants showed a statistically significant association with a partial or complete ACL lesion ($p<0.05$). All determinants resulted in a higher probability of an ACL lesion when found positive. Four of these 10 determinants were obtained from history taking including "continuation of activity impossible", "immediate pain at trauma", "popping sensation during trauma" and "giving way (Lysholm score)". The remaining six determinants were obtained from physical examination, including "pain at passive flexion", "laxity valgus stress 0^o", laxity valgus stress 30^o", "laxity anterior drawer test", "laxity Lachman test" and "effusion fossa poplitea" (Table 2).

After multivariate modelling, the determinants "effusion", "popping sensation", "giving way" and "laxity anterior drawer test" showed a significant association ($p<0.05$) with the presence of a partial or complete ACL lesion (Table 3). All four variables increased the probability of an ACL lesion when found positive.

Table 3. Multivariate association (OR (95% confidence interval) with ACL lesions

Variable	Partial / complete ACL lesion‡ n=28 OR (95% CI)	Complete ACL lesion‡ n=17 OR (95% CI)
History taking		
Effusion (continuous)	4.4* (1.4-14.5)	6.1* (1.6-23.0)
Popping" sensation at trauma	6.1* (1.9-19.5)	4.8* (1.3-18.3)
Giving way (Lysholm)	3.5* (1.1-10.9)	3.7* (1.0-13.8)
Physical examination		
Anterior drawer test	6.4* (1.8-23.0)	8.8* (1.7-45.8)
Explained variance (%)	41%	40%

‡ As detected on MR imaging / *p < 0.05

The bivariate analysis of the subgroup with only complete ACL lesions showed eight determinants with a statistically significant association ($p<0.15$) including "popping sensation during trauma", "continuation of activity impossible", "effusion", "giving way (Lysholm score)", "pain palpation medial collateral ligament", "pain at passive flexion", "laxity anterior drawer test" and the "laxity Lachman test" (Table 2). After multivariate modelling, the diagnostic model resulted in the same determinants as in the group with partial or complete ACL lesion (Table 3).

Diagnostic value of history taking and physical examination

In this study population, the prevalence of a partial or complete ACL lesion was 0.21 and for a complete ACL lesion 0.13. The sensitivity (Se), specificity (Sp), predictive value-positive (PVP), predictive value-negative (PVN) and the likelihood ratios (LR+ and LR-) are presented in Table 4. After the diagnostic work-up, the precision to predict an ACL lesion (PVP) increased from 0.21 to 0.39 (95% CI 0.24-0.53) with a positive "popping sensation during trauma". A positive anterior drawer test (ADT) had a Se, Sp and PVP of 0.83 (95% CI 0.68-0.98), 0.57 (95% CI 0.48-0.67) and 0.31 (95% CI 0.20-0.43), respectively. The precision to predict absence of an ACL lesion (PVN) increased from 0.79 to 0.88 (95% CI 0.81-0.95) with a negative "popping sensation during trauma" and to 0.94 (95% CI 0.88-1.00) with a negative ADT. The likelihood ratio of a positive "popping sensation during trauma" (LR+) was 2.3 (95% CI 1.5-3.6) and 2.0 (95% CI 1.5-2.6) for a positive ADT. The likelihood ratio of a negative ADT (LR-) was 0.3 ((95% CI 0.1-0.7).

We also combined determinants from the diagnostic model for assessing ACL lesions (table 4). When at least two out of three items from history taking scored positive the precision to predict an ACL lesion (PVP) was 0.42 (95% CI 0.28-0.56), Se was 0.71 (95% CI 0.55-0.88) and Sp was 0.71 (95% CI 0.62-0.80). A negative score resulted in a prediction of absence of an ACL lesion (PVN) of 0.90 (95% CI 0.83-0.96). All three items positive resulted in a Se of 0.18 (95% CI 0.04-0.32), a Sp of 0.99 (95% CI 0.98-1.00), a PVP of 0.83 (95% CI 0.66-1.00) and a PVN of 0.81 (95% CI 0.74-0.88). Adding the result of the ADT to the combinations mentioned above resulted in a Se of 0.63 (95% CI 0.43-0.82), a Sp of 0.85 (95% CI 0.78-0.92), a PVP of 0.52 (95% CI 0.34-0.70) and a PVN of 0.90 (95% CI 0.84-0.96).

Adding the ADT to the combination of all three items positive from history taking, the Se decreased to 0.16 (95% CI 0.02-0.30), Sp increased to 0.99 (95% CI 0.98-1.00), the PVP increased to 0.80 (95% CI 0.60-1.00) and PVN decreased to 0.82 (95% CI 0.75-0.89). The likelihood of two out of three items positive (LR+) was 2.5 (95% CI 1.7-3.7), and was 0.4 (95% CI 0.2-0.7) with two or three items negative (LR-). Adding the ADT to this combination, the LR+ and LR- became 4.2 (95% CI 2.4-7.5) and 0.4 (95% CI 0.3-0.7), respectively. In the subgroup with complete ACL lesions, overall the PVP was lower than in the subgroup with partial and complete ACL lesions (table 4).

Table 4. Diagnostic values (and 95% confidence interval) of isolated determinants and combinations of determinants with ACL lesions

	N[†]	SE[Φ]	SP[Φ]	PVP[Φ]	PVN[Φ]	LR+[Φ]	LR-[Φ]
Partial and complete ACL lesions (n = 28 / prevalence = 0.21)							
History taking							
Effusion	39	0.43 (0.25-0.61)	0.73 (0.64-0.82)	0.31 (0.16-0.45)	0.82 (0.74-0.90)	1.6 (0.9-2.7)	0.8 (0.6-1.0)
Popping" sensation	44	0.63 (0.45-0.81)	0.73 (0.64-0.82)	0.39 (0.24-0.53)	0.88 (0.81-0.95)	2.3 (1.5-3.6)	0.5 (0.3-0.8)
Giving way	55	0.61 (0.43-0.79)	0.63 (0.53-0.67)	0.31 (0.19-0.43)	0.85 0.77-0.93)	1.6 (1.1-2.4)	0.6 (0.4-1.0)
Physical examination							
Anterior drawer test (ADT)	64	0.83 (0.68-0.98)	0.57 (0.48-0.67)	0.31 (0.20-0.43)	0.94 (0.88-1.00)	2.0 (1.5-2.6)	0.3 (0.1-0.7)
Combinations							
History ≥ 1+	93	1.00 (1.00-1.00)	0.23 (0.15-0.32)	0.27 (0.18-0.35)	1.00 (1.00-1.00)	1.3 (1.2-1.5)	0.0
History ≥ 2+	41	0.71 (0.55-0.88)	0.71 (0.62-0.80)	0.42 (0.28-0.56)	0.90 (0.83-0.96)	2.5 (1.7-3.7)	0.4 (0.2-0.7)
History 3+	5	0.18 (0.04-0.32)	0.99 (0.98-1.00)	0.83 (0.66-1.00)	0.81 (0.74-0.88)	17.7 (2.2-145)	0.8 (0.7-1.0)
History ≥ 1+ / ADT+	47	0.83 (0.68-0.98)	0.64 (0.54-0.73)	0.36 (0.24-0.49)	0.94 (0.88-1.00)	2.3 (1.7-3.2)	0.3 (0.1-0.6)
History ≥ 2+ / ADT+	21	0.63 (0.43-0.82)	0.85 (0.78-0.92)	0.52 (0.34-0.70)	0.90 (0.84-0.96)	4.2 (2.4-7.5)	0.4 (0.3-0.7)
History 3+ / ADT+	4	0.16 (0.02-0.30)	0.99 (0.98-1.00)	0.80 (0.60-1.00)	0.82 (0.75-0.89)	15.4 (1.8-131)	0.8 0.7-1.0)
Complete ACL lesions (n = 17 / prevalence = 0.13)							
History taking							
Effusion	39	0.53 0.29-0.77	0.73 0.65-0.81	0.23 0.10-0.36	0.91 0.85-0.97	2.0 1.1-3.4	0.6 0.4-1.0
Popping" sensation	44	0.65 0.42-0.87	0.70 0.61-0.78	0.25 0.12-0.38	0.93 0.87-0.98	2.1 1.4-3.4	0.5 0.3-1.0
Giving way	55	0.65 0.42-0.87	0.61 0.52-0.70	0.20 0.09-0.31	0.92 0.86-0.98	1.7 1.1-2.5	0.6 0.3-1.1
Physical examination							
Anterior drawer test (ADT)	64	0.88 0.71-1.00	0.55 0.46-0.64	0.22 0.12-0.32	0.97 0.92-1.00	1.9 1.5-2.6	0.2 0.1-0.8
Combinations							
History ≥ 1+	93	0.88 0.73-1.00	0.31 0.22-0.39	0.16 0.09-0.24	0.95 0.87-1.00	1.3 1.0-1.6	0.4 0.1-1.0
History ≥ 2+	41	0.76 0.56-0.97	0.75 0.67-0.83	0.32 0.17-0.46	0.95 0.91-1.00	3.1 2.0-4.6	0.3 0.1-0.7
History 3+	5	0.18 0.00-0.36	0.98 0.96-1.00	0.60 0.17-1.00	0.89 0.83-0.94	9.8 1.8-54.4	0.8 0.7-1.0
History ≥ 1+ / ADT+	47	0.81 0.62-1.00	0.69 0.60-0.77	0.28 0.15-0.40	0.96 0.92-1.00	2.6 1.8-3.7	0.3 0.1-0.8
History ≥ 2+ / ADT+	27	0.65 0.42-0.87	0.91 0.86-0.96	0.52 0.31-0.74	0.94 0.90-0.99	7.2 3.6-14.4	0.4 0.2-0.7
History 3+ / ADT+	4	0.19 0.00-0.38	0.99 0.98-1.00	0.75 0.50-1.00	0.89 0.83-0.95	19.9 2.2-179.6	0.8 0.6-1.0

[†] n = prevalence of the determinant or combination
[Φ] Se = sensitivity, SP = specificity, PVP = predictive value positive, PVN = predictive value negative, LR+ = positive likelihood ratio, LR- = negative likelihood ratio

Discussion

The present study is the first to investigate the diagnostic value of history taking and physical examination in patients with an ACL lesion in a primary care setting. The injuries of the included patients ranged from no abnormalities at the time of the MR imaging to complete ACL lesions in combination with meniscal tears and collateral ligament lesions; an ACL lesion was seen in 21% of these patients.

Our results show diagnostic value of isolated determinants from history taking in detecting ACL lesions especially "popping sensation during trauma". A positive test result of the ADT, obtained from physical examination, has less diagnostic value. On the other hand, a negative test result of the ADT has higher diagnostic value compared to history taking. However, combining the ADT with the determinants from history taking adds little to the diagnostic value. Therefore, both isolated determinants, "popping sensation during trauma" and ADT, are diagnostic tools for the GP in predicting the presence or absence of an ACL lesion.

The systematic review of Scholten et al. reported that the pivot shift test was preferable to the ADT or Lachman test [10]. The Lachman test is considered to be most useful to detect anterior-posterior instability due to ruptures of the anterior-medial bundle of the ACL, while the pivot shift test is believed to be more valuable to detect rotational instability due to ruptures of the posterior-lateral bundle. However, in our study population this pivot shift test was performed in the acute phase after the injury in only 98 patients; in 32 patients pain hindered the performance of this test. This phenomenon clearly demonstrates a difference in results from studies in primary and secondary care settings, more specifically regarding the moment of examination (acute phase vs. late phase after injury). Both Scholten et al.[10] and Jackson et al.[11] reported that the Lachman test is preferable to the ADT. In our study, both the Lachman test and the ADT show an almost equal association with ACL lesions and are highly correlated (not reported). In the multivariate analysis only the ADT remained in the model; however, the diagnostic value is very similar. The Lachman test is equally useful in clinical practice, especially for those who are more acquainted with this test than with the ADT, or prefer this test to the ADT.

In the present study composite examination indeed increased the diagnostic value as hypothesized. This finding is in line with the expectation reported by Solomon et al. [12]. When all four items from the diagnostic model are positive the diagnosis ACL lesion can be made with reasonable (i.e. 80%) certainty (Table 4); however, this applies to very few cases. With at least two of the three items from history taking positive and with a positive ADT (which applies to many more cases) the probability of an ACL lesion is doubled, but is still only 52%. If no item from history taking is positive an ACL lesion can be excluded, which again only applies to a few cases. In case of a negative ADT there is a probability of only 6% of having an ACL lesion, and this applies to 50% of the present cases.
Based on our results, the GP can reasonably exclude ACL lesions mainly by history taking, which is important in order to reassure the patient and to argue against further diagnostic and therapeutic

interventions. This strategy may avoid unnecessary restriction of daily activities and/or use of healthcare resources.

In the present study the determinants "weight bearing during trauma" and "ballottement" almost reached the cut-off point of 0.15; with a larger study population these determinants might have been included in the final model. Further, the results of the present study should preferably be validated in another study in primary care including a similar study population of patients consulting for acute traumatic knee disorders.

Some limitations of the present study need to be addressed. History taking was obtained with a questionnaire and not by a face to face interview. Because of the need for standardisation and the number of items asked for, we used a questionnaire. Although this does not represent daily practice we expect that the results are not influenced by doing so. Furthermore the patients may not suffer from ACL lesions alone. In our study 15 patients had an ACL lesion and a meniscal tear. It has been reported that the accuracy of clinical examination of ACL lesions with associated lesions is reduced compared to isolated ACL lesions [36]. In our statistical analysis we corrected for meniscal tears and saw no significant alterations in the diagnostic model. Furthermore, we included less than 10 events per covariate which could resulted in biased estimates and over- or underestimated variances. Another limitation is that the MR imaging is considered to be less accurate in detecting partial ACL lesions [29-30].

Because a management decision might differ depending on whether the ACL lesion is partial or complete, we performed a subgroup analysis including only the complete ACL lesions. The results showed no clear difference in diagnostic value compared with the combined group of ACL lesions. In addition, more prospective observational and experimental studies on the treatment and prognosis of ACL lesions (including cost-effectiveness analysis) are recommended.

Conclusions

ACL lesions are seen frequently. Based on history taking (effusion, popping sensation, and/or giving way) and physical examination (ADT), GPs can screen for ACL lesions in primary care. In addition, more prospective observational and experimental studies of the treatment and prognosis of ACL lesions (including cost-effectiveness analysis) are recommended.

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Appendix 1. Items from history taking analysed for association with ACL lesions[18]

Variable[reference]	Description of the question asked for	Positive result
Demographics		
Age	Date of birth in years	Positive if age over 40 years
Gender	Male or female	Positive if gender is male
Mechanism of injury		
Fall on the knee	Did you fall on your knee? (yes / no / do not remember*)	Positive if yes
Injury by external force to knee	Was there an external force to your knee due to a kick, bang, or knock? (yes / no / do not remember*)	Positive if yes
Injury while landing on leg	Did the injury happen when landing on your leg? (yes / no / do not remember*)	Positive if yes
Weightbearing knee during injury	Was your knee bearing weight during the injury? (yes / no / do not remember*)	Positive if yes
Rotational injury	Did you twist your knee during the injury by twisting your body compared to the position of your leg? (yes / no / do not remember*)	Positive if yes
Foot/leg blocked	Was your foot / leg blocked during the injury? (yes / no / do not remember*)	Positive if yes
"Popping" sensation	Did you hear or feel a "popping" sensation during the injury? (yes / no / do not remember*)	Positive if yes
Signs at injury		
Continuation activity impossible	Was it possible for you to continue your activities for some time after the injury by continuing the game, the assignment, etc? (yes / no)	Positive if yes
Immediate pain at injury	When did the pain develop after the injury? (not at all/immediately/ after some hours / within 24 hours / after 24 hours)	Positive if the pain developed immediately after the injury
Immediate effusion after injury	When did the swelling develop after the injury? (not at all / within two hours after the injury / more than two hours after the injury but within 24 hours)	Positive if the swelling developed within two hours after the injury
Present symptoms		
Pain score	Numerical rating scale (0-10) for severity of pain.	Positive if the NRS pain Score is 6 or higher
Lysholm score < 80[19]	Scoring list of 9 questions	Positive if Lysholm score under 80
Effusion	Does your knee feel swollen? (no, sometimes, all the time)	Positive if the knee feels swollen all the time
Crepitation	Do your feel/hear crack inside the knee? (no, sometimes, all the time)	Positive if crack all the time
Warm knee	Does your knee feel warm? (no, sometimes, all the time)	Positive if the knee feels warm all the time

* when the answer was "do not remember" the variable was defined as missing

Appendix 2. Items from the physical examination for association with an ACL lesion

Variable[reference]	Description of a positive test result
Genu flexum[20]	Positive if the knee is in flexed position during weight bearing.
Increased temperature[20]	Positive if the same or increased temperature of the knee is felt by the examiner compared to the adjacent thigh/lower leg.
Ballottement test[20]	Positive if the patella strikes the trochlea with a distinct impact or flows back to its former position, when the examiner pushes the patient's patella posteriorly with 2 or 3 fingers using a quick, sharp motion.
Minor effusion test (fluctuation)[20]	Positive if, after the examiner milks the fluid from the suprapatellar pouch and lateral side into the medial side of the knee (extended knee) and gently taps the joint over the fluid, the fluid transverses the knee and creates fullness on the lateral side.
Pain palpation medial joint line[20]	Positive if pain is felt when the examiner palpates the medial part of the anterior joint line of the flexed knee (90°).
Pain palpation lateral joint line[20]	Positive if pain is felt when the examiner palpates the lateral part of the anterior joint line of the flexed knee (90°).
Pain palpation MCL[20]	Positive if pain is felt when the examiner palpates the MCL of the slightly flexed knee.
Pain palpation LCL[20]	Positive if pain is felt when the examiner palpates the LCL of the flexed knee (90°) with the hip in external rotation and abduction.
Pain at passive flexion[21]	Positive if pain is felt when the knee is gently forced in full flexion by the examiner.
Pain at passive extension[21]	Positive if pain is felt when the knee is gently forced in full extension (hyperextension) by the examiner.
Laxity varus stress 0° test[22]	Positive if increased laxity is felt by the examiner when the extended knee is forced in varus.
Laxity valgus stress 0° test[22]	Positive if increased laxity is felt by the examiner, palpating the medial joint space, when the extended knee is forced in valgus.
Laxity varus stress 30° test[22]	Positive if increased laxity is felt by the examiner when the 30° flexed knee is forced in varus.
Laxity valgus stress 30° test[22]	Positive if increased laxity is felt by the examiner, palpating the medial joint space, when the 30° flexed knee is forced in valgus.
Laxity anterior drawer test[22]	Positive if essentially more laxity is felt compared to the other knee in the 45° flexed knee (with hip 90° flexed, and the foot fixed by the examiner sitting on it) when the examiner gently translates the proximal tibia forward with both his hands.
Laxity posterior drawer[22]	Positive if essentially more laxity is felt compared to the other knee in the 45° flexed knee (with hip 90° flexed, and the foot fixed by the examiner sitting on it) when the examiner gently translates the proximal tibia backward with both his hands.
Laxity Lachman test[23]	Positive if essentially more laxity is felt in the slightly flexed (20°) knee than when proximal tibia is translated forward with one hand of the examiner while the distal part of the femur is fixed by the other hand.
Pivot shift test[24]	Positive if subluxation by the tibiae occurs during internal rotation.
Effusion popliteal fossa[20]	Positive if the examiner judges that there is effusion and/or Baker's cyst during palpation in the fossa of the extended knee.

4

Assessing Medial Collateral Ligament Knee Lesions in General Practice

M. Kastelein, H.P.A. Wagemakers, P.A.J. Luijsterburg, J.A.N. Verhaar, B.W. Koes, S.M.A. Bierma-Zeinstra

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Abstract

Purpose

To assess the diagnostic value of history taking and physical examination of medial collateral ligament (MCL) lesions after a knee injury presenting in general practice.

Methods

Patients aged 18 to 65 years with a traumatic knee injury who consulted their general practitioner within 5 weeks after trauma filled out a questionnaire, underwent a standardized physical examination and underwent a MR imaging scan. Logistic regression analysis was used to test possible associations between determinants from history taking/physical examination and MCL lesions. The diagnostic value of history taking and physical examination was determined for those variables indicating an association ($p<0.15$) with MCL lesions and was assessed by sensitivity, specificity, predictive value and likelihood ratios.

Results

Of the 134 patients included in this study, 35 had an MCL lesion seen on IMAGING. From history taking the determinants "trauma by external force to leg" and "rotational trauma" showed an association with MCL lesion after multivariate analysis ($p<0.15$). From physical examination "pain valgus stress 30°" and "laxity valgus stress 30°" showed an association ($p<0.15$). Isolated determinants from history taking and physical examination showed some diagnostic value; the likelihood ratio positive (LR+) was 2.0 for "trauma by external force to leg" and for "pain valgus stress 30°" 2.3. Adding "pain valgus stress 30°" and "laxity valgus stress 30°" from physical examination to history taking improved the diagnostic value to a LR+ of 6.4.

Conclusion

MCL lesions are frequently seen in patients with traumatic knee injury. History taking has a diagnostic value, while adding physical examination increase the diagnostic value.

Introduction

General practitioners (GPs) are frequently consulted by patients who have sustained a traumatic knee injury. The incidence of these injuries (excluding fractures) reported in Dutch general practice is about 5.3 per 1000 patients per year [1]. The medial collateral ligament (MCL) is important for knee joint stability [2]. A rupture of the MCL, due to trauma, is reported frequently: 25.7% of patients in primary care have a partial lesion and 0.7% have a complete lesion [3].

In the Dutch healthcare system, the GP plays a key role as a gatekeeper. After history and physical examination the GP decides on a wait-and-see policy, initiates conservative treatment or considers referral for further diagnostic imaging or secondary care. About 25% of all patients with traumatic knee injuries in the Netherlands is referred to secondary care [4].

Careful history taking and physical examination should help the GP making a clinical diagnosis in knee injury [5]. However, the diagnostic value of history taking and physical examination is often questioned by clinicians [6-7]. Four systematic reviews summarized available knowledge on this issue [8-11]. However, most studies reported on meniscus and cruciate lesions [8-10]. Only Solomon et al. [11] reported about MCL lesions. They concluded that there were no data available to determine the accuracy of physical examination of the MCL [11]. One comparative studies has looked at the diagnostic value of physical examination at MCL lesions [12]. Rasenberg et al. [12] concluded that there is a very high degree of agreement between the results in grading acute MCL injuries with MR imaging and an instrumented valgus-varus laxity tester [12]. However, the conclusion from this study [12] is based on patients presenting of a secondary care setting. There are no studies available concerning patients with traumatic lesions of the knee in primary care. The likelihood of actual lesions of the knee in secondary care settings is expected to be higher, because the selection of patients has already taken place in primary care.

The present study aims to determine the diagnostic value of items from history taking and physical examination for detecting MCL lesions in primary care, for isolated determinants as well as combinations of determinants.

Methods

Design

The present prospective, observational cohort study is part of the research network HONEUR (40 GPs) established by the department of General Practice of Erasmus Medical Center Rotterdam[13]. New complaints were defined as episodes of complaints presented to the GP for the first time. Patients were eligible for the present study if they were aged 18 to 65 years and had consulted their GP for a traumatic knee complaint within 5 weeks after the initial trauma. Patients with MR imaging contraindications (pregnancy, metal implants or a pacemaker) were excluded.

The study protocol was approved by the Medical Ethics committees of the Erasmus Medical Center Rotterdam and of the Medical Center Rijnmond Zuid.

Data collection

Patients filled out a self-report questionnaire and an appointment was made for the MR imaging. A standardized physical examination was carried out immediately after the MR imaging by a trained physical therapist (HPAW). The physical therapist was blinded for the MR imaging results, as was the radiologist for the results of the physical examination and questionnaire. Neither the patient nor the GP were informed about the outcome of the MR imaging or physical examination.

The baseline questionnaire [13] collected data including age, gender, socio-economic status, history of previous knee injuries and/or operations, present symptoms, mechanism of injury, level of activity in work, household, study, sports and the Lysholm knee score [14].

Physical examination [13] of both knees consisted of inspection (alignment and joint effusion [15]), palpation (temperature, collateral ligaments and joint line tenderness [15]), assessment of effusion [15-16], passive range of motion in flexion and extension [15-16] and the valgus stress test in 0° and 30° flexion [17]. Also other stability tests and meniscal tests, as the anterior drawer test [17] and MCMurray test [18] are performed, but not used for analysis in the present study.

MR imaging was selected as the reference test because it is a highly accurate diagnostic tool for detecting MCL lesions [2]. In the present study MR imaging was scheduled 3 to 6 weeks after the initial trauma using a 1.0 Tesla General Electric device. Detailed information about the MR imaging procedure is reported elsewhere [3].

Patient outcome was defined as presence or absence of an MCL lesion as seen on MR imaging. Two radiologists classified the MR imaging scans independent from one another. In case of disagreement, the findings were discussed until consensus was reached.

Statistical analysis

Descriptive statistics were used to present the results of the MR imaging. Univariate logistic regression analysis (SPSS, version 11.0) was used to determine the association of separate determinants from history taking and physical examination with MCL lesions, expressed as odds ratios (OR). Determinants showing a univariate association ($p<0.15$) with an MCL lesion were analysed in a multivariate logistic regression analysis (Backward Wald method, entry 0.10, removal 0.20) to eliminate redundant variables. Separate analyses were performed for history taking and physical examination. Finally, the remaining determinants ($p<0.15$) were analysed together (using the Enter method) to compose a diagnostic model for MCL lesions.

We determined the diagnostic value of the isolated determinants from history taking and physical examination with a statistically significant independent relationship with MCL lesions ($p<0.15$) by calculating the sensitivity (Se), specificity (Sp), predictive value-positive (PVP) and predictive value-negative (PVN) [19]. We also determined the likelihood ratio (LR) for positive (LR+) and negative (LR-) examination [19]. Finally, we combined determinants from the composed diagnostic model for MCL lesions ($p<0.15$) and determined the diagnostic value of these combinations.

Results

Study population

Of the 184 eligible patients, 134 (73%) were included in the present study (March 2002 to October 2003). Figure 1 shows the flowchart of eligible patients. Reasons for non-participation were unwillingness or missing appointments for the MR imaging (n=21), no availability of MR imaging appointment (n=14) and other reasons (n=15). No patient was excluded because of the MR imaging exclusion criteria.

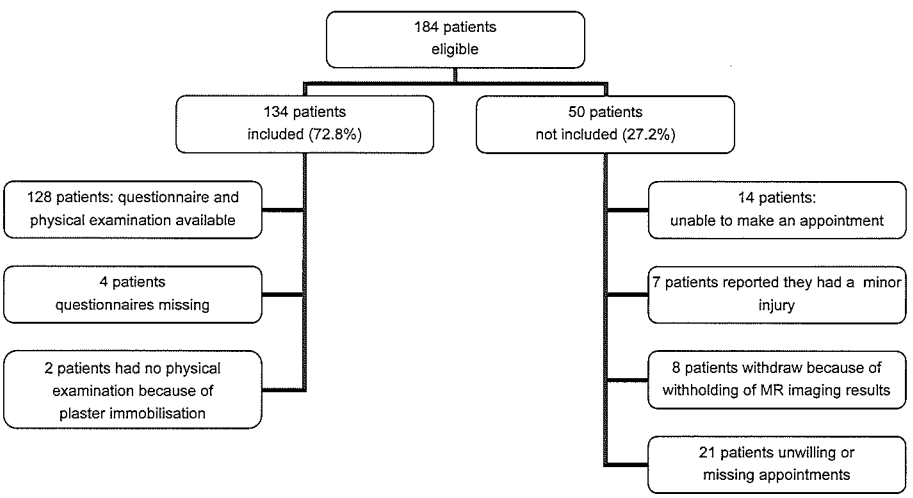

Figure 1. Flow chart of eligible patients

No significant differences were found between the baseline characteristics of the participants and non-participants (Table 1).

Mean age of the participants was 40.2 years (SD 12.2) and a small majority is male (55.2%). Sixty-one patients (45.5%) reported that sport activities were the cause of the sustained knee injury. At baseline, the mean pain severity, measured with a numerical rating scale, was 4.7 (0 = no pain to 10 = unbearable pain) and the mean Lysholm knee score was 63.7 (0 = worse to 100 = best).

Table 1. Comparison of baseline characteristics of participants and non-participants

Characteristic	Participants (n=134)	Non-participants (n=50)
Age, years, (mean ± sd)	40.2 ± 12.2	40.4 ± 11.3
Gender male, (n,(%))	74 (55.2)	32 (66.7)
Onset during sports activity, (n,(%))	61 (45.5)	16 (33.5)
Symptom side right, (n, (%))	70 (52.2)	19 (39.6)
Pain severity (0-10), (mean ± sd)	4.7 ± 2.4	4.2 ± 2.5
Lysholm knee function score (0-100), (mean ± sd)	63.7 ± 18.9	66.5 ± 23.3

MR imaging results

The average time period between trauma and MR imaging was 38 days (range 9-81 days); 70% of all patients had their MR imaging within 6 weeks after the initial trauma. In 14 patients (10.4%) there were no signs of effusion, ligamentous lesions or meniscal tears on MR imaging, and 38 patients (28.4%) showed only effusion without detectable ligamentous lesions or meniscal tears. Thus, 52 patients (38.8%) had no signs of meniscal tears or ligamentous lesions. Meniscal tear is defined as all meniscal tears, excluding degenerative meniscal tears.

MCL lesions detected by MR imaging were seen in 35 patients (26.1%). Eight patients had a LCL lesion (6.0%). Of all patients, 16 (11.9%) had an isolated MCL lesion and 12 (9.0%) had a combination of MCL lesion with meniscal tear.

The results from MR imaging are presented in Table 2.

Table 2. Imaging findings in patients with knee injury (n=134) in general practice

Diagnosis as seen on MR imaging	N (%)
No lesion or hydrops, n (%)	14 (10.4)
Contusion (hydrops, no ligament or meniscal lesion), n (%)	38 (28.4)
Medial collateral ligament lesion, n (%)	35 (26.1)
Lateral collateral ligament lesion, n (%)	8 (6.0)
Anterior cruciate ligament lesion, n (%)	28 (20.9)
Posterior cruciate ligament, n (%)	6 (4.4)
Meniscal tear, n (%)	47 (35.1)
Isolated Medial collateral ligament lesion, n (%)	16 (11.9)
Isolated Lateral collateral ligament lesion, n (%)	2 (1.5)
Medial collateral ligament lesion and meniscal tear, n (%)	12 (9.0)

History taking and physical examination

In 128 patients (95.5%) both the history taking and the physical examination were available. The questionnaires were available for 130 patients (97.0%); four questionnaires were not returned by the patient (Figure 1). Physical examination was performed in 132 patients (98.5%); 2 patients had plaster immobilization at the time of MR imaging. From history taking five determinants showed an association ($p<0.15$) with MCL lesions (Table 3).

Table 3. Number of patients with positive test result and association of items with MCL lesions

Variables [reference]	Patients available N	MCL lesion present‡ (n=35)	MCL lesion absent‡ (n=99)	OR	95% CI
History taking					
Age over 40	134	20	44	1.7	0.8-3.6
Gender (male/female)	134	21/14	53/46	0.8	0.4-0.7
Mechanism of injury					
Trauma during sport	126	20	41	2.2**	0.9-4.9
> 90° of flexion during trauma	124	8	20	1.2	0.5-3.1
Fall on the knee	124	8	23	1.0	0.4-2.5
Trauma by external force to leg	127	7	10	2.3*	0.8-6.5
Trauma while landing on leg	125	11	31	1.0	0.4-2.3
Trauma by forceful rising	126	2	10	0.6	0.1-2.7
Trauma during push off	127	7	23	0.8	0.3-2.2
Weight bearing on the knee	113	21	61	1.4	0.5-4.0
Rotational trauma	93	13	27	2.7**	1.0-7.4
Foot/leg blocked	107	16	27	2.9***	1.2-7.0
Signs at trauma					
Continuation activity impossible	*127*	*19*	*46*	*1.4*	*0.6-3.2*
Immediate pain at trauma	*126*	*24*	*78*	*0.5*	*0.2-1.3*
Immediate effusion after trauma	*125*	*13*	*38*	*1.0*	*0.4-2.2*
"Popping" sensation during trauma	*126*	*14*	*30*	*1.5*	*0.7-3.5*
Present symptoms					
Pain score ≥ 6 (0-10 NRS)	127	15	37	1.2	0.5-2.6
Effusion (continuous)	128	14	25	2.1**	0.9-4.7
Crepitation (continuous)	129	6	24	0.6	0.2-1.7
Lysholm knee score < 80 [14]	130	26	75	0.9	0.4-2.3
Physical examination					
Genu flexum [15-16]	132	14	20	2.6***	1.1-5.9
Increased temperature [15]	132	20	36	2.3***	1.0-5.0
Ballottement test [15-16]	132	22	56	1.2	0.6-2.7
Fluctuation / Minor effusion test [15]	128	7	6	3.8***	1.2-12.3
Medial joint line pain [15]	132	27	48	3.4***	1.4-8.3
Pain palpation MCL§ [15]	132	28	43	5.0***	2.0-12.6
Pain at passive flexion [15-16]	134	27	60	2.2**	0.9-5.3
Pain passive extension [15]	134	24	44	2.7***	1.2-6.2
Pain valgus stress 0° [15-16]	121	20	22	7.1***	2.8-17.8
Laxity valgus stress 0° [15-16]	121	8	27	0.9	0.4-2.3
Pain valgus stress 30° [15-16]	128	25	32	7.1***	2.8-18.3
Laxity valgus stress 30° [15-16]	128	29	49	9.3***	2.6-32.5

‡ as detected on MR imaging
§ MCL= Medial Collateral Ligament
*p < 0.15, **p < 0.10, ***p < 0.05

These five determinants, "trauma during sport", "trauma by external force to knee", "rotational trauma", "foot/leg blocked" and "effusion (continuous)" result in a higher probability when found positive. Ten test results obtained by physical examination, "genu flexum", "increased temperature", "fluctuation/minor effusion test", "medial joint line pain", "pain palpation MCL", "pain at passive flexion", "pain at passive extension", "pain valgus stress 0°", "pain valgus stress 30°" and "laxity valgus stress 30°", showed an

association ($p<0.15$) with MCL lesions (Table 3). These ten variables raise the probability of an MCL lesion when found positive.

After multivariate modelling "trauma by external force to leg", "rotational trauma", "pain valgus stress 30°" and "laxity valgus stress 30°" indicated an independent association ($p<0.15$) with the presence of a MCL lesion. Table 4 shows the multivariate association of items with MCL lesions.

Table 4 Multivariate association (and 95% confidence interval) of items with MCL lesions

Variable	MCL lesion‡
History taking	OR 95% CI
Trauma by external force to leg	4.1** (0.8-20.9)
Rotational trauma	5.7*** (1.5-21.8)
Physical examination	
Pain valgus stress 30°	3.1* (0.8-12.3)
Laxity valgus stress 30°	4.2** (0.8-20.8)
Explained variance (%)	35

‡ As detected on MR imaging
*p < 0.15, **p < 0.1, ***p < 0.05

Diagnostic value of history taking and physical examination

The prevalence of MCL lesion (prior probability) in this study population was 0.26. The sensitivity (Se), specificity (Sp), predictive value-positive (PVP), predictive value-negative (PVN), the likelihood ratio positive (LR+) and the likelihood ratio negative (LR-) are presented in Table 5.

The PVP of an MCL lesion increased from 0.26 to 0.41 (0.18-0.47) for "trauma by external force to leg", to 0.33 (0.18-0.47) with a positive "rotational trauma", to 0.44 (0.31-0.57) for "pain valgus stress 30°" and to 0.37 (0.26-0.48) for "laxity valgus stress 30°". Combining the determinants from history taking did not increase the PVP significantly. Adding "pain valgus stress 30°" or "laxity valgus stress 30°" to the combination of determinants from history taking when at least one out of two determinants was positive, increased the PVP to 0.56 (0.33-0.79) and to 0.43 (0.26-0.61) respectively. The PVP increased to 0.63 (0.39-0.86) when combining at least one out of two determinants from history taking was positive, combined with "pain valgus stress 30°" and "laxity valgus stress 30°".

The probability of the absence of an MCL lesion increased from 0.74 to 0.85 (0.75-0.95) for negative test results for "rotational trauma", to 0.90 (0.83-0.97) for "pain valgus stress 30°" and to 0.94 (0.87-1.00) for

"laxity valgus stress 30°". Combining the determinants of history taking did not increase the PVN substantial. Also, adding the determinants from physical examination did not increase the PVN.

The isolated determinants "trauma by external force to leg" and "pain valgus stress 30o" had a clinically important LR+, 2.0 (0.8-4.8) and 2.3 (1.7-3.3) respectively. Combining determinants from history taking did not increase the LR+. De LR+ increased to 4.8 (2.2-10.4) when at least one of the two determinants

from history taking positive was combined with "pain valgus stress 30o", to 2.9 (1.8-4.8) when combined with "laxity valgus stress 30°" and to 6.4 (2.7-15.2) when combined with "pain valgus stress 30°" and "laxity valgus stress 30°". The determinants "pain valgus stress 30°" and "laxity valgus stress 30°" had a low LR-, 0.3 (0.2-0.6) and 0.2 (0.1-0.6) respectively. The combinations did not alter the LR- substantially.

Table 5 Diagnostic values (and 95% confidence interval) of isolated determinants and combinations of determinants with MCL lesions (prevalence = 0.26/N=35)

Variable	N[†]	SE[Φ]	SP[Φ]	PVP[Φ]	PVN[Φ]	LR+[Φ]	LR-[Φ]
Isolated determinants							
Trauma by external force to leg	17	0.21 (0.07-0.35)	0.89 (0.83-0.96	0.41 (0.18-0.65)	0.76 (0.68-0.84)	2.0 (0.8-4.8)	0.9 (0.7-1.1)
Rotational trauma	40	0.62 (0.41-0.83)	0.63 (0.51- 0.74)	0.33 (0.18-0.47)	0.85 (0.75-0.95)	1.7 (1.1-2.6)	0.6 (0.3-1.1)
Pain valgus stress 30[0]	57	0.78 (0.64-0.92)	0.67 (0.57- 0.76)	0.44 (0.31-0.57)	0.90 (0.83-0.97)	2.3 (1.7-3.3)	0.3 (0.2-0.6)
Laxity valgus stress 30[0]	78	0.91 (0.81-1.00)	0.49 (0.39-0.59)	0.37 (0.26-0.48)	0.94 (0.87-1.00)	1.8 (1.4-2.2)	0.2 (0.1-0.6)
Combinations							
History ≥ 1 out 2	49	0.86 (0.71-1.00)	0.57 (0.46-0.68)	0.37 (0.23-0.50)	0.93 (0.86-1.00)	2.0 (1.4-2.7)	0.3 (0.1-0.7)
History ≥ 2 out 2	6	0.05 (0.00-0.14)	0.93 (0.87-0.99)	0.17 (0.00-0.46)	0.77 (0.68-0.86)	0.7 (0.1-5.6)	1.0 (0.9-1.0)
History ≥ 1 out 2 + PVLS30	18	0.56 (0.33-0.79)	0.88 (0.81-0.96)	0.56 (0.33-0.79)	0.88 (0.81-0.96)	4.8 (2.2-10.4)	0.5 (0.3-0.8)
History ≥ 1 out 2 + LVLS30	30	0.72 (0.52-0.93)	0.75 (0.65-0.86)	0.43 (0.26-0.61)	0.91 (0.84-0.99)	2.9 (1.8-4.8)	0.4 (0.2-0.8)
History ≥ 2 out 2 + LVLS30	3	0.06 (0.00-0.16)	0.97 (0.93-1.00)	0.33 (0.00-0.87)	0.80 (0.71-0.80)	1.9 (0.2-20.0)	1.0 (0.9-1.1)
History ≥ 1 out 2 + PVLS30 + LVLS30	16	0.56 (0.33-0.79)	0.91 (0.85-0.98)	0.63 (0.39-0.86)	0.89 (0.81-0.96)	6.4 (2.7-15.2)	0.5 (0.3-0.8)

PVLS30 = pain valgus stress 30[0]
LVLS30 = laxity valgus stress 30[0]
[†] N = prevalence of the determinant or combination
Φ Se = sensitivity, SP = specificity, PVP = predictive value positive, PVN = predictive value negative, LR+ = positive likelihood ratio, LR- = negative likelihood ratio
"History ≥ 2 out 2 + PVLS30" and "History ≥ 2 out 2 + PVLS30 + LVLS30" not executed because n=1.

Discussion

The present study is the first study to investigate the diagnostic value of history taking and physical examination in patients with an MCL lesion in a primary care setting. In this study MCL lesions were seen in 26% of the 134 included patients.

There is limited literature available on the diagnostic value of history taking and physical examination of MCL lesions [11]. The study of Rasenberg et al. [12] reported on MCL lesions, but concerned patients in secondary care. They concluded that there is a very high degree of agreement between the results in grading acute MCL injuries with MR imaging and an instrumented valgus-varus laxity tester. However, they did not report about the prediction whether there is an MCL lesion or not. Therefore no relevant information is available to which we can compare our results.

The present study shows that the isolated determinants "trauma by external force to leg" from history taking and "pain valgus stress 30°" from physical examination maybe considered diagnostic tools for the

GP in predicting MCL lesions. Also the absence of the isolated determinants "pain valgus stress 30°" and "laxity valgus stress 30°" from physical examination are potentially relevant diagnostic tools for excluding MCL lesions.

The most important isolated determinant of history taking seems to be "trauma by external force to leg". The PVP and LR+ of this determinant are higher than that for "rotational trauma". However, the patients available (n=93) for evaluating the determinant "rotational trauma" is only moderate, because 37 patients answered "I don't know" for this question. Twelve of these 37 patients had an MCL lesion. Therefore, the diagnostic value of "rotational trauma" could be over- or underestimated in detecting MCL lesions.

The present study shows also that history taking combined with physical examination increased the diagnostic value. The GP can nearly exclude MCL lesions when "laxity valgus stress 30°" is negative or when at least one of the two of determinants of history taking is negative, which is important to avoid unnecessary diagnostic interventions and treatment. The GP can predict with a maximum of 63% chance whether there is an MCL lesion, when at least one of the two determinants from history taking is positive combined with a positive "pain valgus stress 30°" and positive "laxity valgus stress 30°", but he cannot be certain about the presence of an MCL lesion. Therefore, MR imaging could be useful to confirm the diagnosis MCL lesion. However a MR imaging scan is only necessary when the GP considered surgery; in case of great instability of the MCL and in suspicion of an MCL lesion combined with anterior cruciate injury [20].

Some limitations of our study have to be mentioned. In the present study only MCL lesions are considered, even though some patients may suffer from a combination of MCL lesion with other lesions, especially meniscal tears. These combinations might influence the outcome of determinants and thereby the diagnostic value. In our study 14 (40%) of the patients had a combined MCL lesion and meniscal tear (excluding degenerative tears).

We had a small study population (n=134) and we used a cut-off point of 0.15 in our univariate analysis for inclusion in the multivariate model. Some determinants nearly reached the cut-off point and might have been included with a larger study population. Therefore, the results we presented should preferably be validated in a larger study population in general practice.

A strong element of our study is the use of the MR imaging as reference method. Most research of traumatic knee disorders has been done in secondary care with arthroscopy as gold standard [8-11]. The advantage of using the MR imaging as gold standard is the absence of verification bias in contrast to an arthroscopy. Another advantage is the excellent visualizing of the MCL on MR imaging in contrast to arthroscopy, because the MCL is an extra-articulair ligament and frequently not seen by arthroscopy.

The Dutch Guideline "traumatic knee disorders" [21] for GPs recommend a "wait and see policy" unless there is locking of the knee or suspicion of a fracture. Only non-randomised clinical trials [20, 22-25] investigating the effect of the treatment of MCL lesions are available. Three clinical trials [20, 22-23] reported that surgical repair of a complete isolated MCL lesion has the same results as a conservative treatment. For partial isolated MCL lesions, two clinical trials [24-25] reported that partial MCL lesions successfully can be treated with a conservative treatment. Conservative treatment of an MCL lesion consisted of relative rest, cold application, compression and elevation of the leg in the first 48 to 72 hours [24]. We suggest if the GP predicts there is high chance of MCL lesion, conservative treatment should take place. If the knee complaints after several weeks of conservative treatment have not decreased, a MR imaging and referral to secondary care should be considered. Because there is a lack of information about the treatment and prognosis of MCL lesions, randomised controlled trials about the treatment of MCL lesions with a long follow-up are recommended, especially for complete MCL lesions.

Conclusions

Based on history taking and physical examination the GP can reasonably diagnose the absence of an MCL lesion. Our study also shows that a GP can predict the existence of an MCL lesion with a maximum of 63% certainty, therefore he can not be completely certain whether there is an MCL lesion. Clinically, this may not be a problem, because the treatment of an MCL lesion initially consists of conservative treatment. If complaints persist further diagnostic testing including MR imaging may be indicated.

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Part Three

The physician who cannot inform his patient
what would be the probable issue of his complaint,
if allowed to follow its natural course,
is not qualified to prescribe any rational treatment for its cure.

Hippocrates (460-375 B.C.)

5

Outcome of Knee Injuries in General Practice

One Year Follow-Up

H.P.A. Wagemakers, P.A.J. Luijsterburg, E.M. Heintjes, M.Y. Berger, J.A.N. Verhaar, B.W. Koes, S.M.A. Bierma-Zeinstra

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Abstract

Background

Knee injuries may lead to pain and to functional limitations in the activities of daily living. Patients with knee injuries are frequently seen in general practice, however the outcome and management in these patients is not known.

Aim

To assess the outcome and management of knee injuries at 12 months follow-up in general practice.

Design of study

A prospective observational cohort study with an one year follow-up.

Setting

Primary healthcare.

Methods

Adult patients consulting their GP after knee injury (n=134) participated the cohort. A MR imaging was made and patients were diagnosed either no lesion or an isolated meniscal tear, an isolated collateral or cruciate ligament lesion or a combination. Follow-up questionnaires were filled out up to 12 months follow-up.

Results

At 12 months follow-up 34 patients reported full recovery and 67 patients reported major improvement. At baseline 37 patients (28%) were referred to physical therapy and 17 patients (13%) were referred to secondary care. During one year of follow-up, another 21 referrals to physical therapy and 11 referrals to secondary care took place. The pain severity decreased the most and the Lysholm knee score increased in the majority of patients during the first three months after injury. In total 18 arthroscopies were performed in 15 patients. One patient underwent an anterior cruciate ligament reconstruction.

Conclusion

The vast majority of patients report clinically relevant recovery. There is no clear difference in outcomes between patients with meniscal tears or ligament lesions and patients without these diagnosis.

Introduction

Patients with knee injuries often consult a general practitioner (GP). The annual incidence is estimated at 5.3 per 1000 patients [1]. Knee injuries may lead to complaints and to functional limitations at work, in sports activities, or activities of daily living and bother the patient both on the short [2] and long term [3, 4].

Knowledge on the outcome of knee injuries is based on reports from secondary care cohorts usually representing the more serious injuries [5, 6]. Some studies reported on the outcome of knee injuries diagnosed with MR imaging and were summarized in a review by Boks et al. [7]. Although the study populations were small, these studies indicated that at follow-up the majority of patients had no persistent complaints [7].

The outcome of knee injuries in primary care is, to our knowledge, not yet known. In Dutch primary care a wait and see policy is at present the advocated initial management [8].

The objective of the present study is to determine the outcome and management of patients consulting the GP with knee injuries during one year of follow-up.

Methods

Design

The present study was part of a large prospective observational cohort study on knee complaints in general practice.[9] Forty GPs from five municipalities in the southwest region of The Netherlands, participating in the Erasmus MC GP research network HONEUR, asked patients with all new knee complaints to participate in the general cohort study with a follow-up of 12 months. This network represents a total patient population of around 84.000 patients. Detailed information about the study design has been published elsewhere [9].

Patients for the present study if the complaint was brought on by trauma within 5 weeks of presentation, were aged between 18 and 65 years. These patients were asked to undergo MR imaging. Patients with MR imaging contraindications (pregnancy, metal implants or a pacemaker) were excluded. Detailed information about the MR imaging protocol is also published elsewhere [10].

Data collection

At baseline the patients filled in a questionnaire to collect data on age, gender, socioeconomic status, history of previous knee injuries and/or operations, general health, present symptoms, the mechanism of injury, the level of activity in both work and sports, and the management initiated by the GP at baseline [9].

The severity of pain was assessed with a validated 11-point numeric rating scale (NRS) ranging from 0 (no pain) to 10 (unbearable pain) [11]. The Lysholm knee score provides information on instability and functional limitations such as walking and stair climbing [12]. The Lysholm score ranged from 0 (worse) to 100 (best) and was obtained using a standard form, filled in by the patient. The Tegner knee function score (range 0-10) was used to determine the level of activity in work and sports prior to the knee injury [12].

MR imaging was selected as reference diagnostic test because it is highly accurate in detecting meniscal tears and ligament lesions [13, 14]. MR imaging was scheduled 2 to 6 weeks after the initial trauma using a 1.0 Tesla General Electric device. Two radiologists determined the results of the MR imaging independently based on a standardized classification form. The results of the MR imaging were also used to evaluate the diagnostic value of history taking and physical examination [15-17].

After the MR imaging a standardized physical examination was carried out by a trained physical therapist. Physical examination consisted of inspection, palpation, assessment of effusion, passive range of motion, meniscal tests and ligament stability tests, and was performed in both the injured and the contralateral knee [9].

To avoid influencing the patient's behaviour or the GP's management, neither the patients nor their GPs were informed about the results of the MR imaging or physical examination during the 12 months follow-up.

At 3, 6 and 12 months after the knee injury, a follow-up questionnaire was sent to the participating patients who were asked to return the questionnaire by post. If patients did not return the questionnaire a reminder was sent by post or a telephone call was made to the patient. These questionnaires collected data on medical consumption (GP consultations, referral to secondary care or to physical therapy). Also the severity of pain (NRS [11]) and the Lysholm [12] score were obtained. At 12 months follow-up the patients also reported on their perceived recovery using a 7-item Likert scale categorized as full recovery, major improvement, minor improvement, approximately equal, minor deterioration, major deterioration and worse than ever. The categories full recovery and major improvement were defined as clinically relevant recovery.

Statistical analysis

The results are presented with descriptive statistics (frequencies, median, means and standard deviation (SD)) using SPSS version 11.0. The pain score and Lysholm score are presented for the total group and the subgroups with and without any lesion, as well as for four specific subgroups: isolated meniscal tear, isolated cruciate or collateral ligament lesion or a combination. Perceived recovery is reported for the total group, as well as for the subgroups with and without any lesion.

Results

Study population

134 of 184 eligible patients (73%) with a knee injury consulting their GP were included. The remaining 50 patients filled in the baseline and follow-up questionnaires because they participated in the general cohort study, but were unwilling or unable to participate in this additional study. The reasons for non-participation are listed in figure1. The groups "participants" and "non-participants" showed no significant differences at baseline (Table 1) with regard to gender [OR 0.69 (95% CI 0.24 to 1.28)], age [mean difference (MD) 0.2, p=0.92], pain severity (MD 0.5, p=0.22) or Lysholm knee score (MD 3, p=0.40). No patient had to be excluded because of the exclusion criteria for the MR imaging.

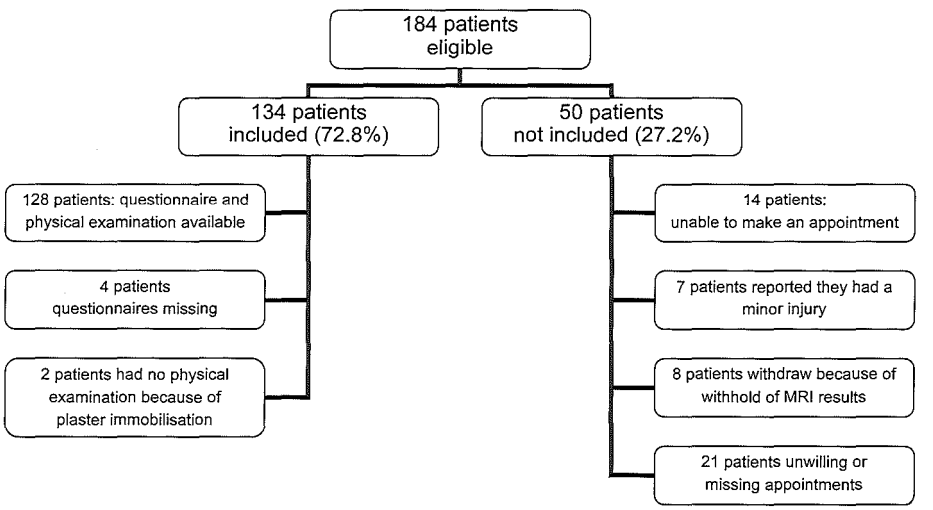


Figure 1. Flow chart of eligible patients

Baseline questionnaires were available for 130 patients (97%). Some baseline characteristics from the remaining four patients were obtained from the physical examination or from the MR imaging procedure. The mean age of the participants was 40 (range 18-64) years and a small majority is male (55%). Participation in sports was reported by 97 (72%) of the 134 participating patients. Sixty-one (46%) patients reported that the onset of the knee injury was during sports activity.

MR imaging results

In 52 patients (39%) no meniscal tears or ligament lesions were seen on the MR imaging. 82 patients (61%) showed either an isolated meniscal tear (18 patients, 13%), an isolated cruciate (10 patients, 8%) or collateral ligament lesion (18 patients, 13%), or a combination of these (36 patients, 27%).

Table 1. Baseline characteristics and result from MR imaging of the participants and non-participants

Characteristic	Participants (n=134)	Non-participants (n=50)
Age in years , mean (sd)	40.2 (12.2)	40.4 (11.3)
Gender male, n (%)	74 (55)	32 (67)
Gender female, n (%)	60 (45)	18 (33)
BMI, mean (sd)	26.4 (4.3)	28.1 (4.8)
SF-36 general health, mean (sd)	76.1 (18.0)	79.9 (15.6)
CPV, mean (sd)	34.0 (6.8)	34.1 (7.5)
Tampa score, mean (sd)	7.2 (7.7)	7.8 (9.4)
Symptom side right, n (%)	70 (52)	16 (34)
Pain severity [0-10], mean (sd)	4.7 (2.4)	4.2 (2.5)
Lysholm knee function score [0-100], mean (sd)	62 (22)	67 (23)
Employed, n (%)	113 (84)	39 (73)
Sports participation, n (%)	97 (72)	29 (58)
Cause of trauma		
Work related, n (%)	20 (15)	9 (18)
Onset during sports activity, n (%)	61 (46)	17 (34)
No lesion on MR imaging, n (%)	52 (39)	^
Any lesion on MR inmaging, n (%)	82 (61)	^
isolated meniscal tear#	18 (13)	^
isolated cruciate ligament lesion*	10 (8)	^
isolated collateral ligament lesion**	18 (13)	^
combination of meniscal tears and/or ligament lesion	36 (27)	^

horizontal, longitudinal, radial or complex meniscal tear
* partial or complete anterior or posterior cruciate ligament lesion
** partial or complete medial or lateral collateral ligament lesion
^ not available because of non-participating in the MRI study

Follow-up

At 3, 6 and 12 months follow-up, 104 (78%), 92 (69%) and 112 (84%) patients, respectively, returned the questionnaire. Another 10 patients reported their perceived recovery by telephone, thus perceived recovery was obtained from 122 patients (91%) while 12 patients (9%) were lost to follow-up; 7 of them showed no lesion on the baseline MR imaging.

Perceived recovery

122 patients (91%) reported on their perceived recovery (Table 2). 34 (28%) reported full recovery and 67 (55%) reported major improvement. Overall, 101 patients (83%) reported a clinically relevant recovery, 18 patients (15%) reported minor improvement or approximately equal status, and 3 patients (2%) reported minor deterioration. One of these 3 latter patients underwent an ACL reconstruction operation 10 months after initial trauma. No patient reported major deterioration or feeling worse than ever. In the 34 patients who reported full recovery the median time to recovery was 5 months (range 2-12). Of the 15 patients that were operated on during the 12 months follow-up, 10 patients (67%) reported clinically relevant recovery.

Table 2. Perceived recovery in 122 patients at 12 months follow-up

Perceived recovery	Full recovery	Major improvement	Minor improvement	Approximately equal	Minor deterioration
Total group[#] (n=122) (n (%))	34 (28)	67 (55)	14 (12)	4 (3)	3 (2)
No lesion group (n=45) (n (%))	15 (33)	22 (49)	5 (12)	2 (4)	1 (2)
Any lesion group (n=77) (n (%))	19 (25)	45 (59)	9 (12)	2 (2)	2 (2)
isolated meniscal tear (n=17) (n (%))	3 (18)	13 (76)	1 (6)	0	0
isolated cruciate lesion (n=10) (n (%))	4 (40)	5 (50)	1 (10)	0	0
isolated collateral lesion (n=16) (n (%))	3 (19)	11 (69)	2 (12)	0	0
combination tear/lesion (n=34) (n (%))	9 (27)	16 (46)	5 (15)	2 (6)	2 (6)

[#] 12 patients were lost to follow-up (7 in no lesion group and 5 in lesion group)

Severity of pain

At baseline the mean pain severity score for the total study population was 4.8 (SD 2.4) (Table 3). The mean pain score decreased to 2.5 (SD 2.3) at 3 months follow-up, to 2.2 (SD 2.3) at 6 months follow-up, and to 1.8 (SD 2.3) at 12 months follow-up. The subgroup with isolated cruciate ligament lesions had the lowest pain score both at baseline and over the entire study period (Figure 2). The subgroup isolated meniscal tears had the highest mean pain score at baseline and during follow-up. The subgroup without lesion showed intermediate mean pain scores.

Table 3. Pain severity, Lysholm and Tegner score, sick leave, hindrance and adaptation at work during follow-up

Variable	Baseline n=130	0-3 months* n=104	3-6 months* n=92	6-12 months[#] n=112
Pain score (NRS 0-10) (mean ± sd)				
Total group	4.8 ± 2.4	2.5 ± 2.3	2.2 ± 2.3	1.8 ± 2.3
No lesion group	4.9 ± 2.3	2.7 ± 2.4	2.2 ± 2.4	1.6 ± 2.2
Any lesion group	4.7 ± 2.5	2.3 ± 2.2	2.2 ± 2.2	2.0 ± 2.4
Lysholm knee score (0-100) (mean ± sd)				
Total group	62 ± 22	78 ± 19	80 ± 18	85 ± 17
No lesion group	64 ± 23	80 ± 17	81 ± 18	86 ± 16
Any lesion group	60 ± 22	76 ± 20	80 ± 18	84 ± 17
Tegner function score (0-10) (mean ± sd)				
Total group	4.5 ± 1.9	^	^	4.1 ± 1.8
No lesion group	4.5 ± 1.8	^	^	4.4 ± 2.1
Any lesion group	4.4 ± 2.0	^	^	3.9 ± 1.6
Sick leave (n (%))				
1 - 5 days	31 (25)	20 (19)	6 (7)	3 (3)
6 - 10 days	4 (3)	9 (9)	3 (3)	0
> 10 days	7 (5)	16 (15)	3 (3)	1 (1)
Hindrance at work (n (%))	76 (59)	30 (29)	20 (12)	14 (13)
Adaptation at work (n (%))	25 (19)	16 (15)	9 (10)	9 (8)

* reported over a period of 3 months / [#] reported over a period of 6 months / ^ not available

Figure 2. Pain score (NRS) for the various isolated and combination lesions

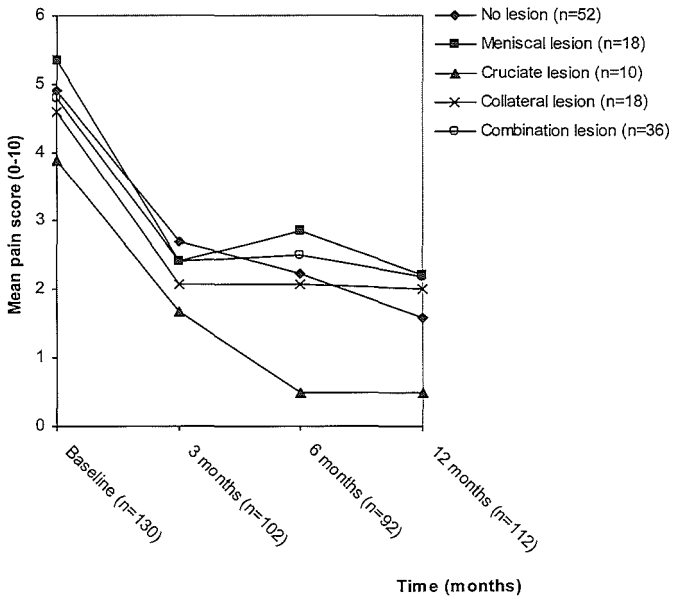
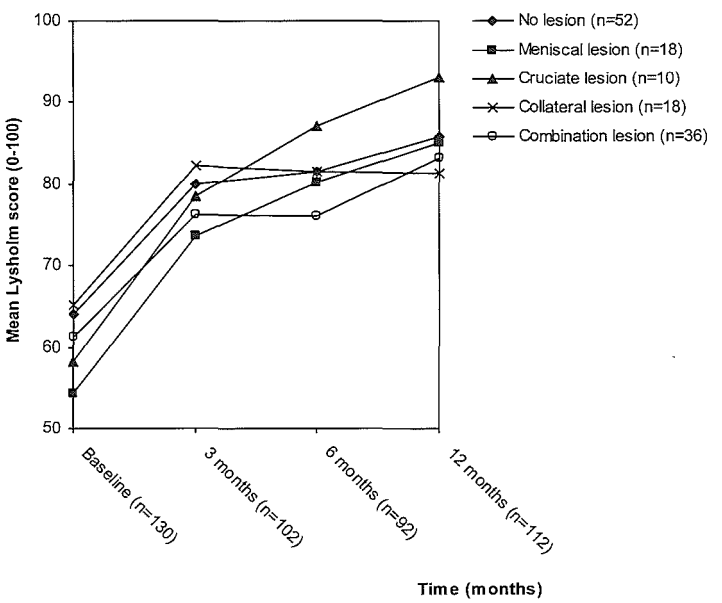


Figure 3. Lysholm score for the various isolated and combination lesions



Lysholm and Tegner knee score

At baseline the mean Lysholm score was 62 (SD 22) for the total study population (Table 3). The mean Lysholm score increased to 78 (SD 20) at 3 months follow-up, to 80 (SD 18) at 6 months follow-up, and to 85 (17) at 12 months follow-up. At 12 months follow-up the subgroup isolated cruciate ligament lesions reported the highest mean Lysholm knee score (Figure 3). At baseline the mean Tegner knee score was 4.5 (SD 1.9). The mean Tegner score decreased to 4.1 (SD 1.8) at 12 months follow-up.

Table 4. Management of knee injuries during one year of follow-up (number of events (%))

Management (n (%))	**Baseline** n=130	**0-3 months*** n=104	**3-6 months*** n=92	**6-12 months#** n=112	**Total events/patients^**
Re-consulting the GP					
total group	--------	47 (45)	17 (18)	12 (11)	76/54
no lesion	--------	14 (26)	5 (5)	8 (7)	27/19
any lesion	--------	33 (32)	12 (13)	4 (5)	49/35
Medication					
total group	35 (17)	4 (4)	4 (4)	4 (4)	47/35
no lesion	14 (11)	2 (2)	1 (1)	1 (1)	18/14
any lesion	21 (16)	2 (2)	3 (3)	3 (3)	29/21
Referral to physical therapy					
total group	37 (22)	11 (11)	4 (4)	6 (6)	58/54
no lesion	14 (11)	3 (3)	2 (2)	2 (2)	21/21
any lesion	23 (18)	8 (8)	2 (2)	4 (4)	37/33
Referral to secondary care					
total group	17 (13)	5 (5)	2 (2)	4 (4)	28/26
no lesion	6 (5)	3 (3)	0	3 (3)	12/12
any lesion	11 (8)	2 (2)	2 (2)	1 (1)	16/14
Arthroscopy					
total group	--------	9 (6)	4 (4)	5 (5)	18/18
no lesion	--------	2 (2)	1 (1)	3 (3)	6/6
any lesion	--------	7 (7)	3 (3)	2 (2)	12/12
Surgery					
total group	--------	0	0	1	1/1
no lesion	--------	0	0	0	0/0
any lesion	--------	0	0	1	1/1

* reported over a period of 3 months
\# reported over a period of 6 months
^ total number of events over the number of patients involved during one year follow-up

Management

During the 12 months follow-up, 54 patients (40%) re-consulted the GP with a total of 76 consultations (range 1 to 4 consultations) (Table 4). Of these 76 consultations, 27 (36%) were made by patients without any lesion as seen on MR imaging. The majority of the re-consultations, namely 47 (62%), took place during the first 3 months after the initial knee injury.

During the 12 months follow-up, 47 patients (27%) were referred to physical therapy of which the majority of 37 patients (79%) were referred at baseline (Table 4). Of these 37 patients, 14 (38%) showed no lesion on MR imaging. During the 12 months follow-up, 25 patients (19%) were referred to secondary care. Again, the majority of these referrals, i.e. 17 (68%), took place at baseline; 6 of these patients had

no lesion on the MR imaging. There was no clear pattern on referral to either physical therapy or secondary care in relation to determinants obtained by history taking or physical examination.
Over the 12-month study period, 18 arthroscopies were performed in 15 patients either diagnostic or interventional. In seven cases a meniscal tear was involved as seen on MR imaging. Collateral ligament lesions will not be treated operatively however in three patients arthroscopy was performed while six cases showed no meniscal tear or ligament lesion on MR imaging at all. In one of the patients with arthroscopy an ACL reconstruction was performed 10 months after the initial injury.

Discussion

Summary of main findings

The present study is, to our knowledge, the first to report on the outcome of patients with a knee injury in a primary care setting. Of all included patients, 61% showed a meniscal tear, ligament lesion or a combination on MR imaging. Two studies reporting on knee injuries in emergency departments show similar percentages of abnormalities compared to our results [18, 19].

Strengths and the limitations of this study

Information on perceived recovery was obtained from 122 patients of whom a majority of 83% reported clinically relevant recovery. The subgroups without lesion and with a lesion, as seen on MR imaging, showed no difference in clinically relevant perceived recovery. The subgroup without lesion had a higher percentage of loss to follow-up than the subgroup with any type of lesion. Patients with no lesions may have had fewer complaints and functional limitations and may be less motivated to participate during follow-up. The percentage clinically relevant recovery in our study may therefore be somewhat underestimated. The 50 non-participants in the present study showed no difference as to clinical relevant perceived recovery compared with the participants (81% vs. 83%, respectively) [16].

Almost 40% of the patients showed no meniscal or ligament damage on MR imaging but still this subgroup reported almost equal pain severity, Lysholm scores and recovery rates compared to the patients with meniscal or ligament damage seen on MR imaging. This phenomenon might be explained by the fact that we classified only meniscal and ligament damage. Contusions, distorsions and other abnormalities were not classified in this study however can cause complaints and limitations in patients.

No clear relation emerges between the type of lesion and the severity of reported pain. The subgroup of patients with isolated meniscal tears showed the highest mean pain scores. This phenomenon may be explained by the degenerative aspects observed on MR imaging in both the injured knee and the contralateral knee [10]. Also, this subgroup had the highest average age of 48 years resulting in a higher proportion of degenerative aspects at the time of the injury. The subgroup with isolated cruciate ligament lesions showed the lowest pain score during the complete study period. This phenomenon might be explained by the fact that the average age in this subgroup (32 years) is more than 10 years lower than

in other subgroups (range 42-48 years). The younger patients may have a more active lifestyle and therefore a better recovery. However, it might also indicate that isolated cruciate ligament lesions are indeed less painful.

The subgroup with a cruciate ligament lesion showed the highest Lysholm score at six and 12 months follow-up. The Lysholm score is a combination score of functional limitations of which instability is only a single item. Only 4 of the 28 patients with an isolated or combined cruciate ligament lesion reported instability at 12 months follow-up. The Tegner knee score showed that on average patients had some decrease in level of activity during work and sport; however, this decrease was only marginal.

Comparison with existing literature

Cardol reported that 25% of their patients were referred to secondary care, compared with only 13% in our study [20]. In our study GPs were aware of the fact that MR imaging was standard procedure and that injuries in need of immediate intervention (e.g. fractures) would be noticed at the time of MR imaging. Therefore the GP was less trigged to refer to secondary care. Because the spectrum of lesions involved in the present study and presented to the participating GPs is wide, we assume that this study population does well represent the traumatic knee patient in general practice.

The average time to full recovery was 5 months. The results of this outcome study seem to be in accordance with the Dutch general practice guideline for traumatic knee complaints which advocates a 'wait and see' policy as a valid option for the majority of patients with traumatic knee disorders [8]. Our results do not support the need for diagnostic evaluation by an orthopaedic surgeon during the first months after injury. Furthermore, we have to emphasise that this was an observational study with a follow-up for only one year. Marked differences between the lesion and no-lesion group (or within the lesion groups) might emerge with a longer follow-up (>12 months). One might expect an increased frequency of radiological osteoarthritis in those with meniscal or cruciate ligament damage [21, 22]. Also, because knowledge of the diagnosis could have led to a different management and a different outcome, lesion diagnosis was not revealed to either the GP or the patient. Finally, as there were no standardized treatments following certain diagnoses, it is possible that specific management tailored to the diagnoses could have resulted in different outcomes.

Implications for future research or clinical practice

With regard to the management during the 12 months follow-up, we expect some underestimation due to recall bias because patients were asked retrospectively over a period of 3 or 6 months. Also, we must take into account the number of missing questionnaires during follow-up leading to underestimation of the referral rate to either physical examination or secondary care, and the number of performed surgeries and arthroscopies. Almost 45% of the study population consulted the GP again for their complaints, some patients more than 3 times in a period of 3 months.

At baseline, referral to a physical therapist was almost equally distributed among patients with or without a lesion. This raises the question: on what grounds does a GP make a referral to the therapist? The same holds true for referral to secondary care; at baseline, almost the same percentage of patients with and without a lesion was referred to secondary care. Up to now there is no strong evidence that physical therapy is effective in patients dealing with a meniscal tear or anterior cruciate ligament lesion [23, 24]. The same holds true for surgical intervention of meniscal tears and cruciate ligament lesions in secondary care.[25, 26] Also, the need for screening in secondary care in relation to the outcome or prognosis of patients with traumatic knee injuries remains inconclusive. Studies with a longer follow-up duration (>12 months) are recommended with particular focus on the relation between type of injury and the onset of osteoarthritis. There is some evidence that a knee injury is an important risk factor for the development of osteoarthritis [27].

Aknowledgement

The study protocol was approved by the medical ethics committee of Erasmus Medical Center Rotterdam.

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6

Predictors of persistent complaints after a knee injury in primary care

H.P.A. Wagemakers, P.A.J. Luijsterburg, E.M. Heintjes, M.Y. Berger, J.A.N. Verhaar, B.W. Koes, S.M.A. Bierma-Zeinstra

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Abstract

Background

Prognosis of persistent complaints after knee injury is based on secondary care populations. In a primary care setting, however, no studies have addressed this issue.

Aim

To identify possible predictors of persistent complaints one year after a knee injury. These predictors are important for guiding the general practitioner's (GP) therapeutic management, and giving advice to patients about work and/or sports-related activities.

Design

Prospective cohort study with a one year follow-up period.

Setting

Primary care.

Method

A GP research network with ± 84,000 patients and 40 participating GPs recruited eligible patients. A total of 134 patients (aged 18-65 years) who consulted their GP within 5 weeks after a knee injury entered the study. Follow-up after one year was conducted in 122 patients. The main outcome was persistent complaints one year after injury. Possible predictors for these complaints were obtained with a questionnaire, physical examination and MR imaging, according to a standardized protocol.

Results

After one year, of the 122 available patients, 21 (17%) reported persistent complaints and 101 (83%) reported full recovery or major improvement. In this study "age over 40" had a significant association ($p<0.05$) with persistent complaints (OR 8.0: 95%CI 2.1-30.5). Physical examination and MR imaging findings revealed no predictors that were associated with these complaints.

Conclusions

"Age over 40" was the only determinant with a significant association with persistent complaints. Because physical examination and MR imaging had no predictive value, they are not recommended for prognosis of persistent complaints.

How this fits in

Prognosis of persistent complaints after a knee injury is based on secondary care populations. In a primary care setting, however, no studies have addressed this issue. Age over 40 years was found to be a predictor for persistent complaints one year after a knee injury, whereas physical examination and MR imaging findings showed no association for persistent complaints. At present, use of physical examination or MR imaging for prognosis of persistent complaints after knee injury is not recommended.

Introduction

Patients consulting their general practitioner (GP) for disorders related to a knee injury are interested in a prediction of the course of these disorders, and about resuming work and/or sports activities. The GP has the difficult but indispensable task of predicting the patient's prognosis as accurately as possible [1-4]. However, in the case of a knee injury the GP is faced with lack of evidence.

The second Dutch national survey of complaints consulted for in general practice reported an incidence of traumatic knee disorders of 5.3 per 1000 patients annually [5]. Studies on the natural course of ligamentous knee injuries (reviewed by Boks et al. [6]) showed that in the case of an anterior cruciate ligament (ACL) rupture, a normal ACL was found on MR imaging in 42% (95%CI 28-57%) at 3-months follow-up; at 11-months follow-up, results showed that further repair was possible.[7-8] Partial or complete posterior cruciate ligament (PCL) ruptures showed regained continuity on MR imaging in 93% of the cases (95%CI 80-98%) at 3-years follow-up [7-10].

Data on the prognosis of recovery after a knee injury are solely based on secondary care populations [11-13]. Long-term studies show that knee injuries are an important risk factor for the development of osteoarthritis (OA) of the knee [14-16].

MR imaging has become a normal procedure for non-invasive diagnosis and gradation of the severity of knee injuries in secondary care [17-18]. In primary care, however, the use of MR imaging in knee injuries is not yet common practice, but is slowly being introduced. We previously showed that patient characteristics, history taking, and physical examination have limited value in diagnosing meniscal and ligament damage [19-21]. Because MR imaging is an additional tool in diagnosing such damage, [17-18] it is worthwhile to establish whether MR imaging has additive prognostic value in primary care. This study determines whether specific determinants from history taking and physical examination in primary care have predictive value for the prognosis of persistent complaints one year after an acute knee injury. In addition, whether MR imaging has additional predictive value for the prognosis of these persistent knee complaints.

Method

Design

The department of General Practice of Erasmus MC, University Medical Center Rotterdam conducted a large prospective cohort study on knee complaints in primary care. A total of 40 GPs from five municipalities in the southwest region of the Netherlands asked patients with new knee complaints to participate in the general cohort study, with a follow-up of 1 year. This network represented a total patient population of ± 84,000 patients. Detailed information about the study design has been published previously [22].

Patients with knee complaints were informed about the general cohort study during the initial consult with the GP and were invited to participate in this study. Patients aged 18-65 years with a traumatic onset of knee complaints and who visited their GP within 5 weeks after initial injury were also asked to participate in an additional MR imaging study. After registration of the patient at the research centre of our department, an appointment was made, informed consent was acquired, and the baseline questionnaire was filled out by the patients. If patients gave consent for the additional MR imaging study, an appointment for the MR imaging was scheduled. Following this MR imaging, a physical examination was performed. Patients with MR imaging contraindications (such as pregnancy, metal implants or a pacemaker) were excluded from this MR imaging study.

The study protocol was approved by the Medical Ethics committees of both Erasmus Medical Center Rotterdam (the study centre) and the Hospital Rijnmond Zuid (the MR imaging location).

Data collection

At baseline, the participating patients completed a self-report questionnaire. The questionnaire collected data on age, gender, socio-economic state, history of previous knee injuries and/or surgery, present symptoms, mechanism of injury, and the level of activity during work or sport. The therapeutic management initiated by the GP at baseline was also recorded. The severity of pain was obtained by an 11-point numeric rating scale ranging from 0 (no pain) to 10 (unbearable pain) [23]. The Lysholm knee score was used to provide relevant information regarding pain, swelling, instability and functional limitations such as walking and stair climbing [24]. The Lysholm score ranged from 0 (worst possible score) to 100 (excellent score). The Tegner knee function score (range 0-10) was used to determine the level of activity in work and sports prior to the knee injury [24]. The Tegner score was obtained with the determinants "level of work" and "sports activities" from the questionnaires. With the final questionnaire at 1-year after baseline, patients were asked to report their perceived recovery using a 7-item Likert scale categorized as "full recovery", "major improvement", "minor improvement", "about the same", "minor deterioration", "major deterioration" or "worse than ever" [22, 25].

One year after the initial knee injury, patients' reports of "minor improvement", "about the same", "minor deterioration", "major deterioration" or "worse than ever" were defined as persistent complaints. Patients' reports of either "full recovery" or "major improvement" were defined as a clinically relevant recovery.

The MR imaging was scheduled 2-6 weeks after the initial trauma using a 1.0 Tesla General Electric device. The results of the MR imaging were determined by two radiologists independently based on a standardized classification form. In case of disagreement, the findings were discussed until consensus was reached. Meniscal tears were classified as horizontal, longitudinal, radial or complex. ACL, PCL, medial (MCL) and lateral collateral ligament (LCL) lesions were classified as either partial or complete. At the moment of data collection for this study there was no validated scoring system for osteoarthritic

features seen on MR imaging. Therefore, we adapted the most frequently used method to score the severity of OA on X-rays, the Kellgren & Lawrence method [26]. Detailed information about the MR imaging procedure is reported elsewhere [27].

A standardized physical examination was performed immediately after the MR imaging, according to a standardized protocol [22]. A trained physical therapist with ≥15 years experience in performing physical examination in patients with knee injuries and with ≥10 years experience in diagnostic research performed the examination [28]. Physical examination of both knees consisted of inspection of alignment and joint effusion, palpation of temperature, collateral ligaments and joint line tenderness, assessment of effusion, and passive range of motion in flexion and extension [29-30]. Cruciate and collateral ligament integrity were assessed by means of the anterior and posterior drawer tests [31], the Lachman test [32], the pivot shift [33], and the valgus and varus stress tests [34].

To avoid influencing the behaviour of the patient or the management by the GP according their clinical guideline 'traumatic knee complaints' [35], the patients and their GPs were not informed about the findings of the MR imaging or physical examination during the 1-year follow-up.

Statistical analysis

Descriptive statistics were used to present the baseline characteristics of the study population and the findings on the MR imaging (SPSS, version 15.0). Binary logistic regression analysis was used to determine the association of isolated determinants from history taking, physical examination and MR imaging with the presence of persistent knee complaints after 1 year, expressed as odds ratios (OR) with a 95% confidence interval (95% CI). To assess the independent prognostic value of related determinants with persistent complaints, multivariate backward logistic regression analysis (p entry 0.10, p removal 0.20) was used, using determinants with an isolated association ($p<0.10$) to eliminate redundant variables. With the results of this multivariate analysis, a prognostic model was built and the area under the curve (AUC) of the receiver operating characteristic curve (ROC) was calculated. Complete case analysis was used.

To determine the additive predictive value of MR imaging for the prognosis of persistent complaints, the associated determinants from MR imaging ($p<0.10$) were added in the prognostic model using the Enter method. Again, we calculated the AUC. The additive predictive value of MR imaging was determined by the difference in the AUC in both models.

Results

Study population

During the inclusion period, 184 patients consulting their GP because of complaints caused by a knee injury were eligible to enter the MR imaging study; 134 patients (73%) were included in the MR imaging study. The 50 non-participants filled in the baseline questionnaire to enter in the general cohort study but were unwilling or unable to participate in the additional MR imaging study. The "participants" and "non-participants" showed no clinically significant differences at baseline with regard to age, gender, pain severity or Lysholm knee score.[20] Also, the patients available at follow-up (n=122) showed no relevant differences compared with the patients who were initially included (n=134) (Table 1).

The baseline questionnaires were available for 130 patients. In two patients physical examination could not be performed because of plaster immobilisation at the time of the MR imaging. The mean age of the participants was 40 (range 18-64) years and a small majority was male (55%) (Table 1). The majority of patients (84%) had paid employment. Before the initial trauma 97 patients (72%) participated in sports. Knee injuries were frequently acquired during sports activities (46%).

Table 1: Characteristics of the participants at baseline (n=134) and at 1-year follow-up (n=122)

Characteristic	Participants at baseline (n=134)	Participants at follow-up (n=122)
Age in years, mean (sd)	40.2 (12.2)	40.8 (12.1)
Gender female, n (%)	70 (45)	54 (44)
BMI, mean (sd)	26 (4.3)	26 (4.2)
SF-36 general health, mean (sd)	76 (18)	77 (18)
Symptom side right, n (%)	70 (52)	60 (49)
Pain severity [0-10], mean (sd)	4.7 (2.4)	4.7 (2.3)
Lysholm knee function score [0-100], mean (sd)	62 (22)	62 (22)
Employed, n (%)	113 (84)	89 (80)
Sports participation, n (%)	97 (72)	76 (68)
Cause of trauma		
work related, n (%)	20 (15)	18 (15)
onset during sports activity, n (%)	61 (46)	58 (48)
Diagnosis as seen on MR imaging, n (%)		
no lesion	52 (39)	45 (37)
any lesion	82 (61)	77 (63)
ACL lesion	28 (21)	26 (21)
PCL lesion	6 (4)	5 (4)
MCL lesion	35 (26)	32 (26)
LCL lesion	8 (6)	8 (6)
meniscal tear	47 (35)	45 (35)

ACL: anterior cruciate ligament
PCL: posterior cruciate ligament
MCL: medial collateral ligament
LCL: lateral collateral ligament

MR imaging findings

In 52 patients (39%) no meniscal tears, cruciate or collateral ligament lesions were seen on the baseline MR imaging (Table 1). In the remaining 82 patients (61%) one of the above-mentioned tears or lesions were found on the MR imaging. More specifically, in 47 patients (35%) a meniscal tear was found while

34 patients (25%) showed an ACL or PCL lesion. MCL or LCL lesions were found in 43 patients (32%). In total, 36% of the patients showed a combination of these lesions on MR imaging.

One-year follow-up

At 1-year follow-up, a perceived recovery score was available for 122 patients (91%) (Table 2). Of these patients, 21 (17%) reported persistent complaints with 14 patients reported 'minor improvement', 4 patients reported 'about the same', and 3 patients reported 'minor deterioration'. None of the patients reported 'major deterioration' or 'worse than ever'.

A total of 34 patients (28%) reported complete recovery and 67 (55%) reported major improvement. Thus, overall, 101 patients (83%) reported a clinically relevant recovery.

In 15 patients, a total of 19 surgical interventions were performed during the 1-year follow-up: one ACL reconstruction and 18 arthroscopies.

Table 2: Perceived recovery at 1-year follow-up

Perceived recovery	Clinically relevant recovery		Persistent complaints		
	Full recovery	Major improvement	Minor improvement	About the same	Minor deterioration
Total group[#] (n=122) (n,(%))	34 (28)	67 (55)	14 (12)	4 (3)	3 (2)
No lesion group (n=45) (n,(%))	15 (33)	22 (49)	5 (12)	2 (4)	1 (2)
Any lesion group (n=77) (n,(%))	19 (25)	45 (59)	9 (12)	2 (2)	2 (2)

[#] 12 patients were lost to follow-up (7 in the no lesion group and 5 in the lesion group)

Binary analysis

After the binary logistic regression analysis, four determinants from history taking showed an association with persistent complaints ($p<0.10$), namely "age over 40", "female gender", "pain score 6 or higher" and "popping sensation during trauma" (Table 3). From physical examination one determinant showed an association, namely "pain at passive extension" ($p<0.10$) (Table 3). From the findings on the MR imaging, "effusion" and "adapted Kellgren & Lawrence score of 2 or more" showed an association ($p<0.10$) (Table 3).

Table 3: Univariate associations with persistent complaints, one year after a knee injury

Variables	Data available (n)	Clinical recovery (n=101)	Persistent complaints (n=21)	P-value*	OR (95% CI)
History taking					
Patient characteristics					
Age over 40 years	122	43	18	0.01	8.1 (2.2-29.2)
Gender (female)	122	41	13	0.08	2.4 (1.0-6.2)
High education	118	49	8	0.42	0.7 (0.3-1.8)
Body mass index >30	122	13	5	0.21	2.1 (0.7-6.8)
Work load knee	101	31	6	0.77	1.2 (0.4-3.6)
Mechanism of injury					
Trauma during sport	114	49	7	0.17	0.5 (0.2-1.4)
Fall on the knee	113	22	7	0.23	1.9 (0.7-5.4)
Weight bearing on the knee	103	63	12	0.52	0.7 (0.2-2.1)
Rotational trauma	87	53	9	0.39	1.5 (0.6-3.8)
Foot/leg blocked	98	33	7	0.91	1.0 (0.4-2.6)
Signs at trauma					
Immediate pain at trauma	114	75	17	0.59	1.4 (0.4-5.4)
Immediate effusion after Trauma	115	40	8	0.86	0.9 (0.3-2.5)
"Popping" sensation at trauma	114	28	10	0.09	2.4 (0.9-2.5)
Continuation activity Impossible	115	45	13	0.16	2.1 (0.8-5.6)
Present symptoms					
Pain score > 5 (0-10 NRS)	118	34	12	0.04	2.7 (1.1-7.3)
Effusion (continuous)	116	27	8	0.22	1.9 (0.7-5.2)
Crepitation (continuous)	117	18	7	0.11	2.4 (0.8-6.8)
Lysholm knee score < 80	118	74	16	0.67	1.3 (0.4-1.3)
Giving way (Lysholm)	118	37	10	0.31	1.6 (0.6-4.3)
Locked knee (Lysholm)	118	15	3	0.97	1.0 (0.3-3.7)
Physical examination					
Increased temperature	120	41	8	0.78	0.9 (0.3-237)
Ballottement test	120	55	14	0.35	1.6 (0.6-4.3)
Pain at passive flexion	122	63	17	0.11	2.6 (0.8-8.6)
Pain passive extension	122	46	16	0.02	3.8 (1.3-11.2)
Laxity valgus stress 30^0	119	57	14	0.54	1.4 (0.5-3.7)
Laxity varus stress 30^0	119	20	7	0.24	1.9 (0.7-5.2)
Laxity anterior drawer test	115	45	11	0.71	1.2 (0.5-3.0)
Effusion fossa poplitea	118	65	16	0.41	1.6 (0.5-4.7)
McMurray meniscal test	84	10	2	0.59	0.6 (0.3-8.6)
Appley grinding test	103	31	7	0.69	1.2 (0.4-3.6)
Appley traction test	102	28	5	0.92	0.9 (0.3-3.0)
MR imaging findings					
No lesion	122	37	8	0.90	1.1 (0.4-3.6)
Effusion	122	29	10	0.09	2.3 (0.9-5.8)
Meniscal tear	122	37	8	0.90	1.1 (0.4-2.8)
Anterior cruciate lesion	122	20	6	0.38	1.6 (0.6-4.7)
Posterior cruciate lesion	122	3	2	0.19	3.4 (0.5-22.0)
Medial collateral ligament lesion	122	27	5	0.78	0.9 (0.3-2.6)
Lateral collateral ligament lesion	122	5	3	0.13	3.2 (0.7-14.6)
Kellgren & Lawrence score ≥ 2	122	8	5	0.04	3.6 (1.1-12.5)

p-value < 0.10
NRS = Numerical Rating Scale

Multivariate analysis

After multivariate logistic regression analysis, at 1-year follow-up only "age over 40" showed a significant ($p<0.05$) association (OR 8.0; 95% CI 2.1-30.5) with persistent complaints (Table 4). The AUC of the ROC of this model was 0.81.

Adding the determinants from MR imaging with an additive association ($p<0.10$) to the model does not alter the results of the analysis including the AUC of the ROC.

Table 4: Predictors of persistent complaints, one year after a knee injury

	Model history taking and physical examination (n=112)		**Model history taking, physical examination and MR imaging (n=112)**	
	P-value	OR (95% CI)	P-value	OR (95% CI)
Variables				
Age over 40 years	0.01*	8.0 (2.1-30.5)	0.01*	7.5 (1.9-29.6)
Gender (female)	0.06	3.0 (0.9-9.1)	0.06	3.0 (1.0-9.4)
Pain score NRS > 5	0.13	2.4 (0.8-7.1)	0.17	2.2 (0.7-6.9)
Popping sensation during trauma	0.14	2.3 (0.8-7.7)	0.19	2.2 (0.7-7.0)
Effusion seen on MR imaging	------	----------	0.90	1.1 (0.3-3.5)
Kellgren & Lawrence score ≥ 2	------	----------	0.72	1.3 (0.3-6.1)
AUC		0.81		0.81
Explained variance (%)		31		31

NRS = Numerical Rating Scale
AUC = Area under the Receiver Operating Curve (ROC)
* $p < 0.05$

Discussion

Summary of main findings

To our knowledge, this is the first study in primary care to report on the prognosis of persistent complaints, 1 year after having sustained a knee injury. Of the 134 included patients, on the baseline MR imaging 82 patients (61%) showed an isolated meniscal tear, a ligament lesion, or a combination of both. In the remaining 52 patients (39%) none of these damages was reported. The spectrum of the damage to the knee presented to the participating GPs is wide. Therefore we assume that this study population represents the population of patients with disorders caused by a knee injury consulting the GP.

Of the 122 patients available at 1-year follow-up, 21 (17%) suffered from persistent complaints. The results of the multivariate analysis showed that "age over 40" is the main predictor for persistent complaints 1 year after injury ($p<0.05$). In spite of ORs of 2.5 and over, other determinants such as "gender", "baseline pain score" and "popping sensation during trauma" were not significantly associated, probably due to lack of power. Physical examination showed no predictive value at all on the prognosis of persistent complaints. Also, the MR imaging showed no additive prognostic value when added to the model with factors from history taking. The AUC in the model including MR imaging equalled the AUC only with determinants from history taking and physical examination.

During follow-up some of the patients underwent a surgical intervention due to their knee injury. Because these patients may have a different perceived recovery compared to patients without such interventions, we performed an additional analysis excluding patients that underwent arthroscopy or surgery during the 1-year follow-up. The results of this analysis showed no difference with regard to the determinants involved.

Strengths and limitations of the study

In the present study, the sample was relatively limited and many variables were tested. However, all these variables are part of the normal clinical evaluation and should, in our opinion, be tested for their relationship with persistent complaints. For this reason, we performed bootstrapping with 500 replications and this showed that our main predictive variable "age over 40" could only be replicated in 269 samples. This shows that caution is needed not to 'over-interpret' the presented results. Therefore, the relationships found should preferably be replicated in other primary care cohorts. Because of our limited sample less prominent but related variables might have been missed, and clinically relevant subgroup analyses (e.g. stratifications for age categories, or patients with any confirmed lesion on MR imaging, or even per lesion) could not be performed.

Comparison with existing literature

The results suggest an influence of the presence of OA on persistent complaints after knee injuries, although only less than 10% showed OA on the MR imaging at baseline. Further, almost all patients with persisting complaints were aged 40 years or older, which was the main predictive factor for persistent complaints and overruled the predictive value of the presence of OA; in these patients early OA might be due to the persistent complaints. In our analysis, we included MR imaging features usually reported in a clinical setting. All kinds of features that might relate to early OA were not included. For example, degenerative meniscal lesions were scored as such, but not included as meniscal tears in the analyses because they were present in a high percentage of the study patients (i.e. over 60%).[27] Further, they were equally distributed in the traumatic and non-traumatic knee and subsequently not related to the trauma [27]. However, including such features might better explain persistent complaints. The influence of trauma with respect to the acceleration of OA needs more studies with a longer follow-up to monitor complaints and functional capacity over time.

Implications for future research or clinical practice

In this heterogeneous population consulting after a knee injury in general practice, MR imaging does not seem to have additive predictive value in the one-year prognosis after such injury. However, in larger populations, or in a more homogeneous population, MR imaging or physical examination might be of prognostic value; this needs further investigation. At present, only history taking shows some prognostic value and we cannot recommend physical examination or MR imaging examination for prognostic use.

Competing interests

The author(s) declare that they have no competing interests.

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7

The instability of knee instability in primary care patients with traumatic knee disorders

P.A.J. Luijsterburg, H.P.A. Wagemakers, M. Kastelein, J.A.N.Verhaar, I.M. Koster, E.H.G. Oei , B.W. Koes, S.M.A. Bierma-Zeinstra,

In preparation for submitting

Abstract

Background

There is a lack of knowledge about the course of knee instability in patients with traumatic knee disorders presented in general practice.

Objective

To determine in general practice the course of traumatic knee instability during one-year follow-up and to observe the treatment of knee instability by general practitioners.

Setting, study design and methods

Patients (n=134) aged 18 to 65 years with traumatic knee disorders who consulted their general practitioner within 5 weeks after trauma were enrolled in a prospective cohort study. Data were collected using self-administered questionnaires at baseline and at 3, 6, and 12 months follow-up. Magnetic Resonance Imaging (MRI) and physical examination of the knee were performed at baseline and at one-year follow-up.

Results

At baseline, 28% of the 134 patients had no knee instability, 17% reported knee instability (according Lysholm score), 31% tested positive on knee instability (according Lachman test) and 24% both self reported and tested positive on instability of the knee. At baseline and at one-year follow-up, no differences between MRI findings of the defined groups of knee instability were found. Also, the treatment and course during one-year follow-up showed no clear differences. At one-year follow-up, 13% of the patients reported (persistent) knee instability of which 33% stated that they were clinically recovered. Of the patients with positive tested knee instability, 31% had (persistent) tested knee instability of which 77% stated clinical recovery at one-year follow-up.

Conclusions

During one-year follow-up, there were no clear differences regarding course, treatment and MRI findings of the knee between no instability and the three defined knee instability groups, between the three instability groups, nor between patients with (persistent) and without knee instability at follow-up.

Introduction

General practitioners (GPs) are consulted regularly by patients who have sustained a traumatic knee injury. The incidence of these injuries (excluding fractures) reported in Dutch general practices is about 5.3 per 1000 patients yearly and includes contusion, distortion, collateral ligament lesions, cruciate ligament lesions and mensical tears [1].
In the Netherlands, the GP is in most cases the first clinician to be consulted by the patient. In Dutch clinical guidelines regarding traumatic knee disorders for GPs it is recommended not to perform tests that evaluate knee instability because of their poor diagnostic value especially in the initial stage after trauma and the minor consequences regarding further treatment [2-6].

With regard to physical examination and treatment of traumatic knee disorders there is a lot of attention for knee instability [7-9]. When knee instability complaints persist over time the GP may refer the patient to an orthopaedic surgeon [2]. The orthopaedic surgeon will decide based on clinical findings (including instability-tests of the knee) whether additional diagnostics such as Magnetic Resonance Imaging (MRI) or arthroscopy is necessary. However, the clinical course of knee instability reported by patients and/or tested during physical examination is not known.

Therefore, the objective of this study was to determine the course of traumatic knee instability during one-year follow-up in general practice and to observe the treatment of knee instability by general practitioners.

Methods

Study design and setting

The present study was part of a prospective, observational cohort study in patients with new knee complaints in general practice [10]. New complaints were defined as complaints presented to the GP for the first time. Patients were recruited by 40 GPs participating in the HONEUR research network established by the Department of General Practice of Erasmus Medical Center Rotterdam. The follow-up of patients in the general cohort was one year. Detailed information about the study design has been published elsewhere [10].

Participants

Patients were eligible for the present study if they were aged 18 to 65 years and had consulted their GP for traumatic knee complaints within 5 weeks after the initial trauma. In addition to their participation in the general cohort study, these patients were asked for informed consent for additional MRI. Patients with MRI contraindications (e.g. pacemaker, surgery in the past 6 weeks, metal splinters in the eye) were excluded. The study protocol was approved by the Medical Ethics committees of the Erasmus Medical Center Rotterdam and of the Medical Center Rijnmond Zuid.

Data measurement

Data were collected using patients' self-administered questionnaires, physical examination of the knees and findings on the MR scan of the index knee. At baseline the patients filled in a questionnaire to collect data on age, gender, socioeconomic status, history of previous knee injuries and/or operations, general health, present symptoms, the mechanism of injury, the level of activity in both work and sports, and the management initiated by the GP at baseline. The severity of knee pain was assessed with an 11-point numeric rating scale ranging from 0 (no pain) to 10 (unbearable pain). The Lysholm knee scoring scale provides information on patients' perceived knee instability and functional limitations such as walking and stair climbing [11].

The Lysholm scores ranges from 0 (worst knee function) to 100 (best knee function). The Tegner knee function score was used to determine the level of activity in work and sports prior to the knee injury [11]. The Tegner method scores a person's activity level between 0 and 10 where 0 is 'on sick leave/disability' and 10 is 'participation in competitive sports such as soccer at a national or international elite level'.

MRI was selected as reference diagnostic test for knee lesions because it is highly accurate in detecting meniscal tears and ligament lesions [12-13]. MRI was scheduled 2 to 6 weeks after the initial trauma and at one-year follow-up. For both MRI scans the same technique and pulse sequences we applied, using a 1.0 Tesla wholebody MRI unit and a dedicated knee coil. The imaging protocol consisted of sagittal T1-, T2-, and proton density weighted fast spin echo sequences, coronal T2*-weighted gradient echo and fat-suppressed T2-weighted fast spin echo sequences, and an axial proton density-weighted fast spin-echo sequence [14].

After the MRI at baseline a standardized physical examination was carried out by a trained physical therapist. Physical examination consisted of inspection, palpation, assessment of effusion, passive range of motion, meniscal tests and ligament stability tests (e.g. Lachman test), and was performed in both the injured and the contralateral knee [10].

At 3, 6 and 12 months after knee injury, a follow-up questionnaire was sent to the participating patients who were asked to return the questionnaire by post. If patients did not return the questionnaire a reminder was sent by post or a telephone call was made to the patient. These questionnaires collected the same outcomes as the baseline questionnaire (i.e. knee pain severity, Lysholm and Tegner knee function scores). In addition medical consumption (GP consultations, medication use, referral to secondary care or to physical therapy, and arthroscopy/surgery) and patients' perceived recovery were measured. Perceived recovery was measured using a 7-item Likert scale categorized as full recovery, major improvement, minor improvement, approximately equal, minor deterioration, major deterioration and worse than ever.

MRI interpretation

Two radiologists determined the MRI findings independently based on a standardized classification form, unaware of patients' clinical findings. To avoid influencing of patients' behaviour or the GP's management, neither the patients nor their GP's were informed about the MRI findings or results from physical examination during the one-year follow-up, unless the findings required immediate clinical attention (e.g. fractures).

Definition of knee instability and outcome

In present study patients were defined as 'self reported instability of the knee' when the Lysholm "instability" knee function subscore was 3 or more (range: 1 'never giving away' to 5 'instability at every step'). Patients were defined as 'tested positive on instability of the knee' when the Lachman test was positive. Patients with 'self reported and tested positive on instability of the knee' had a 3 or more on the Lysholm "instability" knee function subscore and a positive Lachman test.

Patients were defined 'clinically relevant recovered' when the categories full recovery or major improvement were scored on the 7-item Likert scale of perceived recovery.

Statistical analysis

Descriptive statistics were used to describe patient characteristics, knee complaint characteristics, severity of knee complaints, MRI-findings, course of knee complaints, GP's management of the knee complaints and perceived recovery. Differences between groups (no knee instability, self reported knee instability, tested knee instability, and self reported with tested knee instability were analysed using the Pearson chi-square ($p<0.05$) in the crosstabs procedure for dichotome variables and the One-way ANOVA procedure for continue variables with normal distribution. Normality was tested using Kolmogorov-Smirnov statistic with a Lilliefors significance level for testing normality ($p<0.05$). Between groups differences for not normal distributed variables were analysed with the Kruskal-Wallis test ($p<0.05$). When these tests leaded to significant results, then at least one of the groups was different from the other groups. To determine which specific groups differed we used pairwise post-hoc comparisons with the test of Scheffé in the One-way ANOVA procedure. Analyses were adjusted for sports participation and gender and performed with SPSS version 17.02 (SPSS Inc., Chicago, Ill, USA).

Results

Study population

During the inclusion period (March 2002 to October 2003) 134 (73%) out of 184 eligible patients were included. The 50 patients who did not participate had the following reasons: 14 were unable to make an appointment for the MRI, 7 reported that they had a minor injury, 8 patients withdraw their informed consent because the results from MRI were not communicated to the patient and the GP, and 21 patients were unwilling to participate for unknown reasons or missed their appointments. There were no relevant clinical differences between the participants and non-participants.

Table 1 shows the baseline characteristics of all patients (n=134), patients with no knee instability (n=37, 28%), patients with self reported knee instability (n=23, 17%), with tested positive on instability (n=42, 31%) and both self reported and tested positive on instability of the knee (n=32, 24%).

Table 1: Baseline characteristics of all participating patients, patients with no knee instability, patients reporting knee instability, patients tested positive on instability of the knee, or both self reported and tested positive on knee instability.

	Total group (n=134)	**No instability** (n=37)	**Reported instability** (n=23)	**Tested instability** (n=42)	**Reported and tested** (n=32)	**P-value**
Age in years, mean (SD)	40.3 (12.2)	42.0 (13.3)	42.0 (13.2)	39.2 (11.8)	38.5 (10.6)	0.54
Age 40 and younger, mean (SD)	70 (52.2)	16 (43.2)	11 (47.8)	25 (59.5)	18 (56,3)	0.48
Gender, number of women (%)	60 (44.8)	14 (37.8)	11 (47.8)	19 (45.2)	16 (50.0)	0.76
BMI, mean (SD)	26.4 (4.3)	25.1 (3.7)	27.5 (5.8)	26.6 (3.9)	26.8 (4.0)	0.14
Employed, n (%)	113 (84.3)	31 (83.8)	20 (87.0)	37 (88.1)	29 (90.6)	0.61
Sports participation, n (%)	97 (72.4)	24 (64.9)	16 (69.6)	32 (76.2)	25 (78.1)	0.79
Onset during sports, n (%)	61 (45.5)	14 (37.8)	8 (34.8)	28 (66.7)	11 (34.4)	0.09[+]
Symptom side right knee, n (%)	66 (49.3)	20 (54.1)	11 (47.8)	20 (47.6)	15 (46.9)	
Knee pain severity, mean (SD)[$]	4.8 (2.4)	4.4 (2.6)	5.6 (2.2)	4.3 (2.1)	5.2 (2.7)	0.12
Lysholm knee score, mean (SD)[&]	61.8 (22.4)	66.7 (24.8)	47.8 (17.5)	73.0 (19.2)	51.6 (16.7)	<0.01[a]
Tegner knee score, mean (SD)[@]	4.5 (1.9)	4.5 (2.0)	4.6 (1.8)	4.9 (1.8)	4.1 (1.8)	0.49
No lesion on MRI, n (%)	52 (38.8)	12 (32.4)	8 (34.8)	21 (50)	11 (34.4)	0.35
Any lesion on MRI, n (%)	82 (61.2)	25 (67.6)	15 (65.2)	21 (50)	21 (65.6)	
Meniscal tear[#], n (%)	47 (35.1)	14 (37.8)	7 (30.4)	14 (33.3)	12 (37.5)	0.92
Cruciate ligament lesion[*], n (%)	33 (24.6)	5 (13.5)	5 (21.7)	10 (23.8)	13 (40.6)	0.06[+]
Collateral ligament lesion[^], n (%)	41 (30.6)	15 (40.5)	6 (26.1)	9 (21.4)	11 (34.4)	0.28
Knee osteoarthritis on MRI, n (%)	15 (11.2)	5 (13.5)	1 (4.3)	5 (11.9)	4 (12.5)	0.22
Patella osteoarthritis on MRI, n (%)	16 (11.9)	5 (13.5)	2 (8.7)	5 (11.9)	4 (12.5)	0.25

BMI: Body Mass Index, SD: standard deviation.
[+]: Adjusted for sports participation and gender.
[$]: Knee pain severity measured with an 11-point numerical rating scale with 0 = no pain and 10 = unbearable pain.
[&]: Range of Lysholm knee function score 0 = worst knee function to 100 = best knee function.
[@]: Range of Tegner knee function score 0 = on sick leave/disability to 10 = 'participation in competitive sports.
[#]: Horizontal, longitudinal, radial or complex meniscal tear.
[*]: Partial or complete anterior or posterior cruciate ligament lesion.
[^]: Partial or complete medial or lateral collateral ligament lesion.
[a]: Significant differences between: no instability vs reported instability, no instability vs both reported and tested instability, reported instability vs tested instability, and tested instability vs both reported and tested instability.

The mean age of all patients was 40.3 years (age range 18 to 64 years) and 45% was female. Sixty-one patients (46%) sustained a knee trauma during sports activities. At baseline the mean knee pain severity (11-point numerical rating scale) was 4.8 (SD 2.4) and the mean Lysholm knee function score was 61.8 (SD 22.4).

Patients who were tested positive on instability of the knee reported relatively more an onset of their traumatic knee complaints during sports activities, 67% versus 35% in self reported instability and 34% in self reported and tested positive on instability: there was no significant difference between groups regarding onset during sports (p=0.09). Patients with self reported knee instability showed the lowest mean score on the Lysholm score (47.8;SD 17.5 versus 66.7;SD 24.8 in no knee instability, 73.0;SD 19.2 in tested positive on instability and 51.6;SD 16.7 in self reported and tested positive on instability). The group with no knee instability differed significantly from the self reported instability and the both self reported and tested positive on instability group ($p<0.05$). The self reported group differed significantly from the tested positive group ($p<0.05$). Also, the tested positive group differed significantly from the both self reported and tested positive on instability group ($p<0.05$). Patients with both self reported and tested positive on knee instability had relatively more cruciate ligament lesions (41% versus 22% in the self reported instability, 24% in tested positive instability) seen on MRI: a borderline significance between groups regarding cruciate lesions (p=0.06).

During the one-year course of the knee complaints (table 2) the patients with self reported knee instability showed the highest decrease in knee pain severity (from 5.6 to 1.4 on the 11-point numerical rating scale) and the highest increase in the Lysholm knee function score (from 47.8 at baseline to 87.9 at one-year follow-up). The total group, the no instability group as well as the three defined instability groups of patients reported a mean Tegner knee function score that (slightly) decreased at one-year follow-up, indicating no (slightly) improvement of function regarding participation in competitive sports. At 12 months follow-up, the group tested positive on instability significantly (p=0.02) differed from the group with both self reported and tested instability. Patients with both self reported and tested positive on knee instability showed relatively less perceived recovery compared to the no instability group, 56% versus 89% respectively.

Table 2: Course of knee pain intensity, Lysholm and Tegner knee function score and perceived recovery of all participating patients (n=134), patients with no knee instability (n=37), patients reporting knee instability (n=23), patients tested positive on instability of the knee (n=42), or both self reported and tested positive on knee instability (n=32) at baseline and at 3, 6, and 12 months follow-up.

	Baseline	3 months[#]	6 months[#]	12 months[#]
Knee pain severity, mean (SD)[$]				
- Total group	4.8 (2.4)	2.5 (2.3)	2.2 (2.3)	1.8 (2.3)
- No instability	4.4 (2.6)	2.1 (2.3)	2.2 (2.2)	1.6 (2.0)
- Reported instability group	5.6 (2.2)	2.4 (2.0)	1.9 (2.3)	1.4 (2.2)
- Tested instability group	4.3 (2.1)	2.1 (2.0)	2.2 (2.3)	1.8 (2.4)
- Reported and tested instability	5.2 (2.7)	3.6 (2.7)	2.6 (2.4)	2.6 (2.7)
P-value	*0.12*	*0.08*	*0.64*	*0.35*
Lysholm knee function score, mean (SD)[&]				
- Total group	61.8 (22.4)	77.9 (19.4)	80.2 (17.9)	84.5 (16.5)
- No instability	66.7 (24.8)	81.2 (17.9)	80.5 (21.0)	84.5 (16.2)
- Reported instability group	47.8 (17.5)	77.4 (17.5)	79.6 (18.5)	87.9 (15.8)
- Tested instability group	73.0 (19.2)	81.7 (19.3)	83.5 (15.6)	86.7 (16.4)
- Reported and tested instability	51.6 (16.7)	68.1 (20.6)	76.3 (16.3)	76.8 (16.8)
P-value	***0.00***[a]	*0.05*	*0.59*	*0.12*
Tegner knee function score, mean (SD)[@]				
- Total group	4.5 (1.9)	--	--	4.1 (1.8)
- No instability	4.5 (2.0)	--	--	4.3 (1.9)
- Reported instability group	4.6 (1.8)	--	--	3.8 (1.7)
- Tested instability group	4.9 (1.8)	--	--	4.6 (1.8)
- Reported and tested instability	4.1 (1.8)	--	--	3.3 (1.6)
P-value	*0.49*	--	--	***0.02***[b]
Peceived recovery, n (%)				
- Total group	--	--	--	101 (75.4)
- No instability	--	--	--	33 (89.2)
- Reported instability group	--	--	--	19 (82.6)
- Tested instability group	--	--	--	31 (73.8)
- Reported and tested instability	--	--	--	18 (56.3)
P-value	--	--	--	0.10

[$]: Knee pain severity measured with an 11-point numerical rating scale with 0 = no pain and 10 = unbearable pain.
[&]: Range of Lysholm knee function score 0 = worst knee function to 100 = best knee function.
[@]: Range of Tegner knee function score 0 = on sick leave/disability to 10 = participation in competitive sports.
[#]: Missing values ranged from 21% to 37%.
[a]: Significant differences between: no instability vs reported instability, no instability vs both reported and tested instability, reported instability vs tested instability, and tested instability vs both reported and tested instability.
[b]: Significant differences between tested instability vs both reported and tested instability.

Table 3 shows the management of the patients at baseline and during the one-year follow-up. Regarding re-consulting the GP, medication use and arthroscopy/surgery there were no clinical or statistical differences between the defined knee instability groups. The patients with self reported and tested positive on knee instability were more frequently referred to secondary care, 22% versus 9% of the reported instability group and 14% in the tested instability group at baseline.

Table 3: Management of of all participating patients (n=134), patients with no knee instability (n=37), patients reporting knee instability (n=23), patients tested positive on instability of the knee (n=42), or both self reported and tested positive on knee instability (n=32) at baseline and at 3, 6, and 12 months follow-up.

Management	Baseline	3 months[#]	6 months[#]	12 months[#]
Re-consulting GP, n (%)				
- Total group	--	47 (35)	17 (13)	12 (9)
- No instability	--	11 (30)	5 (14)	3 (8)
- Reported instability	--	8 (35)	2 (9)	1 (4)
- Tested instability	--	15 (36)	4 (10)	4 (10)
- Reported and tested	--	13 (41)	6 (19)	4 (13)
P-value	--	*0.53*	*0.58*	*0.49*
Medication, n (%)				
- Total group	35 (26)	4 (3)	4 (3)	3 (2)
- No instability	12 (32)	1 (3)	2 (5)	1 (3)
- Reported instability	7 (30)	2 (9)	1 (4)	1 (4)
- Tested instability	8 (19)	0 (0)	0 (0)	0 (0)
- Reported and tested	8 (25)	1 (3)	1 (3)	1 (3)
P-value	*0.35*	*0.32*	*0.58*	*0.60*
Referral physical therapy, n (%)				
- Total group	37 (28)	11 (8)	4 (3)	6 (5)
- No instability	7 (19)	9 (24)	0 (0)	1 (3)
- Reported instability	9 (39)	2 (9)	0 (0)	0 (0)
- Tested instability	13 (31)	4 (10)	1 (2)	2 (7)
- Reported and tested	8 (25)	5 (16)	3 (9)	3 (9)
P-value	*0.60*	*0.08*	*0.09*	*0.18*
Referral secondary care, n (%)				
- Total group	17 (13)	3 (2)	2 (2)	7 (5)
- No instability	2 (5)	0 (0)	0 (0)	2 (5)
- Reported instability	2 (9)	2 (9)	0 (0))	0 (0)
- Tested instability	6 (14)	0 (0)	0 (0)	3 (7)
- Reported and tested	7 (22)	1 (3)	2 (6)	2 (6)
P-value	*0.16*	*0.11*	*0.09*	*0.59*
Arthroscopy/surgery, n (%)				
- Total group	--	9 (7)	4 (3)	6 (5)
- No instability	--	3 (8)	1 (3)	2 (5)
- Reported instability	--	1 (4)	1 (4)	0 (0)
- Tested instability	--	2 (5)	1 (2)	3 (7)
- Reported and tested	--	3 (9)	1 (3)	1 (3)
P-value	--	*0.70*	*0.99*	*0.65*

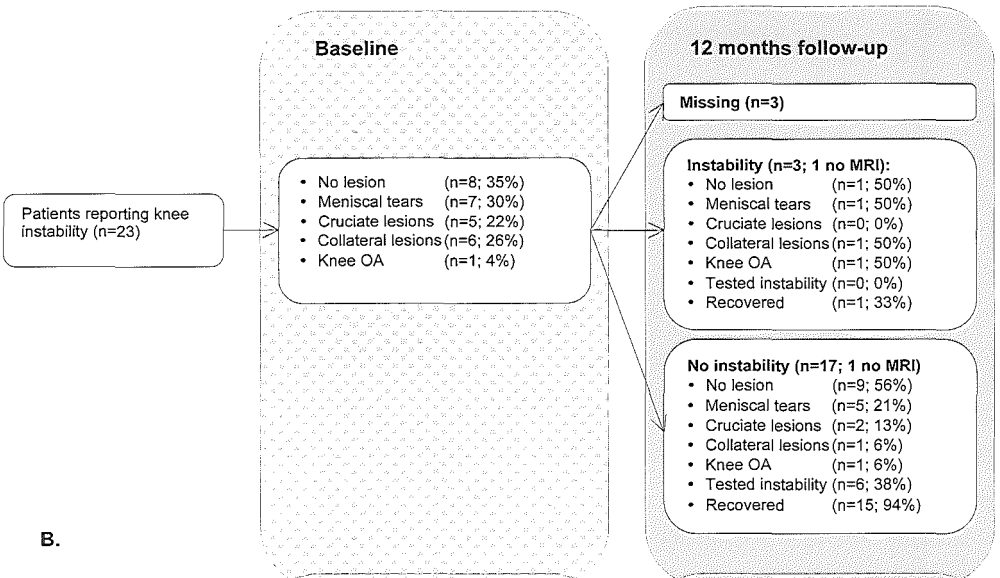
[#]: Missing values ranged from 21% to 37%.

The opposite was observed regarding percieved recovery for patients tested positive on knee instability (figure 1B). Figure 1C shows the MRI findings of the patients with both self reported and tested positive on knee instability. At one-year follow-up these patients with no knee instability had more meniscal tears, cruciate and collateral ligament lesions on MRI than the patients with knee instability.

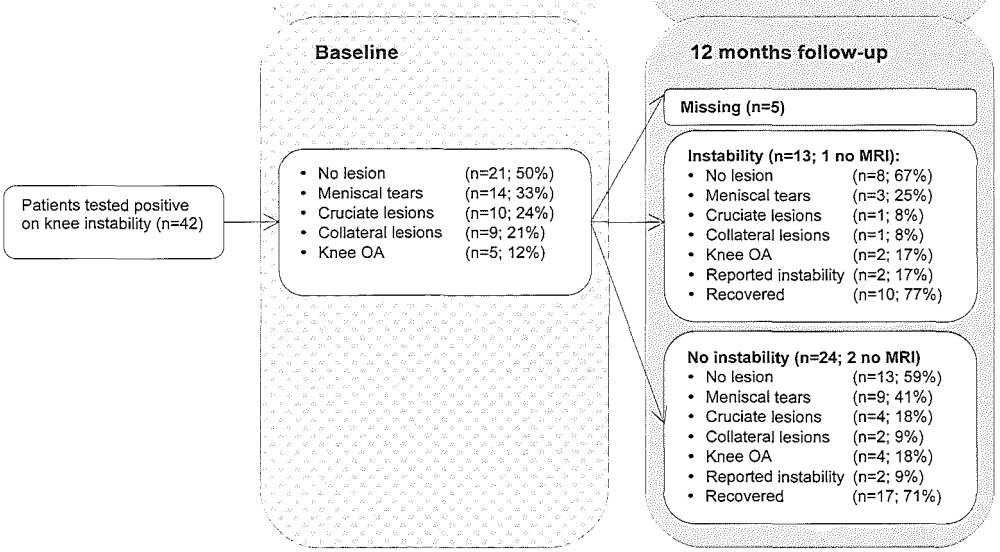
Patients' perceived recovery showed no clinical difference between patients with or without knee instability (figure 1B and 1C).

Figure 1: MRI findings of (**A**) patients reporting knee instability (n=23), (**B**) patients tested positive on knee instability (n=42), (**C**) patients with self reported and tested positive on knee instability (n=32) at baseline and at 1-year follow-up. (OA=osteoarthritis)

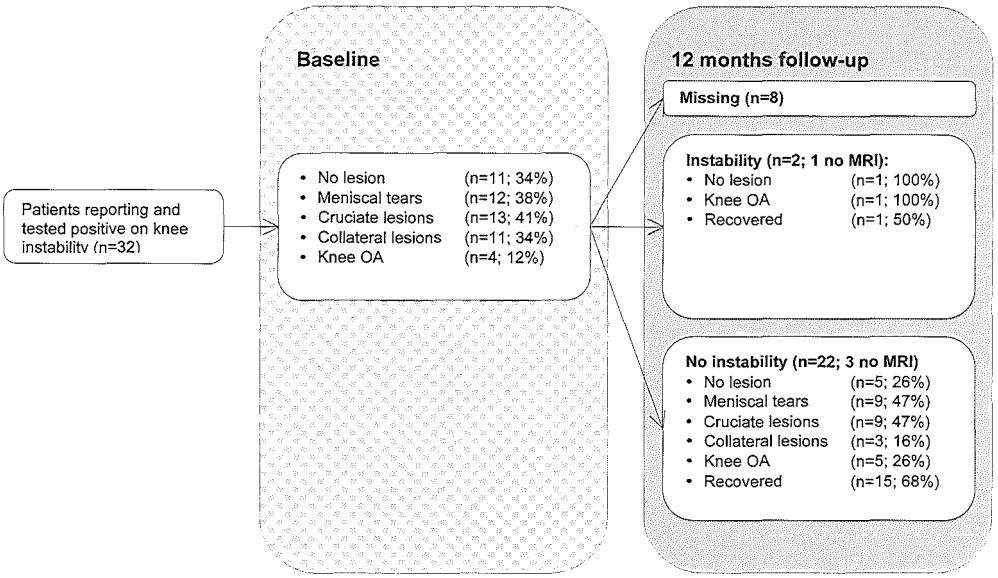
A.



B.



C.



Discussion

Key results

Of the 134 included patients with traumatic knee disorders at baseline, 28% had no knee instability, 17% self reported knee instability, 31% were tested positive on knee instability and 24% both self reported and tested positive on instability of the knee. At baseline, there were no clear differences in MRI findings between the groups of patients. Also, the treatment and course showed no differences, exept only at 12 months follow-up for the Tegner score between the tested group and the both reported and tested group (p=0.02). However, in mangement no differences between groups were found in the 12 months follow-up. Although the patients in the both reported and tested group were less clinically recovered (56% versus 82% in the self reported knee instability group) at one-year follow-up.

At one-year follow-up, 13% of the patients reported (persistent) knee instability of which 33% stated that they were clinically recovered. For patients tested positive on knee instability, 31% was tested positive on (persistent) knee instability of which 77% stated clinical recovery at one-year follow-up. Also at one-year follow-up, there were no clear differences between MRI findings of the knee between the three defined knee instability groups, nor between patients with (persistent) and without knee instability at one-year follow-up.

Limitations

Patients without lesions may have had less severe knee complaints and functional limitations and may be less motivated to participate during follow-up. The percentage of clinically relevant recovery in this study may therefore be underestimated. With regard to the treatment during the one-year follow-up, it is likely there was some underestimation due to recall bias because patients were asked retrospectively over at least a period of 3 months. It is also important to take into account the number of missing questionnaires during follow-up, leading to underestimation of the referral rate to either physical examination or secondary care, and the number of performed surgeries and arthroscopies.

Because knowledge of the findings of the MRI of the knee could lead to different management and therefore to different outcome, MRI findings were not revealed to either the GP or the patient. As there were no standardised treatments following certain diagnoses, it is possible that specific treatment tailored to that diagnoses or certain MRI findings could have resulted in different outcomes. Furthermore, we included 134 patients and divided them in 4 groups which leaded to limited power in our statistical analyses regarding between group differences.

Interpretation

To our knowledge, the present study is the first that describes the course of knee instability in primary care patients with traumatic knee complaints. Therefore, we can not compare our results with existing literature. We recommend more prospective studies that include primary care patients with traumatic knee disorders that will measure and report regarding knee instability. A standardized physical examination was carried out by a trained physical therapist in this study. In daily practice the GP will perform physcial examination of the knee during consultation. It is not expected that a GP will perform the physcial examination very different than a physcial therapist in these primary care patients. However, when orthopaedic surgeons perfom a physical examination than there could be differences, because these patients are a selected group of patients referred by the GPs (5% in our study).

Generalizability

In this study, GPs could be less triggered to refer to secondary care because they knew that MRI was part of the study protocol and that they would be notified of injuries detected on MRI requiring immediate intervention (for example fractures). Although, because the spectrum of lesions involved in the present study and presented to the participating GPs is wide, it is reasonable to assume that this study population represent the common traumatic knee patient in general practice.

Conclusions

In the heterogeneous population with traumatic knee disorders that consulted the general practitioner, self reported knee instability, tested positive on knee instability and both self reported and tested instability was present in 17%, 31% and 24% respectively. At one-year follow-up, 13% of the patients reported (persistent) knee instability of which 33% stated that they were clinically recovered. For patients tested positive on knee instability, at one-year follow-up, 31% tested positive on (persistent) knee instability of which 77% stated clinical recovery. At one-year follow-up, 6% of the patients with both self reported and tested knee instability reported (persistent) knee instability of which 50% stated clincal recovery.

There were no differences between MRI findings between between no instability and the three defined knee instability groups, between the three instability groups, nor between patients with (persistent) and without knee instability at follow-up.

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Competing interests

The authors stated that there are none.

Authors' contributions

JANV, BWK and SMAB-Z substantial contributed to conception and design of the study. HPAW, EMH, IMK, EHGO were involved in acquisition of data. PAJL, HPAW, MK and SMAB-Z were involved in the analysis and interpretation of data and in drafting the manuscript. All authors revised the draft manuscript critically and have read and approved the final manuscript.

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Part Four

Problems cannot be solved at the same level of awareness that created them.

Albert Einstein (1879-1955)

8

General Discussion

Traumatic knee disorders in general practice

The main issue addressed in this thesis is the apparent lack of evidence concerning the value of diagnostic tests, and the outcome and prognosis of patients who have sustained a knee injury and consult the general practitioner (GP). The Dutch National Guideline for general practitioners concerning traumatic knee disorders dates back to 1998 [1]. Although the guideline was updated in 2010, it contains more-or-less the same recommendations as in the original version [2]. The guideline states that the diagnostic value of history taking and physical examination is limited and advocates a wait-and-see policy in the treatment of traumatic knee disorders [1]. However, the guideline is mainly based on studies performed in secondary care settings, and these study populations may differ in nature and severity of lesions compared to patients in primary care [3]. Therefore, the overall aim of the studies presented in this thesis was to explore the diagnostic value of history taking and physical examination, and to study the outcome and prognostic value of history taking, physical examination and magnetic resonance imaging (MRI) in patients with traumatic knee disorders who present in general practice.

In short, we found that physical examination has no additional diagnostic value above history taking. We also found that history taking, physical examination, and MRI cannot predict the 1-year prognosis of persistent knee complaints. However, in our study the 1-year prognosis is good in the vast majority of the patients.

In this general discussion we discuss the strengths and limitations of the methods used, and their implications for our results. In addition, we place our findings in a clinical perspective and make some recommendations for future research.

Methods and results of our studies

Study population

Our MRI study was part of a large general cohort study in primary care [4]. During the inclusion period for the MRI study (March 2002 to October 2003) 184 patients with a traumatic onset of their knee disorders (included in the general cohort study) were eligible for the MRI study, based on the additional criteria of age 18-65 years and a consultation with the general practitioner within 5 weeks after the initial injury.

Of the 184 eligible patients, 134 (73%) were included in the MRI study, and underwent an additional physical examination and MRI of the knee. No patient had to be excluded because of the additional exclusion criteria for the MRI study (i.e. pregnancy, metal implants or a pacemaker). The remaining 50 patients (27%) were unwilling or unable to participate. Reasons given for non-participation were: lack of interest or missing appointments (n=21), distance to the hospital for the MRI too far or lack of time (n=14), withholding of the MRI results because of the study design (n=8), and sustained only a minor

injury according to the patient (n=7). Especially this last subgroup, but possibly also others, might have led to overestimation of the diagnostic value and underestimation of the recovery rates.
Both the participants and non-participants had a similar distribution in age and level of activity (as determined with the Tegner activity score). The baseline mean pain severity score in the non-participants group was somewhat lower compared to the study population, and the Lysholm function knee score was slightly higher in the non-participants. In the group of non-participants males are overrepresented (67% vs. 55% in the study population). Overall, among the non-participants the sense of urgency to participate in the study is probably lower than among the participants. However, we assume that the influence of the 50 non-participants is limited.

The included patients had a mean age of 40 (range 18-64) years and 55% were male. Sports activities were frequently reported to be the cause of the knee injury (46%), which is in line with other studies [5-6]. The knee complaints had to be related to any kind of injury (sudden impact or wrong movement) less than 5 weeks before consultation. In the general cohort study recurrent complaints for which the general practitioner was not consulted within the last 3 months were also considered as new complaints. In our MRI study this was not the case due to the relationship with an injury maximally 5 weeks prior to consultation. Due to appointments to be made for the MRI and physical examination, the time between MRI/physical examination and the initial injury exceeded these 5 weeks (range 1 to ± 12 weeks) [7]. However, we think this is an acceptable range and in fact reflects normal clinical practice.

Overall, we argue that the study population represents typical patients consulting in general practice for new traumatic knee complaints. However, we must take in account that some patients who sustain a knee injury (particularly in the evening and in the weekend during sports activities) will not consult their general practitioner but will visit the emergency department of a general hospital. Nevertheless, in many cases these patients will first be seen by a general practitioner because, in the Netherlands over the last decade, in many hospitals the emergency rooms are transformed into multidisciplinary departments of primary/secondary emergency care during out-of-office hours and in the weekends. However, these latter patients were not included in the MRI study.

MR imaging

The MRI study was performed using a General Electric Signa Horizon 1 Tesla scanner. In the symptomatic knee the following scanning protocols were used: acquired sagittal T1-weighted fast spin-echo sequences, sagittal intermediate-weighted and T2-weighted FSE sequences, coronal gradient-echo T2, T2-weighted fat suppressed sequences and axial intermediate-weighted FSE sequences [7]. These protocols are more extensive than those used in normal daily practice. For feasibility reasons, in the asymptomatic knee only the sagittal intermediate-weighted and T2-weighted and the coronal GE-weighted sequences were obtained [7]. Detailed information on the scanning protocols is available elsewhere [7].

The MRI scans were scored by two radiologists (independently of each other) using a non-validated score list [7]. This list was drawn up by the radiologists based on clinical experience and enabling a semi-quantitative score for most of the items. To our knowledge no validated scoring list is currently available. Both radiologists were blinded for the clinical data. In case of disagreement the findings were discussed until consensus was reached. Effusion was classified as small, moderate or large [7]. Menisci were classified as normal, degenerated or torn [7]. In our analysis degenerated menisci were not considered as meniscal tears. Cruciate and collateral ligaments were classified as normal, partial or complete tear [7]. At the time of our study, for MRI no definition was available to diagnose osteoarthritis of the knee. Therefore, we used a modified Kellgren and Lawrence (K&L) scale and classified osteoarthritis as grade 2 and higher (score range 0-4) [7]. At present there is consensus on the definition of osteoarthritis on MRI [8]. Fortunately, this definition of osteoarthritis is in good agreement with the modified K&L scale used in our MRI study [7-8].

The inter-observer agreement of the radiologists, expressed as the intraclass correlation coefficient (ICC), ranged from 0.90 for the anterior cruciate ligament to 0.98 in the posterior cruciate ligament [7]. For the medial and lateral meniscus the ICC was 0.95 and 0.98, respectively, while for the medial collateral ligament the ICC was 0.94 [7]. For osteoarthritis the ICC was 0.96 [7]. An ICC value of 1 represents perfect agreement while values of 0.8-1 indicate almost perfect agreement [9].

In our study design both the symptomatic and non-symptomatic knee were examined with MRI and by physical examination. In two patients, both knees were considered to be symptomatic. After detailed questioning we decided which knee was to be considered as symptomatic and which knee as non-symptomatic, depending on whether or not a recent injury (according to the inclusion criteria) was reported. Of the 134 included patients, 82 (61%) showed a meniscal tear and/or cruciate or collateral ligament lesion on baseline MRI. Of the 134 patients, in 52 (39%) no meniscal tears or ligament lesions were seen on MRI. In 38 of these 52 patients (28%) effusion was reported without meniscal or ligament damage, while in the remaining 14 patients (11%) no effusion, meniscal or ligament damage was reported. Based on the MRI, meniscal tears were reported in 47 patients (35%). In 35 patients (26%) a medial collateral ligament lesion was detected and in 28 patients (21%) an anterior cruciate ligament lesion was found (11 partial and 17 complete lesions). In 20 patients (15%) a so-called "unhappy, or O'Donoghue's, triad" (a combination of a meniscal tear and anterior cruciate ligament and medial collateral lesion) was detected [10].

An interesting finding was that the number of degenerative meniscal lesions in both the symptomatic and the non-symptomatic knee was almost the same [7]. Bearing in mind the average age of our study population (over 40 years) this finding might indicate degenerative features already present in most of the included patients [7, 11].

In our study MRI was used as a reference test to determine the diagnostic value of history taking and physical examination, the course at 1-year follow-up, and to identify prognostic factors for persistent knee complaints at 1-year follow-up. MRI is considered to be a highly accurate diagnostic tool to identify meniscal tears [12-13]. In our study degenerative meniscal lesions as seen on MRI were not considered to be meniscal tears. Complete or partially collateral ligament lesions can also be detected on MRI (with a high level of accuracy) as complete cruciate ligament lesions [12-13]. However, partial cruciate ligament lesions show a lower accuracy compared to complete cruciate ligament lesions [14]. In our study most of the anterior cruciate lesions were complete lesions (17 complete vs. 11 partial lesions). After performing a subanalysis, with and without including partial cruciate ligament lesions in the multivariate analysis, no significant differences were found between the two analyses (Chapter 3). From both models the data were very similar (Chapter 3). For the above-mentioned reasons we relied on MRI as the reference test for the diagnostic studies and as a prognostic variable in our prognostic studies.

Questionnaire

We constructed a standardized self-report questionnaire to collect information on patient characteristics, medical history, level of activities, present symptoms, and the mechanism of the knee injury [4]. This questionnaire was given to the patient by the general practitioner's assistant (baseline measurement) and was returned during the consultation for MRI and physical examination. In case of incomplete or unclear answers, during this latter visit the patient was asked for additional information. In daily clinical practice, history taking takes places by means of a (structured) interview by the general practitioner. It has been shown that the method we used is valid, thereby yielding more and reproducible information [15-17]. Patients may have some recall bias when filling out the baseline and follow-up questionnaires [18-19]. For example, they might not fully recall the mechanism of injury and immediate symptoms when the injury was up to 5 weeks earlier, or even earlier in some cases. Particularly in the follow-up questionnaires patients were asked to report on symptoms and related items (such as medical consumption) over a period of 3-6 months. This might have led to some underreporting in the answers to some specific items or events. However, in our opinion there was no possibility to reduce this bias. A daily diary kept by the patients might have been an option, but this would entail a substantial extra burden and might have led to non-response and/or to loss to follow-up.

Physical examination

Prior to the start of this study a literature search (data not published) was performed on the available tests, and their validity and reproducibility. The results of this search were used to construct a standardized protocol that was used in the study. Physical examination is often questioned - and not without reason; most tests have a considerable inter-observer variability [20-21]. For example, even between experienced orthopaedic surgeons, the intra- and interobserver variability is large resulting in a variety of clinical diagnoses in one and the same patient at the same time of examination [22]. By means of extensive training, and discussing the methods and interpretation of test results before starting the

study, we tried to limit the intra-observer variability as much as possible. In the MRI study only one examiner performed the physical examination of patients both at baseline and at 1-year follow-up. However, in daily practice the large inter-observer variability remains a fact. Taking this into account, the diagnostic value of tests reported in our study are expected to be lower than in daily practice.

Diagnosis

From the results of our MRI study we concluded that the diagnostic value of isolated determinants from history taking or physical examination for assessing meniscal tears, cruciate or collateral ligament lesions is limited [23-25]. Our findings are in line with two systematic reviews on this subject [26-27]. Both reviews stated that the diagnostic value of physical examination in meniscal tears or cruciate ligament lesions is limited; however, they did not report on the diagnostic value of history taking. From the point of view our study is unique. We have shown that a few determinants from history taking have some diagnostic value, whereas physical examination adds almost nothing to history taking.

A combination of the determinants improved the diagnostic value to some extent; this finding is in line with an earlier review [28]. More specifically, the diagnostic value improved when combining more than two determinants. However, we must take into account that, in these latter combinations, the number of patients in which these combinations were found decreased rapidly, resulting in larger 95% confidence intervals.

The number of patients included (n=134), and the prevalence of the more serious lesions such as complete cruciate ligament lesions (n=17) were rather limited, resulting in large confidence intervals; moreover, less strong associations might have been missed possibly resulting in type II errors (false-negative results) [29]. In addition, we tested many variables at risk for type I errors (false-positive results) that might find associations based on coincidence [29]. However, all the tested variables included diagnostic procedures that are commonly used in clinical practice.

The Standards of Reporting of Diagnostic Accuracy (STARD) steering group have developed a checklist and a generic flow chart to improve the quality of reporting of studies on diagnostic research [30-31]. We adopted this method and used it when reporting the results of our studies on the diagnostic value of history taking and physical examination in assessing meniscal tears, cruciate and collateral ligament lesions [23-25].

Outcome and management

We obtained perceived recovery in 122 of the 134 patients (91%) initially included. At 1-year follow-up, 12 patients were lost to follow-up (9%): 3 patients withdrew their initial informed consent and the remaining 9 patients moved abroad or elsewhere in the Netherlands without providing their new address. Of the 12 patients lost to follow-up, 7 showed no meniscal tear or ligament lesion on the baseline MRI.

This might have led to some underestimation of the perceived recovery among the 122 patients that did report on their recovery.

The majority of patients (n=101, 83%) reported clinically significant recovery at 1-year follow-up. This finding supports the advice given in the Dutch National Guideline for general practitioners on traumatic knee disorders, which advocates a wait-and-see policy [1]. The findings in our MRI study were used in 2010 to update the original guideline dating from 1998 [2]. Our results show that a wait-and-see policy still seems justified. The severity of pain as assessed with the numeric rating scale (NRS, score range 0-10) decreased mainly during the first 3 months after injury. We found no clear relation between pain scores and the type of damage to the knee (meniscal tear or ligament lesion). The subgroup with meniscal tears had higher pain scores; we suggest that there might be a relation with the relatively higher mean age of this group (almost 80 years higher than the overall average) as well as with other determinants such as obesitas or osteoarthritis are of interest. Multivariate analysis confirmed the relation ($p<0.05$) between the higher pain score and age in this subgroup (additional analysis, data not reported).

The Lysholm knee function score showed a greater increase during the first 3 months of rehabilitation, whereas from 3-9 months a smaller increase was found. At 1-year follow-up the study population showed a 10% decrease in the Tegner score compared with baseline, indicating a decrease in the level of activity in work and/or sport after one year. During the analysis of our data we sought an explanation for this finding. We believe that pain severity as experienced by the patients was not the only explanation and suggested that instability of the knee might also play a role. Therefore, we conducted an additional analysis on self-reported instability (obtained from the questionnaires) and tested instability (obtained from physical examination). This analysis showed that patients with self-reported (or both self-reported and tested) instability showed the largest decrease in the Tegner score. The group of patients with both reported and tested instability also reported the lowest percentage of clinical recovery compared to the group of reported or tested instability (56% vs. 83% and 74%) (Chapter 7).

Of all the included patients, 45% re-consulted the general practitioner once or more during the 1-year follow-up. Another study reported 50% re-consultation of the general practitioner [32].

In the Netherlands, about 25% of patients with knee injuries presented in general practice are referred to secondary care [33]; in our study this referral percentage was only 19%. This difference might be attributed to the fact that general practitioners were aware that an MRI study was part of the study design and that secondary care consultation was no longer required. Other studies on referral patterns have shown that the perceived usefulness for the general practitioner, patients' demand for costly diagnostic procedures, and the social context have a considerable influence on the referral for further diagnostics [34-36].

During the 1-year follow-up 18 patients (13%) underwent an arthroscopy. We have no information as to whether or not this was only a diagnostic arthroscopy, or whether at that time minor surgical interventions also took place. Only one patient underwent an anterior cruciate ligament reconstruction 8 months after the initial injury; this patient had a high level of knee load related to an occupation as ski-instructor. Overall, in our study population the frequency of invasive diagnostic or interventional procedures was limited. A recent randomized controlled trial indicated that a strategy of early anterior cruciate ligament reconstruction versus conservative care did not result in significant improvement in primary outcome, obtained with the Knee Injury and Osteoarthritis Outcome Score (KOOS) [37] assessed between baseline and two years. This latter study involved physically active adults. Also, pre-specified secondary outcomes (such as pain, symptoms, function in activities of daily living, sports and recreation and return to preinjury activity level at two years) showed no significant differences [38].

In our study, although 54 patients (40%) were referred to physical therapy it remains inconclusive whether or not this is effective in patients with traumatic knee disorders. We did not record what kind of interventions the physical therapist applied (e.g. exercise therapy, massage, and mobilization or advice).

Prognostic factors

Predictors of persistent knee complaints at 1-year follow-up are "age over 40", "female gender", "pain severity score > 5", "popping sensation during trauma" and adapted "Kellgren & Lawrence score ≥ 2", with only the first determinant being significant. All these determinants are obtained from history taking; from physical examination no determinants were found to be associated with persistent complaints after one year. From MRI only the "adapted Kellgren & Lawrence score ≥ 2" showed an association with persistent knee complaints at 1-year follow-up.

Analysis

Several psychosocial factors were investigated in our study, including the coping with pain score [39], the Tampa kinesiophobia score [40] and the Short-Form Health Survey (SF-36) [41]. Because of the limited number of cases in our study (134 at baseline and 122 at 1-year follow-up) we were restricted in the number of determinants to be included in our analysis, and chose to focus on determinants used by the general practitioner in daily practice obtained with history taking and physical examination.

Although we took great care to collect all the information, some missing values are unavoidable. In our analyses we used a complete-case analysis method rather than imputation for missing data, although it is reported that multiple imputation techniques favor complete-case analysis [42-44]. However, the effect of using of complete-case analysis rather than multiple imputation may be small (or even zero) based on the assumption that the missing values are completely at random [45]. This can be confirmed by using t-tests of the mean differences on age, gender and other key variables between the participants and the

non-participants. We performed these tests and, because no significant differences were found between the two groups, we refrained from multiple imputation.

Another issue that needs to be addressed is the dichotomizing of continuous outcomes. It is reported that dichotomization might influence the results of the analysis, e.g. during statistical analysis one loses information by dichotomizing the variables [46]. However, from a clinical perspective dichotomized variables are easier to interpret compared to continuous variables; therefore, we chose to dichotomize the continuous variables in our analysis.

General conclusion

Based on the studies presented in this thesis, and taking into account the limitations mentioned above, we conclude that in general practice:

- physical examination has little or no diagnostic value in assessing meniscal tears and ligaments lesions, whereas history taking has some diagnostic value.
- the outcome of traumatic knee disorders is good in the vast majority of patients.
- there is hardly any prognostic value of history taking, physical examination or MRI with regard to persistent complaints, one year after knee injury.
- there is no need for extensive changes in the present management by general practitioners.

Implications for general practice

The Dutch guideline for general practitioners for traumatic knee disorders, issued in 1998 [1] was updated in 2010 [2]. Some of the results from our study were used to update this guideline [23-25]. Based on available literature and the results of our study, no major changes were needed in the updated version of the guideline [2].

The following items from history taking in our study are integrated in the updated guideline [2]:
- popping sign during trauma,
- effusion within a short period of time
- giving way (instability).

The absence of these signs decreases the probability of meniscal tears or ligament lesions while the presence of these signs increases this probability. Regarding the physical examination, use of the anterior drawer sign test and the Lachman test remains inconclusive. Both tests showed some diagnostic value in excluding an anterior cruciate ligament lesion; however, the positive predictive value in general practice is low and especially the Lachman test requires adequate performance and interpretation by the general practitioner [24]. Because of the large inter-observer variability in the tests for the physical examination, these tests are not included in the updated guideline [2].

Several studies on the value of MRI in a primary care setting report that it does not significantly alter the diagnosis or treatment strategy [36, 47]. However, after MRI patients had more confidence about the diagnosis and therapy [36, 47-49]. Arguments in favour of the use of MRI are that it supports (less experienced) general practitioners in the diagnostic process, supports management choices, and results in higher patient satisfaction [50]. Arguments against the use of MRI in general practice are that, in case the patient is referred to secondary care because of persistent complaints, an arthroscopy might be warranted and then MRI becomes superfluous [50]. Also, interpretation of the MRI scans by the general practitioner can be problematic [50].

Because the present study shows no additional value of MRI in the prognosis of persistent complaints at 1 year, refraining from MRI in primary care might be considered. However, based on its diagnostic value and implications for further treatment and subsequent outcomes, the use of MRI in traumatic knee disorders in primary care is still under debate.

In our study, as the prognosis of traumatic knee disorders proved to be favourable, the recommendation of the Dutch guideline on traumatic knee disorders (a wait-and-see policy) is justified (Chapter 5) [50]. Follow-up consultations with the general practitioner (with intervals of 1-2 weeks) to monitor rehabilitation is advisable, based on the severity of the complaints [50]. The (natural) course of the complaints (persistent pain, effusion or instability) and perceived limitations in work, sport or daily activities are important indicators for recovery. Although it is unclear what the (cost)effectiveness of physical therapy is, many patients with a traumatic knee disorders in the Netherlands are referred to a physical therapist [51]. In 2008 in the Netherlands about 40,000 patients with traumatic knee disorders visited a physical therapist [51]. Over 50% of these patients were referred by their general practitioner, about 25% by secondary care and about 25% by direct access to the physical therapist [51]. At the moment there is no evidence that interventions applied by a physical therapist are effective. However, the Royal Dutch Physical Therapy Association has developed a guideline which states that physical therapy can be useful in the rehabilitation process after a knee injury [51-52].

Future research

Due to the relatively small number of patients involved we recommend validation of our results in other study populations with (preferably) a larger number of patients consulting the general practitioner for knee traumatic knee disorders.

The use of MRI in primary care might be cost-effective because of a better or equal health outcome related to less direct or indirect costs. However, the cost-effectiveness for the use of MRI in primary care remains unknown and needs further study.

Our follow-up period was one year. To investigate the effects of a knee injury over a longer period our group have started a study among our included patients with a follow-up of 6 years. There is strong evidence that knee injuries are an important risk factor for the development of knee osteoarthritis [53-55]. However, it remains unclear whether or not the choice of management (wait-and-see, conservative or surgical intervention) has a positive effect on the development of osteoarthritis in later years. Because of the disease burden of osteoarthritis, loss of working capacity in the elderly, and the increasing demand on health care (including healthcare costs) it is important to study the possible effectiveness of early intervention or prevention of osteoarthritis in patients with persistent knee complaints due to trauma.
Also, because of the large number of patients visiting a physical therapist due to a knee injury, the cost-effectiveness of exercise therapy (as stated in the guideline of the Royal Dutch Physical Therapy Association) should be assessed in future research [52].

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9

Summary

Summary

In general practice, traumatic knee complaints are frequently encountered by general practitioners (GPs). The annual incidence of knee injuries reported in Dutch general practice is about 5.3 per 1,000 registered patients. Many studies on diagnostic value, outcome and prognosis of knee injuries involve secondary care populations. However, there is a gap in knowledge on diagnostic value, outcome and prognosis of these injuries in the primary care setting. The aim of the work presented in this thesis was to fill this gap.

In **Chapter 2** we determined the diagnostic value of history taking and physical examination for assessing meniscal tears in patients consulting a GP. Patients aged 18-65 years and consulting their GP within 5 weeks after the initial trauma were enrolled in our magnetic resonance imaging (MRI) study. A total of 134 patients were included. At baseline a self-reported questionnaire, physical examination and MRI were carried out. On MRI 47 patients showed a meniscal tear. From history taking "age over 40", "continuation of activity impossible" and "weight bearing during trauma" showed an association ($p<0.05$) with a meniscal tear. From physical examination only "pain at passive flexion" showed an association ($p<0.05$) with a meniscal tear. The highest positive likelihood ratio was 2.0 for "age over 40 years". Although combining these determinants slightly improved the diagnostic value, these combinations applied to only a limited number of patients. We concluded that, in general practice, history taking has some diagnostic value whereas physical examination does not add any diagnostic value in the assessment of meniscal tears.

In **Chapter 3** we assessed the diagnostic accuracy of history taking and physical examination for assessing anterior cruciate ligament lesions in general practice. Of the 134 included patients, 28 showed partial or complete anterior cruciate ligament lesions on MRI. "Effusion", "popping sensation", "giving way" and "anterior drawer test" showed an association ($p<0.05$) with an anterior cruciate ligament lesion. "Popping sensation" had the highest diagnostic value, with a sensitivity of 0.63, a specificity of 0.73, a predictive value positive of 0.39, and a positive likelihood ratio (LR+) of 2.3. Combing the determinants from history taking slightly improved the diagnostic value. Adding "anterior drawer test" to this combination improved the diagnostic value (especially the LR+) up to 4.2. It was concluded that based on history taking and physical examination, the GP can screen for anterior cruciate ligament lesions.

Chapter 4 reported on the diagnostic value of history taking and physical examination for assessing medial collateral ligament lesions. In 35 of the included 134 patients a medial collateral ligament lesion was seen on MRI. From history taking, "trauma by external force to leg" and "rotational trauma" showed an association ($p<0.05$) with medial collateral ligament lesions. From physical examination, "pain valgus stress 30°" and laxity valgus stress 30°" showed an association ($p<0.05$) with these lesions. Isolated determinants from both history taking and physical examination showed some diagnostic value. The positive likelihood ratio (LR+) for "trauma by external force to leg" and "pain valgus stress 30°" was 2.0 and 2.3, respectively. Adding "pain valgus stress 30°" and "laxity valgus stress 30°" from physical

examination improved the diagnostic value to an LR+ of 6.4. Based on these results it was concluded that history taking has some diagnostic value and that adding physical examination increases the diagnostic value.

In **Chapter 5** we assessed the outcome of knee injuries and observed the management initiated by the GP during the 1-year follow-up. Participants in our MRI study filled out a follow-up questionnaires at 3, 6 and 12 months after baseline. At 1-year follow-up, 34 of the available 122 patients reported full recovery and 67 patients reported major improvement. The remaining 21 patients reported persistent complaints. In total, 58 patients (43%) were referred to physical therapy during the 1-year follow-up. Twenty-eight patients (21%) were referred to secondary care during the 1-year follow-up. In total, 18 arthroscopies were performed in 15 patients and only one patient underwent a repair of the anterior cruciate ligament lesion. Based on our results it was demonstrated that the vast majority of patients (101 of 122; 83%) reported a clinically relevant recovery.

In **Chapter 6** we report on the prognostic value of history taking, physical examination and MRI to identify predictors for persistent complaints after a knee injury. After 1 year, 21 of the 122 available patients (17%) reported persistent complaints. "Age over 40" from history taking showed an association ($p<0.05$) with persistent complaints (OR 8.0: 95% CI 2.1-30.5). Physical examination and MRI revealed no predictors with an association with persistent complaints.

In **Chapter 7** the course of reported and tested traumatic knee instability during 1-year follow-up is reported. At baseline, 28% of the 134 patients had no knee instability, 17% reported knee instability (according to the Lysholm score), 31% tested positive on knee instability (according to the Lachman test), and 24% self-reported and also tested positive on instability of the knee. At baseline and at 1-year follow-up, no differences were found on MRI between the defined groups of knee instability. Also, the treatment and course during 1-year follow-up showed no clear differences. At 1-year follow-up, 13% of the patients reported (persistent) knee instability of which 33% stated that they were clinically recovered. Of the patients who tested positive for knee instability, 31% had (persistent) knee instability of which 77% stated clinical recovery at 1-year follow-up. We concluded that there were no clear differences regarding course, treatment and MRI findings of the knee between patients with no instability and patients with reported, tested, or both reported and tested instability knee instability.

In **Chapter 8** we discussed the main findings of our MRI study and the limitations of our results. Implications for clinical practice and future research are also discussed. The general conclusion is that the Dutch NHG guideline for traumatic knee complaints that was issued in 1998 is still valid, with only minor modifications based on our and other recent studies.

Chapter 9 summarizes the main findings of our MRI study on knee injuries in general practice.

10

Samenvatting

Samenvatting

Traumatische knieklachten worden met enige regelmaat gezien in de huisartspraktijk. De gerapporteerde jaarlijkse incidentie van knieletsels in de Nederlandse huisartspraktijk is 5,3 per 1000 geregistreerde patiënten.

Veel studies naar diagnostische waarde, beloop en prognose van knieletsels hebben betrekking op tweedelijns populaties. Er bestaat een lacune in kennis over de diagnostische waarde, het beloop en de prognose van dergelijke letsels in de eerstelijns gezondheidszorg.

Doel van dit proefschrift is deze lacune (deels) op te vullen.

In **hoofdstuk 2** hebben we de diagnostische waarde van de anamnese en het lichamelijk onderzoek bepaald bij het vaststellen van meniscusscheuren bij patiënten die de huisarts consulteerden. Patiënten tussen 18 en 65 jaar oud die hun huisarts binnen 5 weken na het ontstaan van het letsel consulteerden namen deel aan onze Magnetic Resonance Imaging (MRI) studie. In totaal 134 patiënten zijn geïncludeerd. Bij aanvang van de studie werden een vragenlijst ingevuld en een lichamelijk onderzoek en MRI-onderzoek uitgevoerd. Op de MRI bleken 47 patiënten een meniscusscheur te hebben. Uit de anamnese bleken "leeftijd boven 40", "voortzetting van activiteit onmogelijk" en "gewichtdragend tijdens het trauma" geassocieerd ($p<0,05$) met een meniscusscheur. Uit het lichamelijk onderzoek bleek alleen "pijn bij passieve flexie" een associatie ($p<0,05$) met een meniscusscheur te hebben. De hoogste positieve likelihood ratio (LR+) was 2.0 voor "leeftijd boven 40". Combinaties van deze determinanten deden de diagnostische waarde licht toenemen echter deze combinaties waren slechts van toepassing op een beperkt aantal patiënten. We concludeerden dat in de huisartspraktijk de anamnese enige diagnostische waarde heeft terwijl lichamelijk onderzoek geen toegevoegde diagnostische waarde heeft bij het vaststellen of er sprake is van een meniscusscheur.

In **hoofdstuk 3** hebben we de diagnostische waarde bepaald van anamnese en lichamelijk onderzoek voor het vaststellen van voorste kruisband letsels in de huisartspraktijk. Van de 134 geïncludeerde patiënten bleken er 28 een gedeeltelijke of complete voorste kruisbandscheur te vertonen op de MRI. "Zwelling", "knappend geluid tijdens trauma", "instabiliteit" en de "voorste schuiflade test" hadden een associatie ($p<0,05$) met een voorste kruisband ruptuur. "Knappend geluid" had de hoogste diagnostische waarde met een sensitiviteit van 0,63, een specificiteit van 0,73, een positief voorspellende waarde van 0,39 en een positieve likelihood ratio (LR+) van 2,3. Combinaties van determinanten uit de anamnese verbeterden de diagnostische waarde enigszins. Toevoeging van de "voorste schuiflade test" aan deze combinaties verhoogde de diagnostische waarde (in bijzonder de LR+) tot 4,2. Geconcludeerd werd dat op basis van anamnese en lichamelijk onderzoek de huisarts kan screenen op voorste kruisband rupturen.

Hoofdstuk 4 rapporteerde over de diagnostische waarde van anamnese en lichamelijk onderzoek bij het vaststellen van mediale collaterale bandletsels. Bij 35 van de 134 geïncludeerde patiënten werd een mediaal collateraal bandletsel aangetroffen op de MRI. Uit de anamnese vertoonden "trauma door een externe kracht op het been" en "rotatietrauma" een associatie ($p<0,05$) met mediaal collateraal bandletsels. Uit het lichamelijk onderzoek gold dat voor "pijn bij valgus stress in 30°" en "laxiteit bij valgus stress in 30°" vertoonde associatie ($p<0,05$). Geïsoleerde determinanten uit zowel de anamnese als het lichamelijk onderzoek vertoonde diagnostische waarde. De positieve likelihood ratio (LR+) van "trauma door een externe kracht op het been" en "pijn bij valgus stress 30°" bedroeg respectievelijk 2,0 en 2,3. In combinatie met "pijn bij valgus stresstest 30°" en "laxiteit bij valgus stresstest 30°" uit het lichamelijk onderzoek verbeterde de diagnostische waarde van de LR+ tot 6.4. Gebaseerd op deze resultaten concluderen wij dat de anamnese diagnostische waarde heeft en dat combineren met lichamelijk onderzoek de diagnostische waarde doet toenemen.

In **hoofdstuk 5** hebben we het beloop van knieletsels bepaald en beschreven we het beleid, geïniteerd door de huisarts gedurende een 1-jaars follow-up. Deelnemers aan onze MRI-studie vulden een vervolgvragenlijst in op 3, 6 en 13 maanden na de start van het onderzoek. Bij de 1-jaars evaluatie rapporteerden 34 van de beschikbare 122 patiënten volledig herstel en 67 patiënten rapporteerden nagenoeg volledig herstel. De resterende 21 patiënten rapporteerden aanhoudende klachten. Totaal 58 patiënten (43%) waren verwezen naar fysiotherapie gedurende de 1-jaars follow-up. Achtentwintig patiënten (21%) waren verwezen naar de tweedelijns gezondheidszorg gedurende de 1-jaars follow-up. In totaal zijn er 18 arthroscopieen uitgevoerd bij 15 patiënten en 1 patiënt onderging een voorste kruisband reconstructie. Op basis van onze resultaten is vastgesteld dat de overgrote meerderheid van patiënten (101 van de 122; 83%) een klinisch relevant herstel rapporteerden.

In **hoofdstuk 6** rapporteren we over de prognostische waarde van anamneses, lichamelijk onderzoek en MRI om voorspellers van aanhoudende klachten te identificeren na een knieletsel. Na 1 jaar rapporteerden 21 van de 122 beschikbare patiënten (17%) aanhoudende klachten. Uit de anamnese vertoonde "leeftijd boven 40" een associatie ($p<0,05$) met aanhoudende klachten (OR 8,0: 95% CI 2.1-30.5). Lichamelijk onderzoek en MRI toonden geen voorspellers met een associatie met aanhoudende klachten.

In **hoofdstuk 7** is het beloop van gerapporteerde en geteste instabiliteit beschreven. Bij de start van het onderzoek had 28% van de 134 patiënten geen instabiliteit, 17% gerapporteerde knie instabiliteit (volgens de Lysholm score), 31% positief geteste knie instabiliteit (volgens de lachman test) en 24% zowel gerapporteerde als geteste knie instabiliteit. Bij de start en na 1 jaar follow-up zijn er geen verschillen gevonden op de MRI tussen de gedefinieerde groepen van knie instabiliteit. Ook de behandeling en het beloop gedurende 1 jaar follow-up vertoonden geen duidelijke verschillen. Na 1 jaar follow-up rapporteerde 13% van de patiënten aanhoudende knie instabiliteit waarvan 33% verklaarde dat

zij klinisch relevant hersteld waren. Van de patiënten met een positieve instabiliteitstest had 31% aanhoudende knie instabiliteit waarvan 77% verklaarde klinisch relevant herstel te zijn na 1 jaar follow-up. We concludeerden dat er geen duidelijke verschillen zijn in beloop, behandeling en MRI bevindingen tussen patiënten zonder instabiliteit en patiënten met gerapporteerde, geteste of zowel gerapporteerde als geteste knie instabiliteit.

In **hoofdstuk 8** bediscussieerden we de belangrijkste bevindingen van onze MRI-studie en de beperkingen van onze resultaten. Implicaties voor de klinische praktijk en vervolgonderzoek zijn ook bediscussieerd. De algemene conclusie is dat de NHG richtlijn voor traumatische knieklachten uit 1998 nog steeds bruikbaar is, met enkele kleine aanpassingen gebaseerd op onze en andere recente studies.

Hoofdstuk 9 vat de belangrijkste bevindingen van onze MRI studie naar knieletsels in de huisartspraktijk samen.

Dankwoord

Een 10-jaren project, dat is dit onderzoek uiteindelijk geworden. De start van dit onderzoek vond plaats in 2002 terwijl de afronding van de studie inclusief het schrijven van de relevante artikelen en dit proefschrift nog meerdere jaren in beslag heeft genomen. En toch is de afronding er nog van gekomen. Het resultaat van alle inspanningen in de afgelopen tien jaar ligt voor u. De laatste loodjes van dit traject vergeleek ik vaak met het lopen van de marathon van Rotterdam: je bent voorbij de 40 km en al zo ver gevorderd maar hebt de finish nog niet bereikt. Met het opdraaien van de Coolsingel is die finish in zicht maar die laatste meters zijn zwaar. Het uiteindelijk bereiken van de finish is niet alleen een verdienste van mij geweest maar zeker ook te danken aan veel andere mensen. In dit dankwoord wil ik hier nog kort bij stil staan.

Allereerst wil ik alle deelnemers aan het onderzoek bedanken. Zonder uw bereidheid om diverse uitgebreide vragenlijsten in te vullen en tot tweemaal een lichamelijk onderzoek en MRI-onderzoek te ondergaan was ik niet in staat geweest de nu beschikbare gegevens te analyseren, conclusies te trekken en de resultaten te verwerken tot de diverse artikelen die de basis van dit proefschrift zijn geworden.

Ook de deelnemende huisartsen uit Brielle, Etten-Leur, Rotterdam-Hillegersberg, Capelle aan de IJssel en Krimpen aan de IJssel en de praktijkassistenten in de deelnemende praktijken wil ik bedanken voor hun bereidheid en inzet om van dit onderzoek een succes te maken.

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Onderdeel van onze studie is een MRI-onderzoek van de knie geweest zowel bij de start van het onderzoek als na één jaar follow-up. Deze MRI-onderzoeken zijn uitgevoerd binnen de afdeling Radiologie van het Medisch Centrum Rijnmond-Zuid. Ik wil de medewerkers van deze afdeling hartelijk danken voor hun bijdrage aan ons onderzoek. In bijzonder wil ik radioloog Simone Boks bedanken voor het ontwikkelen van het beoordelingsformulier en het scoren van de gemaakte MRI-opnames. Ook de MRI laboranten wil ik bedanken voor hun inzet. In bijzonder Ilse en Simone, bedankt voor jullie strak georganiseerde werkwijze. Ik voelde me komend van buiten altijd bijzonder welkom op jullie afdeling.

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Mijn wetenschappelijke interesse is ontkiemd tijdens de jaren dat ik werkzaam ben geweest bij het Fysiotherapeutisch Instituut Voorneveld. Twee oud-collega's wil ik bedanken voor hun bijdrage aan mijn eerste stappen in de wetenschappelijke wereld. Beste Frits, jij hebt mij als voormalig werkgever gestimuleerd en gefaciliteerd om vanuit een baan te gaan studeren in Nijmegen. Hein Bots wil ik bedanken voor zijn inzet en betrokkenheid bij onze gezamenlijke literatuurstudie naar de effecten van immobilisatie op bindweefsel. Beste Hein, jouw bijdrage hieraan heeft mij gestimuleerd om het wetenschappelijk pad verder te gaan verkennen door de studie Gezondheidswetenschappen in Nijmegen op te pakken.

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totstandkoming en uitvoering van dit onderzoek. Daarnaast heb jij de onderzoekslijn 'knieklachten bij adolescenten' binnen de cohortstudie HONEUR afgerond met je eigen promotie. Ik heb je zien groeien. Je was voor menig collega een steun en toeverlaat in de soms wondere wereld van de wetenschap! Daarnaast heb je het vermogen om mij iedere keer weer scherp bij de les te krijgen als ik weer eens de neiging had minder focus op ons onderzoek te hebben. Het bewaren van de balans tussen werk en privé is voor ons beiden een mooie uitdaging. Ik waardeer onze contact zeer en hoop dat nog tot in lengte van jaren met je voort te kunnen zetten.

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Sinds mijn benoeming tot wethouder in Dordrecht in april 2010 is het schipperen geworden met de beschikbare tijd voor het afronden van dit proefschrift. Mede dankzij het begrip en steun van mijn collega's in het college van B&W is het dan nu toch zover gekomen. Beste Arno, als burgemeester ben je niet alleen een (burger)vader voor de stad (en regio) maar zeker ook voor ons college. Je hebt het vermogen om lastige, complexe problemen aan te pakken. En je gaat daarbij bestuurlijke uitdagingen niet uit de weg. Het is een genoegen en voorrecht om met je te mogen werken. Beste Rinette, Piet, Jasper en Bert, ik ben trots op onze behaalde resultaten de afgelopen tweeënhalf jaar en kijk uit naar onze samenwerking de laatste anderhalf jaar van deze collegeperiode. De wijze waarop wij in collegiaal verband onderling de samenwerking zoeken, ook met partners in stad en regio, is de basis waarop we voort kunnen bouwen de komende jaren.

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Curriculum vitae

Harry Wagemakers is geboren op 17 augustus 1960 in Dordrecht. De eerste vier jaar van zijn leven bracht hij door aan boord van het binnenvaartschip van zijn ouders, de André III. Vanaf 1964 is hij opgegroeid op Dubbeldam. Na de gemeentelijke herindeling in 1970 werd Dubbeldam samengevoegd met de gemeente Dordrecht. Na het afronden van achtereenvolgens de MAVO, HAVO en het Atheneum-B aan het Titus Brandsma College in Dordrecht, startte hij in 1981 op de Academie voor Fysiotherapie Rotterdam welke hij in 1985 succesvol afrondde.

In dat zelfde jaar is hij als eerstelijns fysiotherapeut gaan werken bij Fysiotherapeutisch Instituut Voorneveld in Dordrecht. Hier is de latente interesse in wetenschappelijk onderzoek ontwaakt en zijn de eerste stappen in de wetenschappelijke wereld gezet middels een literatuurstudie naar de effecten van immobilisatie op bindweefsel ("Immobilisatie, een kwestie van tijd!"). In 1990 is hij aan Medische Faculteit van de Katholieke Universiteit Nijmegen, Gezondheidswetenschappen gaan studeren. In 1993 legde hij het doctoraal examen met goed gevolg af. De doctoraal scriptie betrof de ontwikkeling en validering van een geïnstrumenteerde valgus-varus laxiteitsmeter voor de knie. Met dit instrument heeft hij een toegepast patiëntonderzoek uitgevoerd naar de effecten van immobilisatie na een knietrauma.

Vanaf 1993 tot 2000 heeft hij als maatschaplid gewerkt in de eerstelijnspraktijk voor fysiotherapie Doornbos in Breda. Daarnaast was hij jarenlang actief als sportfysiotherapeut bij verschillende sportverenigingen en betrokken bij de begeleiding van individuele (top)sporters. Hierbij heeft hij veel acute knieletsels zien ontstaan en sporters begeleidt tijdens de revalidatie al dan niet vooraf gegaan door een operatieve ingreep.

Tussen 2000 en 2010 werkte hij als zelfstandig bedrijfsfysiotherapeut en veiligheidskundige. In februari 2002 is hij gestart met een onderzoek binnen de afdeling Huisartsgeneeskunde van Erasmus MC Rotterdam naar de evaluatie van de NHG-richtlijn "traumatische knieklachten" uit 1998. Dit onderzoek maakte deel uit van een grotere cohortstudie, HONEUR, naar knieklachten in de huisartspraktijk. Naast de subgroep "traumatische knieklachten" bestond deze onderzoekslijn uit de subgroepen "niet-traumatische knieklachten" en "knieklachten bij adolesenten".

Sinds 2007 is hij voorzitter van het Regionaal Genootschap Fysiotherapie Hollands Midden en Rotterdam. In 2006 werd hij raadslid voor de lokale partij Beter voor Dordt. Na de gemeenteraadsverkiezingen van 2010 trad hij namens Beter voor Dordt toe tot het college van Burgemeester en Wethouders (B&W) in Dordrecht met de portefeuille Maatschappelijke Ondersteuning, inclusief (eerstelijns) gezondheidszorg, Duurzaamheid en Recreatie. Sinds 2012 is hij vanuit zijn functie als wethouder ook bestuursvoorzitter van de GGD Zuid Holland Zuid.

Hij is getrouwd geweest met Neline van Gijzen en samen hebben zij een dochter Anne (1998).

Erasmus MC
Universitair Medisch Centrum Rotterdam

PhD Portfolio:

Summery of PhD training and teaching

Name PhD student:	Harry Wagemakers	PhD period:	2002-2012
Erasmus MC Department:	General Practice	Promotors:	S.M.A. Bierma-Zeinstra B.W. Koes

1. PhD training	**Year**	**Workload (Hours/ECTS)**
Specific courses		
- NIHES Diagnostic Research	2005	0.9 ECTS
- NIHES Prognostic Prognostic	2005	0.9 ECTS
Seminars and workshops		
- Workshop Traumatic Knee Disorders General Practice Keele University	2005	16 hours
Presentations		
- Department of Orthopaedics Erasmus MC Diagnosis of meniscal and ligament lesions	2005	24 hours
(Inter)national conferences		
- NHG Scientific Conference Diagnosis of meniscal and ligament lesions	2005	32 hours
- NHG Scientific Conference Course and prognosis of traumatic knee disorders	2008	32 hours
- KNGF Conference Diagnosis of meniscal and ligament lesions	2009	24 hours
- KNGF Conference Course and prognosis of traumatic knee disorders	2009	24 hours
- University of Birmingham (UK) Diagnosis of meniscal and ligament lesions	2008	32 hours
- University of Birmingham (UK) Course and prognosis of traumatic knee disorders	2008	32 hours

2. Teaching	**Year**	**Workload (Hours/ECTS)**
- Training of assistants in HONEUR	2002	32 hours