Can we predict the clinical outcome of arthroscopic partial meniscectomy? - a systematic review

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ABSTRACT

Objective: In order to make a more evidence-based selection of patients who would benefit the most from arthroscopic partial meniscectomy (APM), knowledge of prognostic factors is essential. We conducted a systematic review of predictors for the clinical outcome following APM.

Methods:
Design: Systematic review
Data-sources:Medline, Embase, Cochrane Central Register, Web-of-science, SPORTDiscus, Pubmed Publisher, Google Scholar
Inclusion criteria: report an association between factor(s) and clinical outcome; validated questionnaire; follow-up >1 year
Exclusion criteria: <20 subjects; ACL-deficient patients; discoid menisci; meniscus repair, -transplantation or -implants; total- or open meniscectomy
Data-extraction and analysis: Two reviewers extracted the data, assessed the risk of bias and performed a bestevidence synthesis

Results: Finally, 32 studies met the inclusion criteria. Moderate evidence was found, that the presence of radiological knee-osteoarthritis at baseline and longer duration of symptoms (>1 year) are associated with worse clinical outcome following APM. In addition, resecting more than 50% of meniscal tissue and leaving a non-intact meniscal rim after meniscectomy are intra-articular predictive factors for worse clinical outcome. Moderate evidence was found that sex, onset (acute or chronic), tear type or pre-operative sport level are no predictors for clinical outcome. Conflicting evidence was found for the prognostic value of age, perioperative chondral damage, BMI and leg-alignment.

Conclusion: Long duration of symptoms (>1 year), radiological knee-osteoarthritis and resecting >50% of meniscus are associated with a worse clinical outcome following APM. These prognostic factors should be considered in clinical decision making for patients with meniscal tears.

INTRODUCTION

A meniscal tear is a very common injury, with an incidence of patients visiting an orthopedic trauma department of 24/100.000 per year [1]. The main symptoms are pain, swelling and dysfunction of the knee. A meniscal tear can be the result of a traumatic event or due to degeneration. Both non-operative and operative treatment options are available. Non-operative treatment mainly involves exercise therapy and pain medication, whereas operative treatment of meniscal tears involves either arthroscopic partial meniscectomy (APM) or, in some cases, repair of the torn meniscus if feasible. For many years, APM has been considered the gold standard for torn menisci, for both traumatic and degenerative tears [2,3]. Yearly, over 700.000 APMs are performed in the U.S. [4].

Although it is still one of the most common surgical procedures in many Western countries [5], several recently published high-quality RCTs challenge the indications of APM [4,6-9]. These trials, summarized in a recent systematic review [10], consistently show no benefit of APM compared to physical therapy or sham surgery in patients with degenerative meniscal tears. Furthermore, there is a growing concern that patients who have undergone APM are at increased risk of developing knee osteoarthritis (OA) [2,11].

Taking the results of the earlier mentioned RCTs and the concern about knee OA into account, a more evidence-based approach in patient selection for APM is needed. Instead of considering APM the standard of care, clinicians need to carefully select subgroup of patients with meniscal pathology who would likely benefit from APM. If one can predict the chance of success following APM based on patient characteristics, a more evidence-based patient selection can be made. In order to predict this chance of success, knowledge of prognostic factors is essential.

To the best of our knowledge, no systematic review of prognostic factors for the clinical outcome following APM has been conducted. We systematically reviewed all available literature, to determine the association between certain preoperative and operative variables and clinical outcome following APM. The purpose of this study was to identify prognostic factors for the clinical, patient-reported outcome of APM in patients with a meniscal tear.

METHODS

The reporting in this systematic review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRISMA) statement [12]. This study was registered in the International Prospective Register for Systematic Reviews (Prospero) of the National Institute for Health Research (NHS), no. 42016048592.

Search strategy

A health science librarian of our institution with extensive experience in the conduct of literature searching for systematic reviews assisted in designing and performing the search. We searched in Medline, Embase, Cochrane Central Register, Web of Science, SPORTDiscus, PubMed Publisher, and Google Scholar for relevant articles (date of search: September 16th, 2016). The following main keywords were used: knee, meniscus, meniscal tear, treatment, and meniscectomy (see Supplementary material 1 for complete search). The articles types included in the search were randomized controlled trials and prospective or retrospective cohort studies. There was no date of publication restriction in the search.

Study selection

The inclusion criteria for the present study were: 1) all subjects had to have a meniscal tear, confirmed by MRI (Magnetic Resonance Imaging)/arthroscopy/X-ray with contrast, treated with APM; 2) subjects had to be over 18 years of age; 3) the study had to describe a correlation/association between certain prognostic factor(s) and clinical outcome of APM; 4) a validated patient reported outcome measure had to be used; 5) there had to be a follow-up of at least 12 months; and 6) the article had to be written in English, German, Dutch, French, Spanish, or Swedish. We choose these languages because members of the project group were able to read these.

We excluded studies which; 1) had less than 20 subjects; 2) included patients with ACL-deficiency or with previous ACL-reconstruction; 3) included patients with discoid menisci; 4) included patients undergoing meniscal repair; 5) included meniscus transplantation or meniscus implants; 6) included patients undergoing total meniscectomy; 7) included patients undergoing open meniscectomy; and 8) included additional surgical interventions carried out at arthroscopy.

Two reviewers independently screened all titles and abstracts for eligibility. Disagreements were discussed and resolved by consensus. A third reviewer was asked in case of unsolved disagreement. Duplicate studies were manually removed. Furthermore, reference lists of all selected studies were searched to identify potential missed articles.

Risk of bias

To assess the potential risk of bias, two reviewers independently assessed each study using the Cochrane Collaboration's tool for assessing risk of bias of prognostic studies [13,14]. This scoring list involves eight questions; two questions concerning selection bias, three questions concerning information bias, and two questions concerning confounding. A low risk of bias was defined as 1) ''yes" to at least 70% of the questions (6 out of 8 questions) and 2) at least one time ''yes" in each risk of bias category (selection bias, information bias, confounding). A moderate risk of bias was defined as 1) ''yes" to at least 60% of the questions (5 out of 8 questions) and 2) at least one time ''yes" in two of the risk of bias categories. All other cases were considered as high risk of bias. The two reviewers discussed their findings and asked a third reviewer for consensus, if necessary.

Data extraction

Data regarding study design, level of evidence, number of patients, population characteristics, arthroscopic findings, outcome measurements, results, and associated prognostic factors were extracted by one reviewer, using a standardized form.

Best evidence synthesis

The clinical and methodological homogeneity of the included studies was checked to evaluate whether a meta-analysis would be appropriate. If not, a Best Evidence Synthesis was performed, using the algorithm developed by van Tulder et al. [15-17]. By summarizing findings while taking the weight of the evidence into account in a standardized way, a Best Evidence Synthesis provides conclusions based on the best available evidence. The following ranking of levels of evidence was used: (1) Strong evidence is provided by two or more studies with low risk of bias and by generally consistent findings in all studies (≥75% of the studies reported consistent findings). (2) Moderate evidence is provided by one low risk of bias study and two or more moderate/high risk of bias studies or by two or more moderate/high risk of bias studies and by generally consistent findings in all studies (≥75%). (3) Limited evidence is provided by one or more moderate/high risk of bias studies or one low risk of bias study and by generally consistent findings (≥75%). (4) Conflicting evidence is provided by conflicting findings (<75% of the studies reported consistent findings). (5) No evidence is provided when no studies could be found. Besides overall analysis, subgroup analysis was performed regarding age (under- and above 45 years old).

RESULTS

Search strategy

We identified 5,150 potentially relevant articles: 5,146 by electronic search and 4 by reference tracking. After screening on title and abstract, 159 studies were considered to be potential eligible (See Figure 1). Full text of these studies was assessed, and 32 studies met our inclusion criteria and were included (See Table 1 for study characteristics and main results).

Characteristics of included studies

We included one randomized controlled trial [6], four prospective follow-up studies [18-21], and 27 retrospective studies. Overall, the included studies had allocated 4,250 patients (range 26 [22] – 1090 [23]). The follow-up ranged from 1 [6,19,23,24] to13 [25,26] year. The mean age of patients of the included studies ranged from 19 [26] to 60 [27] years. Most articles included patients

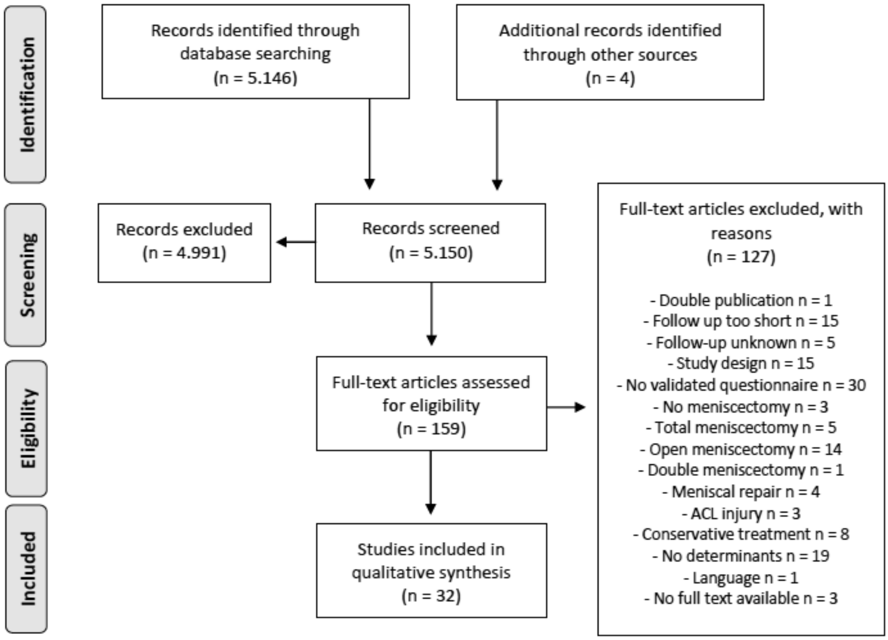

Figure 1. Flow-chart of screening and selection of studies. All steps were conducted according to the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRISMA) statement.

with all types of meniscal tears, however two studies [28,29] only included radial tears, two studies [30,31] only horizontal tears, one study [32] only included root-tears, one study [33] only complex tears, and one study [34] only bucket-handle tears. Five studies excluded patients with a certain degree of chondral damage. Furthermore, 13 studies excluded patients with knee OA (mostly based on radiographs).

Risk of bias of included studies

For two [6,35] of the 32 included studies we found a low risk of bias. For the remaining studies, a moderate to high risk of bias was found. A risk of selection bias was found in 77% of the included studies, a risk of confounding in 94% and a risk of information bias in none of the studies. The agreement between reviewers in the risk of bias assessment was 98%.

Table 1. Study characteristics and main results of included studies

Author, Year of Publication	Study Design	Location: medial/lateral, Type of tear	Sample Size: N	Age: Yr. mean ± SD (range)	Follow-up: Yr. mean ± SD (range)	Female: N (%)	Risk of Bias (type of bias)	Independent variables	Outcome measure	Main conclusions (p-value)
Aune et al, 1995 [18]	Prospective cohort	Medial, all tear types	93	Median 45 (12-75)	3.5, SD: NM (2.1-4.2)	28 (30)	High (Sel., Conf.)	Chondral damage	Lysholm	Chondral damage: worse outcome ($p < 0.04$)
Bin et al, 2004 [19]	Retrospective cohort	Medial posterior horn, radial tears	85 (96 knees)	56, SD: NM (31-77)	2.3, SD: NM (1-4.3)	70 (73)	High (Sel., Conf.)	Tear depth	Lysholm	NS ($p > 0.05$)
Bin et al, 2008 [20]	Retrospective cohort	Medial, all tears	68	63, SD: NM (51-77)	4.3, SD: NM (3.1-6.9)	63 (93)	High (Sel., Conf.)	Location of chondral damage	Lysholm, VAS	NS ($p = 0.16$)
Bolano et al, 1993 [21]	Retrospective cohort	Medial and lateral, all tears	50	30, SD and range: NM	5.6, SD and range: NM	5 (10)	Moderate (Conf.)	Age, sex, duration of symptoms (</> 12 months), tear location/-type, chondral damage	Lysholm, Tegner	Higher age, long duration of symptoms, horizontal/ complex tear and chondral damage: worse outcome ($p < 0.05$) Sex, tear location: NS (p-value NM)
Bonneux et al, 2002 [22]	Retrospective cohort	Lateral, all tears	29 (31 knees)	25, SD and range: NM	8 ± 1.5 (range NM)	9 (36)	High (Sel., Conf.)	Sex, BMI, traumatic/non-traumatic, sport level, amount of resected tissue (subtotal/ limited)	IKDC, Lysholm	Larger amount of resected tissue (subtotal, >50%): worse outcome ($p = 0.02$) Sex, BMI, traumatic /non-traumatic, sport level: NS (p = 0.3, 0.4, 0.2, 0.4 resp.)
Chatain et al, 2003 [23]	Retrospective cohort	Medial and lateral, all tears	471	37 ± 12 (13-70)	11 ± 1.3 (10-15)	99 (21)	High (Sel., Conf.)	Age, sex, BMI, sport level, leg alignment, tear location (medial /lateral), tear type, chondral damage, amount of resected tissue (rim involved yes or no)	IKDC	Larger amount of resected tissue (rim involved): worse outcome ($p = 0.004$) Age, sex, BMI, sport level, leg alignment, tear location, -type, chondral damage: NS ($p \geq 0.05$)

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Author, Year of Publication	Study Design	Location: medial/lateral, Type of tear	Sample Size: N	Age: Yr. mean ± SD (range)	Follow-up: Yr. mean ± SD (range)	Female: N (%)	Risk of Bias (type of bias)	Independent variables	Outcome measure	Main conclusions (p-value)
Covall et al. 1992 [24]	Retrospective cohort	Medial and lateral, all tears	46 (56 knees)	57, SD: NM (45-72)	5.4 ± 1.3 (3-8)	6 (11)	High (Sel., Conf.)	Leg alignment, radiological knee OA	Modified Lysholm, Tegner	Radiological knee OA: worse outcome ($p < 0.05$) Valgus leg alignment: better outcome ($p < 0.001$)
Erdil et al, 2013 [25]	Retrospective cohort	Medial and lateral, all tears	1090	43, SD: NM (18-50)	1, SD and range: NM	423 (35)	Moderate (Conf.)	Sex, BMI, side of knee (left/right), tear type	IKDC, Lysholm, Oxford	Higher BMI: worse outcome ($p < 0.001$) Sex, side of knee, tear type: NS ($p = 0.88$ for sex, p-value for the others NM
Fauno et al, 1993 [26]	Retrospective cohort	Medial and lateral, all tears	88	30, SD: NM (13-62)	8.6 SD: NM (8-11.6)	24 (27)	Moderate (Conf.)	Age, sex, sport level, sport type, tear type, chondral damage	Lysholm	Higher age, ball sports, flap-tears: worse outcome ($p = 0.002$, 0.0001, 0.004 resp.) Sex, sport level, chondral damage: NS (p-value NM)
Ghislain et al, 2016 [27]	Retrospective cohort	Medial and lateral, all tears	117	47 ± 9 (18-72)	4 ± 0.3 (range NM)	69 (59)	High, (Sel., Conf.)	Traumatic/non-traumatic	Lysholm, SF-36	Non-traumatic: worse outcome ($p < 0.0001$)
Han et al, 2010 [28]	Retrospective cohort	Medial posterior horn, root tears	46	59, SD: NM (48-85)	6.5, SD: NM (5-8.6)	36 (78)	High, (Sel., Conf.)	Radiological knee OA, chondral damage	Lysholm	Radiological knee OA, chondral damage: worse outcome ($p =$ 0.004, 0.002 resp.)
Haviv et al, 2015 [29]	Retrospective cohort	Medial, complex tears	135	51, SD: NM (20-80)	2, SD and range: NM	49 (36)	High, (Sel., Conf.)	BMI, chondral damage	Lysholm, VAS	Chondral damage: worse outcome in women ($p = 0.05$) Higher BMI: worse outcome in men ($p = 0.02$)
Haviv et al, 2016 [30]	Prospective cohort	Medial and lateral, all tears	201	44 ± 15 (range NM)	1 ± 0.3 (range NM)	68 (34)	High, (Sel., Conf.)	Age, sex, chondral damage	Lysholm, Tegner	Older age, female, chondral damage: worse outcome ($p <$ 0.0001)
Haviv et al, 2016 [31]	Retrospective cohort	Medial and lateral, all tears	86	48 ± 13 (range NM)	1 ± 0.3 (range NM)	24 (28)	High, (Sel., Conf.)	Traumatic/non-traumatic	Lysholm, Tegner	Traumatic/non-traumatic: NS ($p = 0.24$)

Table 1. Study characteristics and main results of included studies

Author, Year of Publication	Study Design	Location: medial/lateral, Type of tear	Sample Size: N	Age: Yr. mean ± SD (range)	Follow-up: Yr. mean ± SD (range)	Female: N (%)	Risk of Bias (type of bias)	Independent variables	Outcome measure	Main conclusions (p-value)
Haviv et al, 2016 [32]	Retrospective cohort	Medial and lateral, all tears	187	46 ± 15 (range NM)	1 ± 0.3 (range NM)	51 (27)	High, (Sel., Conf.)	Duration of symptoms	Lysholm	Longer duration of symptoms: worse outcome (p = 0.01)
Hoser et al, 2001 [33]	Retrospective cohort	Lateral, all tears	29 (31 knees)	44 ± 13 (range NM)	10.3 ± 0.6 (9.2-12.1)	5 (17)	High, (Sel., Conf.)	Amount of resected tissue	Lysholm	Amount of resected tissue: NS (p-value NM)
Hulet et al, 2001 [34]	Retrospective cohort	Medial, all tears	57 (74 knees)	36 ± 11 (range NM)	12 ± 1 (range NM)	11 (19)	High, (Sel., Conf.)	Age, sex, traumatic/non-traumatic, activity, tear type, chondral damage	IKDC	Age, sex, traumatic/non-traumatic, activity, tear type, chondral damage: NS (p-value NM)
Hulet et al, 2015[35]	Retrospective cohort	Lateral, all tears	89	35 ± 13 (range NM)	22 ± 3 (range NM)	33 (37)	High, (Sel., Conf.)	Sex, tear type, amount of resected tissue	IKDC, KOOS	Larger amount of resected tissue: worse outcome (p-value NM) Sex, tear type: NS (p-value NM)
Jaureguito et al, 1995 [36]	Retrospective cohort	Lateral, all tears	26 (27 knees)	30, SD: NM (14-57)	8, SD: NM (5.5-11.3)	N.m.	High, (Sel., Conf.)	Age, leg alignment, tear type	Lysholm	Leg alignment, tear type, age: NS (p = 0.83, 0.45, NM resp.)
Kim et al, 2013 [37]	Retrospective cohort	Medial and lateral, horizontal tears	40	34, SD: NM (16-40)	2, SD and range: NM	24 (60)	Moderate (Conf.)	Traumatic/non-traumatic	IKDC, Lysholm	Traumatic/non-traumatic: N.S. (p = 0.41)
Kim et al, 2014 [38]	Retrospective cohort	Medial and lateral, all tears	312	41, SD: NM (13-62)	5, SD and range: NM	120 (38)	High (Sel., Conf.)	Amount of resected tissue (vertical resection/horizontal resection/subtotal	IKDC	Larger amount of resected tissue (subtotal): worse outcome (p < 0.001)
Kim et al, 2016 [39]	Retrospective cohort	Medial, horizontal tears	98 (100 knees)	40 ± 8 (range NM)	1.5 ± 1.5 range NM)	21 (21)	High (Sel., Conf.)	Tear type (direction)	IKDC, Tegner	Tear type: NS (p-value NM)

Table 1. Study characteristics and main results of included studies

Author, Year of Publication	Study Design	Location: medial/lateral, Type of tear	Sample Size: N	Age: Yr. mean ± SD (range)	Follow-up: Yr. mean ± SD (range)	Female: N (%)	Risk of Bias (type of bias)	Independent variables	Outcome measure	Main conclusions (p-value)
Maletius et al, 1996 [40]	Retrospective cohort	Medial and lateral, all tears	40	29, SD: NM (18-40)	13, SD: NM (12-15)	8 (20)	Low	Age, chondral damage	Lysholm, Tegner	Higher age: worse outcome ($p = 0.03$) Chondral damage: NS (p-value NM)
Menetrey et al, 2002 [41]	Retrospective cohort	Medial, all tears	32	60, SD: NM (51-74)	6, SD: NM (3-7)	11 (34)	High (Sel., Conf.)	Traumatic/non-traumatic	HSS Knee Score	Non-traumatic: worse outcome ($p = 0.009$)
Ozkoc et al, 2008 [42]	Retrospective cohort	Medial, radial root tears	67	56, SD: NM (38-70)	4.8, SD and range: NM	47 (70)	High (Sel., Conf.)	BMI	Lysholm	BMI: NS ($p > 0.01$)
Rockborn et al, 1995 [43]	Retrospective cohort	Medial and lateral, all tears	43	19, SD: NM (15-22)	13, SD: NM (11-15)	6 (14)	Moderate (Conf.)	Amount of resected tissue (partial/ subtotal)	Lysholm, Tegner	Larger amount of resected tissue (subtotal): worse outcome ($p = 0.02$)
Rosenberger et al, 2010 [44]	Prospective cohort	Medial and lateral, all tears	180	48, SD: NM (17-78)	1, SD and range: NM	79 (44)	High (Sel., Conf.)	Age, sex, BMI, activity, fitness, prior injury, chondral damage	Lysholm, Tegner	Female, lower fitness, prior injury, chondral damage: worse outcome ($p = 0.0001, 0.033, 0.002, 0.028$ resp.) Age, BMI, activity: NS ($p = 0.32, 0.20, 0.42$ resp.)
Scanzello et al, 2013 [45]	Prospective cohort	Medial and lateral, all tears	33	Median 45 (IQR 40-53)	2, SD and range: NM	12 (36)	High (Sel., Conf.)	Synovial inflammation	Lysholm	Synovial inflammation: NS ($p = 0.14$)
Scheller et al, 2001 [46]	Retrospective cohort	Lateral, all tears	75	41, SD and range: NM	9.5, SD: NM (5-15)	32 (42)	High, (Sel., Conf.)	Age, BMI, traumatic/non-traumatic, tear type	Lysholm	Higher age and higher BMI: worse outcome (p-value NM) Traumatic/non-traumatic, tear type: NS (p-value NM)
Shelbourne et al, 2006 [47]	Retrospective cohort	Medial, bucket-handle tears	79	29 ± 11 (13-57)	11.8 ± 6.9 (3-22)	4 (5)	High (Sel., Conf.)	Age	IKDC	Age: NS ($R^2 = -0.33$)

Table 1. Study characteristics and main results of included studies

Author, Year of Publication	Study Design	Location: medial/lateral, Type of tear	Sample Size: N	Age: Yr. mean ± SD (range)	Follow-up: Yr. mean ± SD (range)	Female: N (%)	Risk of Bias (type of bias)	Independent variables	Outcome measure	Main conclusions (p-value)
Sihvonen et al 2013 [6]	Prospective randomized controlled trial	Medial, all tears	146	52 ± 7 (range NM)	1	57 (39)	Low	Traumatic/non-traumatic	Lysholm, WOMET	Traumatic/non-traumatic: NS (p-value NM)
Yilar et al, 2014 [48]	Retrospective cohort	Medial and lateral, all tears	90	58 ± 9 (38-82)	12, SD and range: NM	64 (71)	High, (Sel., Conf.)	Age, sex, BMI (BMI <25/25-29/>29)	Lysholm, WOMAC	Higher BMI (>29): worse outcome ($p < 0.0001$) Age, sex: NS (p-value NM)

Abbreviations: NS = no statistically significant difference found. NM = not mentioned. Sel. = Selection bias, Conf. = Confounding. IQR = Inter-Quartile Range. IKDC = International Knee Documentation Committee. KOOS = Knee injury and Osteoarthritis Outcome Score. VAS = Visual Analogue Scale. HSS Knee Score = Hospital for Special Surgery Knee Score. SF-36 = Short Form health survey. WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index. WOMET = Western Ontario Meniscal Evaluation Tool

Heterogeneity

A significant amount of variety was found between included studies regarding study-population, the definition of subgroups, and outcome measures. Furthermore, clinical outcomes of individual subgroups were often inadequately described or lacking completely. Taking the considerable heterogeneity and lacking subgroup-outcomes into account, pooling data and conducting a meta-analysis was not appropriate. Hence, qualitative analyses were performed, according to the Best Evidence Synthesis principle.

Prognostic factors

In total, 13 different prognostic factors were identified and shown to be associated with clinical outcome following APM. Table 2 shows an overview of prognostic factors, which are described in at least two studies.

1) MODERATE EVIDENCE

Prognostic factors:

Duration of symptoms

Two studies [36,37] evaluated the duration of symptoms in the context of clinical outcome. In one study [36] acute (symptoms existing less than 12 months) and chronic (symptoms existing more than 12 months) lesions are distinguished, one study [37] defined a duration of three months or less as ''short'', and longer than three months as ''long'''. Both studies concluded that a shorter duration of symptoms is statistically significantly associated with better patient reported outcome measures.

Radiological knee OA at baseline

Two studies [38,39] described the presence of radiological knee OA and its association with clinical outcome of APM. In one study [39], patients with no sign of knee OA (Kellgren and Lawrence [40] grade 0) and patients with mild to moderate knee OA (Kellgren and Lawrence grade 1-2) were included. One study [38], also included patients with severe knee OA (Fairbank [41] grade > 2). Both studies reported a statistically significant smaller improvement of Lysholm knee scores in patients with radiological knee OA at baseline.

Amount of resected meniscal tissue

Six studies assessed the relationship between the amount of resected tissue during APM and clinical outcome. Five out of six studies reported a positive association between the amount of resected meniscal tissue and decreased patient reported outcome measures. In two studies [26,42], a ''subtotal'' procedure (more than 50% resected, leaving a small rim of meniscal tissue) was found to result in worse clinical outcome than a ''partial'' procedure (less

Table 2. Infuence of determinants on worse clinical outcome after APM

Group	Determinants	No. of studies	Associated with worse outcome LR/MR/HR: n studies	No significant relationship LR/MR/HR: n studies	Best-evidence-synthesis
Patient-related factors	Older age at baseline	11	LR: 1[40] MR: 2[21 26] HR: 2[30 46]	HR: 6[23 34 44 48 50]	Conflicting Evidence
	Female sex	10	HR: 2[30 44]	MR: 3[21 25 26] HR: 5[22 23 34 35 48]	Moderate Evidence
	Higher BMI	7	MR: 1[25] HR: 3[29 46 48]	HR: 3[22 42 44]	Conflicting Evidence
	Longer duration of symptoms	2	MR: 2[21] HR: 1[32]		Moderate Evidence
	Non-traumatic onset	8	HR: 2[27 41]	LR: 1[6] MR: 1[37] HR: 4[22 31 34 46]	Moderate Evidence
	Lower pre-operative sport level	4		MR: 1[26] HR: 3[22 23 44]	Moderate Evidence
	Leg malalignment	3	HR: 1[24]	HR: 2[23 50]	Conflicting Evidence
Intra-articular factors	Type of meniscal tear	9	Deg/ complex tear: MR: 1[21] Flap tear: MR: 1[26]	HR: 7[23 25 34 35 39 46 50]	Moderate Evidence
	Radiological knee OA at baseline	2	HR: 2[24 28]		Moderate Evidence
	Chondral damage during arthroscopy	10	MR: 1[21] HR: 5[28-30 44 53]	LR: 1[40] MR: 1[26] HR: 2[23 34]	Conflicting Evidence
	Resecting more tissue	6	MR: 2[38 43] HR: 3[22 23 35]	HR: 1[33]	Moderate Evidence

Abbreviations: APM = arthroscopic partial meniscectomy, LR = Low Risk of Bias, MR = Moderate Risk of Bias, HR = High Risk of Bias, OA = osteoarthritis, deg = degenerative, BMI = body mass index

than 50% of meniscal tissue resected). Other studies described the absence of the meniscal rim [43] or a preserved meniscal width of less than 3 mm [44] as a predictor for worse clinical outcome. In one study [45], the method for measuring the influence of this factor on clinical outcome was not further described. One study [46], which investigated the influence of the percentage of removed tissue in 31 knees with lateral meniscal tears, found no association with post-operative Lysholm scores.

Not prognostic factors:

Sex

The influence of sex on outcome after APM was assessed in ten articles. Eight of them reported no statistically significant association between sex and outcome. Two studies [19,21] reported a worse outcome for women.

Traumatic versus degenerative tear

The influence of onset, i.e. traumatic versus degenerative, on outcome after APM was assessed in eight articles and seemed not to be a predictor for clinical outcome. Two studies [27,47] reported a worse outcome for degenerative tears, based on arthroscopic findings. However, six studies reported no statistically significant correlation.

Pre-operative sport level

In four studies preoperative sport level was assessed. Two studies [42,43] distinguished a recreational and competitive sport level, one study [19] measured the hours of exercise per week and one study [48] did not further specify study groups. None of the articles found a correlation between sport level and outcome of APM.

Type of meniscal tear

In nine studies the association between the type of meniscal tear and clinical outcome was assessed. Eight of them found no association, whereas one study [36] reported a worse outcome for complex and for degenerative tears. None of the studies described a classification system used for the type of meniscal tears. Furthermore, a large variety among studies was found regarding the definition of subgroups (types of meniscal tears). The amount of subgroups ranged from two [36,48] to five [23].

2) LIMITED EVIDENCE

An association between the location of the tear (medial versus lateral meniscus) and clinical outcome of APM was only described in one of our included studies [43]; in this study no statistically significant difference was found between medial and lateral APMs. Regarding the side of knee [23], the location of chondral damage [49] and perioperative synovial inflammation [20], no correlation with clinical outcome was found as well. Furthermore, one of the included studies [19] assessed the predictive value of self-reported fitness at baseline and prior knee surgery and found a worse Lysholm score one year after APM for women with lower self-reported fitness.

For men, no influence was found of self-reported fitness on clinical outcome. Prior knee injury resulted in a lower Lysholm after APM in women, in men however no such association was found.

3) CONFLICTING EVIDENCE

Age at baseline

The influence of age on clinical outcome following APM was investigated in 11 studies. In two studies [25,48], patients were divided into two groups; under 30 years old and above 30 years old. One article [36] divided patients in a group under and above 40 years. In the remaining studies, the method for defining age subgroups was not specified. Five studies found a worse clinical outcome for older patients, and six studies did not find a statistically significant association.

Body Mass Index

Seven studies described the association between Body Mass Index (BMI) and clinical outcome. Four of them reported a worse Lysholm score for overweight or obese patients. The remaining studies found no association between BMI and clinical outcome. When we looked at studies with patients above 45 years old, we found evidence for the fact that there is no association between BMI and clinical outcome of APM.

Leg malalignment

The predictive value of leg malalignment was described in three studies. One of them [38] reported a statistical significantly worse Modified Lysholm score for patients with a valgus malalignment (tibiofemoral angle more than 4 degrees on anteroposterior full leg radiograph). However, two studies [22,43] found no significant association between leg malalignment and outcome.

Chondral damage during arthroscopy

Ten studies investigated the association between chondral damage found during surgery and clinical outcome. Three of them used the Outerbridge [50] classification, two of them the ICRS (International Cartilage Repair Society [51]) classification, and the remaining studies only mentioned whether chondral damage was found during arthroscopy or not. Six out of ten studies reported that the presence of chondral damage predicted a worse clinical outcome, and four studies did not find such an association. The relationship between chondral damage and clinical outcome seems to be driven by age; when we looked at studies with patients above 45 years old (n = 4), all studies reported a worse outcome for patients with chondral damage during arthroscopy. Looking at studies with patients below 45 years old (n = 6), almost all studies reported no association between chondral damage and outcome. Furthermore, when specifically looking at medial meniscal tears, chondral damage seems to be a prognostic factor for worse outcome as well.

DISCUSSION

Despite the extensive heterogeneity in study design, in the definition of subgroups and in outcome measurements, several prognostic factors were found for the clinical outcome after APM. We found moderate evidence that a larger amount of resected tissue, the presence of radiological knee OA at baseline, and a longer duration of complaints are associated with a worse clinical outcome following APM. Sex, the preoperative sport level, onset (traumatic versus degenerative), and the type of meniscal tear do not seem to influence clinical outcome. It should be noted that, the phrasing ''worse outcome" does not necessarily mean that the outcome is unsatisfactory. It means that, having a specific factor is associated with a worse patient-reported outcome compared to not having this specific factor.

To the best of our knowledge, this is the first systematic review that focuses specifically on predictors for the clinical outcome following APM. Salata and colleagues [52] conducted a systematic review in 2010 on the radiological and clinical outcome in patients undergoing meniscectomy. The authors primarily assessed outcome measurements of APM in general, but also described some features which might influence this outcome. One of their outcomes was, that degenerative meniscal tears are statistically significant associated with a negative postoperative outcome. This is a very relevant finding, as most APMs are performed in middle-aged and elderly patients, who typically have degenerative meniscal tears [5,53-55]. The findings of Salata are in concordance with Englund et al. [56], who found that degenerative meniscal tears result in worse clinical and radiological outcome after 16 years in 155 patients undergoing APM. By contrast, a recently published and methodologically robust study of Thorlund et al. [57]. reported no clinically relevant difference in patient reported knee function and –satisfaction between degenerative and traumatic meniscal tears after 12 months. This is in line with the results of the current systematic review, in which no difference in patient reported clinical outcome between degenerative and traumatic tears was found as well. Thus, the predictive value of degenerative versus traumatic meniscal tears for the clinical outcome following APM is questionable and needs to be further unraveled.

A factor that does seem to influence clinical outcome following APM, is the duration of symptoms. Although a short duration of symptoms (less than six weeks) is one of the clinical variables that orthopedic surgeons consider to be important in surgical decision making [58], robust evidence regarding the impact of timing awaiting for APM on clinical outcome is scarce. The fact that there is no standard definition of ''acute" and ''chronic" symptoms causes a substantial amount of heterogeneity between studies, which makes them difficult to compare. Nonetheless, in the present systematic review, moderate evidence was found that a longer duration of symptoms (longer than 3-12 months) is associated with a worse clinical outcome following APM.

A third key-finding concerns the amount of resected meniscal tissue during arthroscopy, which appeared to be a relevant factor in predicting the clinical outcome following APM. This is not surprising, given the critical biomechanical role of the meniscus within the knee joint [59]. Our study suggests that the amount of resected meniscal tissue is negatively associated with postoperative clinical outcome following APM, in concordance with Englund [56] and Salata [52]. More specifically, resecting more than 50% of meniscal tissue, leaving less than 3 mm meniscal width and impairing the peripheral third (the meniscal rim) were found to be associated with worse clinical outcome. In conclusion, resecting more meniscal tissue is associated with worse clinical outcome after APM.

Whereas no association was found between degenerative meniscal tears (compared to traumatic tears) and a worse clinical outcome following APM, our study does show that radiological knee OA at baseline is associated with a worse clinical outcome. This is in line with the results of Kirkley and colleagues [60], showing that arthroscopic surgery for patients suffering knee OA, may not lead to satisfactory outcomes. The interesting thing is that a degenerative meniscal tear, as described earlier, does not seem to be associated with a worse clinical outcome following APM. As degenerative meniscal tears are often considered to be a signifying feature of incipient knee OA [61-63], one might expect that this type of tear, compared to traumatic meniscal tears, has a negative association with clinical outcome as well. Further investigation into this topic, for example using novel imaging techniques which provide quantitative information regarding the degree of meniscal degeneration [64], is desired.

Another relevant knee-specific factor that we studied, is chondral damage during surgery. Symptomatic degenerative meniscal tears are frequently associated with cartilage damage to the corresponding articular surfaces [65,66]. In the current systematic review, conflicting evidence was found for the predictive value of chondral damage on clinical outcome after APM.. However, subgroup analysis showed that, when looking at the studies in patients with a mean age of < 45 years, no association was found between chondral damage and outcome. For the studies in patients with a mean age of > 45 years, we did find that chondral damage at time of surgery is associated with a worse clinical outcome. A study by Sofu et al. [67], in which patients above 60 years old with traumatic meniscal tears were included, reported worse pain scores for patients with chondral damage as well. Thus, it is likely that chondral damage in patients aged above 45 years has a negative influence on clinical outcome following APM, however this association needs to be further investigated.

Another factor that could potential be of influence on clinical outcome, is whether the tear is located in the lateral- or the medial meniscus. However, this factor was studied in only one of the included publications, which did not find an association. As a potential prognostic factor needs to be described in at least two studies, according to the Best Evidence Syntheses principle, no conclusions regarding the predictive value of medial versus lateral meniscectomies can be drawn. This factor is particularly relevant as in literature, lateral meniscectomy has been reported to result in poorer postoperative outcome than medial meniscectomy [52,68-70]. A hypothesis is that the lateral meniscus is ‘’less conforming” than the medial meniscus after meniscectomy, resulting in an increased amount of instability and resultant force transmission to the articular cartilage. By all means, the predictive value of this factor too warrants further investigation.

A major strength of the present study is that we performed an extensive search in all relevant databases by aid of an experienced biomedical information specialist of the medical library of our institution. Furthermore, all steps in this systematic review were performed in duplo and acknowledged tools for the assessment of the risk of bias and data extraction were used. A limitation of our systematic review is that, despite the large amount of found publications, relatively few studies could be included in this systematic review. This is a consequence of our selection strategy, involving extensive exclusion criteria. To increase the a priori chance of acquiring reliable and comparable results (and potential conduct a meta-analysis) we defined concrete, well justified and clearly stated eligibility criteria. For example, we only included articles using validated questionnaires, such as the Lysholm- or IKDC (*International Knee Documentation Committee*[71]) score. Publications using outcome measures such as ‘’percentage of satisfied patients” were therefore excluded. The rationale of this exclusion criterion is the relatively low reliability and reproducibility of non-validated patient reported outcome measurements. Although we might have missed information about prognostic factors, we believe that this approach increased the reliability of our results.

Another limitation of this systematic review is, that only rough estimations of the effect size of the found prognostic factors could be provided. This is due to the fact that a substantial amount of heterogeneity in the definition of subgroups and outcome measurements was found. For example, the potential influence of the type of meniscal tear on clinical outcome following APM was reported in nine studies, however none of them described a classification system for the type of tear. In fact, six of them did not provide any information regarding the definition of meniscal tear subgroups at all. Also, in many of the included studies the outcome of subgroups was poorly described. Often only P values were reported; some studies did not even provide a P value but only described the prognostic value of a specific factor (e.g. ‘’No significant correlation was found between the amount of tissue resected and the subjective, clinical and radiological outcome” [46]). Given the found heterogeneity and inadequately described subgroup results, pooling of study results and performing a meta-analysis were not justified. This implied that small studies might not have reported an association based on lower power while pooled results the reported association would have counted in the overall estimation for the association.

Despite the high amount of APMs performed worldwide, there is a lack of consensus on the indications for this procedure, particularly in younger and middle-aged patients. To enable a more evidence-based approach in surgical decision making, knowledge of the predictive value of certain patient-specific factors for the clinical outcome is essential. In this comprehensive systematic review, prognostic factors for the patient-reported outcome of APM were assessed. We have shown that, based on the best available evidence, radiographic knee OA at baseline, a long duration of complaints, and resecting more meniscal tissue during arthroscopy are associated with a worse postoperative clinical outcome. The findings could contribute to the development of a prediction model for the clinical outcome of APM, based on patient-specific factors, which could guide orthopedic surgeons in their clinical decision making. However, within the available literature, the earlier mentioned heterogeneity and inadequately reported subgroup outcomes make it challenging to draw adequate conclusions. Therefore, there is an urgent need for more well-designed, robust clinical trials on arthroscopic meniscal surgery using validated patient reported outcome measurements and with relevant, a priori defined subgroups.

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SUPPLEMENTARY MATERIAL 1: COMPLETE SEARCH

Database:	Original hits:	Without duplicates:
Embase.com	3630	3554
Medline (OvidSP)	3179	806
Web-of-science	1231	363
Cochrane	181	3
SPORTDiscus (Ebsco)	620	79
Google Scholar	200	59
Total	9041	4864

Embase.com:

('knee meniscus rupture'/de OR ('knee meniscus'/de AND (rupture/exp OR 'knee injury'/exp)) OR meniscectomy/de OR ((menisc* NEAR/6 (tear* OR rupture* OR injur* OR lesion* OR damage* OR trauma* OR torn)) OR meniscopath* OR meniscectom*):ab,ti) AND (therapy/exp OR 'treatment outcome'/exp OR exercise/exp OR surgery/exp OR arthroscopy OR rehabilitation/exp OR therapy:lnk OR rehabilitation:lnk OR surgery:lnk OR (therap* OR treat* OR conservativ* OR physiotherap* OR kinesiotherap* OR kinesitherap* OR exercise* OR surg* OR nonsurg* OR postsurg* OR meniscectom* OR remov* OR resect* OR operati* OR postoperati* OR nonoperati* OR rehabilitat*):ab,ti) AND (prognosis/de OR 'follow up'/de OR 'cohort analysis'/de OR 'longitudinal study'/de OR 'retrospective study'/de OR 'prospective study'/de OR (prognos* OR 'follow up' OR followup OR cohort* OR longitudinal OR retrospective OR prospective OR 'long term' OR 'medium term' OR 'late results'):ab,ti) NOT ([animals]/lim NOT [humans]/lim)

Medline (OvidSP):

(Menisci, Tibial/in OR ("Menisci, Tibial"/ AND (rupture/ OR "Knee Injuries"/)) OR ((menisc* ADJ6 (tear* OR rupture* OR injur* OR lesion* OR damage* OR trauma* OR torn)) OR meniscopath* OR meniscectom* OR arthroscopy).ab,ti.) AND (exp therapeutics/ OR exp "treatment outcome"/ OR exp exercise/ OR exp "Surgical Procedures, Operative"/ OR exp rehabilitation/ OR rehabilitation.xs. OR therapy.xs. OR surgery.xs. OR (therap* OR treat* OR conservativ* OR physiotherap* OR kinesiotherap* OR kinesitherap* OR exercise* OR surg* OR nonsurg* OR postsurg* OR meniscectom* OR remov* OR resect* OR operati* OR postoperati* OR nonoperati* OR rehabilitat*).ab,ti.) AND (prognosis/ OR exp "cohort studies"/ OR (prognos* OR "follow up" OR followup OR cohort* OR longitudinal OR retrospective OR prospective OR "long term" OR "medium term" OR "late results").ab,ti.) NOT (exp animals/ NOT humans/)

Cochrane:

(((menisc* NEAR/6 (tear* OR rupture* OR injur* OR lesion* OR damage* OR trauma* OR torn)) OR meniscopath* OR meniscectom*):ab,ti) AND ((therap* OR treat* OR conservativ* OR physiotherap* OR kinesiotherap* OR kinesitherap* OR exercise* OR surg* OR arthroscopy OR nonsurg* OR postsurg* OR meniscectom* OR remov* OR resect* OR operati* OR postoperati* OR nonoperati* OR rehabilitat*):ab,ti) AND ((prognos* OR 'follow up' OR followup OR cohort* OR longitudinal OR retrospective OR prospective OR 'long term' OR 'medium term' OR 'late results'):ab,ti)

Web-of-science:

TS=((((menisc* NEAR/6 (tear* OR rupture* OR injur* OR lesion* OR damage* OR trauma* OR torn)) OR meniscopath* OR meniscectom*)) AND ((therap* OR treat* OR conservativ* OR physiotherap* OR kinesiotherap* OR kinesitherap* OR exercise* OR surg* OR arthroscopy OR nonsurg* OR postsurg* OR meniscectom* OR remov* OR resect* OR operati* OR postoperati* OR nonoperati* OR rehabilitat*)) AND ((prognos* OR "follow up" OR followup OR cohort* OR longitudinal OR retrospective OR prospective OR "long term" OR "medium term" OR "late results")) NOT ((animal* OR rabbit* OR mouse OR mice OR rat OR rats OR canine OR dog OR dogs OR sheep OR cat OR cats OR horse* OR bovine OR goat* OR porcine* OR pig OR swine) NOT (human* OR patient*)))

SPORTDiscus (Ebsco):

(DE "meniscus (Anatomy) - Wounds & injuries" OR ((menisc* N6 (tear* OR rupture* OR injur* OR lesion* OR damage* OR trauma* OR torn)) OR meniscopath* OR meniscectom*)) AND (DE therapeutics+ OR DE "treatment outcomes+" OR DE exercise+ OR DE "OPERATIVE surgery+" OR DE rehabilitation+ OR (therap* OR treat* OR conservativ* OR physiotherap* OR kinesiotherap* OR kinesitherap* OR exercise* OR surg* OR arthroscopy OR nonsurg* OR postsurg* OR meniscectom* OR remov* OR resect* OR operati* OR postoperati* OR nonoperati* OR rehabilitat*)) AND (DE "cohort analysis+" OR (prognos* OR "follow up" OR followup OR cohort* OR longitudinal OR retrospective OR prospective OR "long term" OR "medium term" OR "late results")) NOT (DE animals+ NOT DE humans)

PubMed publisher:

(((menisc*[tiab] AND (tear*[tiab] OR rupture*[tiab] OR injur*[tiab] OR lesion*[tiab] OR damage*[tiab] OR trauma*[tiab] OR torn)) OR meniscopath*[tiab] OR meniscectom*[tiab])) AND ((therap*[tiab] OR treat*[tiab] OR conservativ*[tiab] OR physiotherap*[tiab] OR kinesiotherap*[tiab] OR kinesitherap*[tiab] OR exercise*[tiab] OR arthroscopy OR surg*[tiab] OR nonsurg*[tiab] OR postsurg*[tiab] OR meniscectom*[tiab] OR remov*[tiab] OR resect*[tiab] OR operati*[tiab] OR postoperati*[tiab] OR nonoperati*[tiab] OR rehabilitat*[tiab])) AND ((prognos*[tiab] OR follow up*[tiab] OR followup[tiab] OR cohort*[tiab] OR longitudinal[tiab]

OR retrospective[tiab] OR prospective[tiab] OR long term*[tiab] OR medium term*[tiab] OR late result*[tiab])) AND publisher[sb]

Google scholar:

"meniscus|meniscal tear|rupture|ruptures|injury|lesions|trauma" therapy|treatment|exercise|surgery|therapuetic|rehabilitation|surgery|arthroscopy|surgical|meniscectomy|operative prognosis|"follow up"|cohort|longitudinal|retrospective|prospective|"long|medium term"