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Treatment of the syndrome of knee pain and meniscal tear in middle-aged and older persons: A narrative review

C.G. McHugh^{a,1}, M.B. Opare-Addo^{a,1}, J.E. Collins^{a,c}, M.H. Jones^{a,c}, F. Selzer^{a,c}, E. Losina^{a,c,e}, J.N. Katz^{a,b,c,d,*}

^aOrthopaedic and Arthritis Center for Outcomes Research, Department of Orthopedic Surgery, Brigham and Women's Hospital, USA

^bDivision of Rheumatology, Immunology and Immunity, Brigham and Women's Hospital, USA

^cHarvard Medical School, USA

^dDepartment of Epidemiology, Harvard Chan School of Public Health, USA

^eDepartment of Biostatistics, Boston University School of Public Health, USA

Abstract

Objective: To summarize the literature investigating management, treatment strategies, short- and longer-term outcomes of treatment for meniscal tear in middle-aged and older adults.

Design: We performed a literature search using PubMed to identify relevant articles and selected 15 for a narrative summary on the available evidence.

Results: The literature suggests that middle-age and older adults with meniscal tear may benefit from initial physical therapy (PT) potentially followed by arthroscopic partial meniscectomy (APM) for those who do not experience sufficient benefit after PT and in whom other sources of pain are deemed unlikely. There is moderate evidence to suggest that some factors at baseline, such as radiographic OA, meniscal tear type, and pain at baseline may influence outcomes after

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*Corresponding author. Orthopedic and Arthritis Center for Outcomes Research, Brigham and Women's Hospital, 75 Francis St., Hale, 5016, USA. jnkatz@bwh.harvard.edu (J.N. Katz).

Authorship

All authors should have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted. By signing below each author also verifies that he (she) confirms that neither this manuscript, nor one with substantially similar content, has been submitted, accepted or published elsewhere (except as an abstract). Each manuscript must be accompanied by a declaration of contributions relating to sections (1), (2) and (3) above. This declaration should also name one or more authors who take responsibility for the integrity of the work as a whole, from inception to finished article. These declarations will be included in the published manuscript.

¹Authors McHugh and Opare-Addo contributed equally to this work.

Studies involving humans or animals

Clinical trials or other experimentation on humans must be in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Randomized controlled trials should follow the Consolidated Standards of Reporting Trials (CONSORT) guidelines and be registered in a public trials registry.

Studies involving experiments with animals were in accordance with institution guidelines.

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APM. Over time, APM appears to increase the risk of degenerative changes in cartilage, bone, and other knee structures as evidenced by radiograph and MRI-based assessments.

Conclusion: Evidence from research investigating outcomes of treatment for meniscal tear in middle-aged and older adults demonstrates that PT is a reasonable initial treatment. More research is needed to investigate the best treatment for those who do not benefit substantially from initial PT. The evidence also demonstrates that APM may be associated with greater risk of radiographic osteoarthritic changes, though more research and the addition of enhanced quantitative MRI-assessments are needed to further detail any compositional changes in the knee. Focusing on these areas of further study will clarify whether these imaging findings are clinically meaningful.

1. Introduction

The clinical syndrome of knee pain and meniscal tear is a frequent source of functional loss in middle-aged and older persons. Thirty-five percent of persons greater than 50 years old in a community study had imaging evidence of meniscal tear (95% confidence interval [CI] [32%,38%]), of whom 61% (95% CI [55%,67%]) were asymptomatic [1]. Among individuals with symptomatic, radiographic (Kellgren Lawrence [KL] grade of 2 or higher) knee osteoarthritis (OA), 63% (95% CI [53%,73%]) had meniscal tear, whereas 32% (95% CI [24%, 40%]) of those with knee pain but no radiographic evidence of OA had meniscal tear [1]. It is difficult for clinicians to determine whether knee pain in patients with meniscal tear is due to the torn meniscus per se, or to osteoarthritic lesions in other joint tissues (e.g. synovium, bone) [2].

Two principal options have been evaluated for initial management of knee pain and meniscal tear in middle-aged and older persons. These include 1) arthroscopic partial meniscectomy (APM), a procedure in which the surgeon resects the damaged portion of the meniscus, leaving a stable edge; and 2) physical therapy (PT) focused on strengthening the quadriceps, hamstring, and other lower extremity muscle groups, along with neuromuscular exercise. Prior to 2007, observational studies demonstrated substantial pain relief and functional improvement following APM, supporting the decision to treat the syndrome of knee pain and meniscal tear surgically [3–5]. However, several randomized controlled trials reported over the last 15 years have provided more robust evidence to guide clinicians with treatment decisions (Table 1) [6–17]. Multiple studies (both randomized and observational) have evaluated treatment strategies for patients with this syndrome over the last two decades [6–20]. This narrative review synthesizes key findings from these studies to provide clinicians with guidance for managing persons with knee pain and meniscal tear, and to identify key gaps in knowledge for setting the future research agenda (see Table 2).

2. Methods

We performed a PubMed search for articles that addressed treatment outcomes for meniscal tear in middle-aged and older persons, and articles that analyzed the association between treatment and subsequent total knee replacement and progression of joint damage. We included prospective and retrospective observational studies in addition to randomized clinical trials and meta-analyses. Additionally, we selected studies with radiographic and/or

magnetic resonance imaging (MRI) outcomes of knees following arthroscopic partial meniscectomy. We required a minimum follow-up range of at least 3 months. We excluded cross-sectional studies and editorials. We ultimately identified 15 articles eligible for inclusion in this narrative review.

3. Results

3.1. RCT evidence guiding treatment decisions for meniscal tear

Trials designed to evaluate the efficacy of treatments for meniscal tear have typically compared APM to either PT or to sham surgery (Table 1).

APM vs. PT: Several randomized clinical trials (RCTs) have compared APM (with or without PT) to PT (often including in-person and home exercise components). These studies demonstrate that subjects receiving APM and those receiving PT both improved substantially in the first year [9–16,19,20]. In intention-to-treat (ITT) analyses of five of these trials, investigators did not observe clinically important or statistically significant differences in pain relief between APM and PT/exercise groups in the first two years [12–16,19,20]. In these trials, the difference in pain relief between surgical and PT arms as measured with the Knee injury and Osteoarthritis Outcome Score (KOOS) Pain or Visual Analogue Scales (VAS) (both ranging from 0 to 100) ranged from 9 points in favor of APM to 0.9 points in favor of PT [12,14]. One trial did observe an important difference in pain between APM and PT: Gauffin et al. reported greater improvement in KOOS Pain scores in subjects treated with APM than in those treated with PT (mean between group difference of 10.6 points, 95% CI: 3.4 to 17.7, ITT analysis) at 12 months, exceeding the generally accepted minimal clinically important difference (MCID) on the KOOS Pain scale of 10 points [10,21]. In this trial the difference in improvement narrowed to 7.6 points (95% CI [−0.6, 15.9]; ITT analysis) at 3 years and to 3.2 points (95% CI [−6.1,12.4]; as-treated analysis) after five years of follow-up [9–11].

A meta-analysis by Abram and colleagues summarized these trials of APM vs. PT and estimated that APM was associated with slightly greater improvement on the KOOS Pain Scale than PT 6–12 months after baseline (pooled mean difference between APM and PT of 4.10 points, 95% CI [0.74, 7.46]) [18]. This is a modest difference, with 10 points considered clinically meaningful [21].

In the trials comparing APM to PT, up to 30% of subjects initially randomized to receive PT “crossed over” to undergo APM after experiencing persistent symptoms [18]. Data on the effectiveness of cross-over APM are conflicting and based on small samples. Katz and colleagues reported that 81% (95% CI [70%, 92%]) of MeTeOR (Meniscal Tear in Osteoarthritis) Trial participants who crossed over from PT to APM experienced 10-point improvement in Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Pain scale over 6 months of follow-up [22]. This was similar to 82% (95% CI [76%, 88%]) among those randomized to and receiving APM, and 73% (95% CI [65%, 81%]) of those randomized to PT who did not cross over [22]. A multivariable analysis that adjusted for baseline differences found that those who crossed over from PT to APM had a similar likelihood of a ten-point improvement in WOMAC Pain to those originally

randomized to APM (risk ratio (RR) = 0.95; 95% CI [0.64, 1.41]) [22]. In contrast, van de Graaf et al. reported that subjects who received immediate APM improved by 42 points on the VAS pain scale after 24 months, while the subjects who crossed over from PT to APM (75% of those who crossed over did so in the first 6 months) improved by 30 points [15]. While these as-treated analyses adjusted for baseline differences between the groups, residual confounding may threaten the validity of these comparisons.

APM vs. sham surgery: It could be argued that the improvement following APM results from the placebo effect of surgery. To address this issue, the Finnish Degenerative Meniscal Lesion Study (FIDELITY) randomized 146 participants to receive APM or sham surgery [8]. In the sham procedure, the surgeon inserted the arthroscope into the knee but did not perform partial meniscal resection. The authors found that both groups improved substantially from baseline, but they did not observe clinically important or statistically significant differences between the APM and sham groups in pain relief or functional improvement at 1-, 2-, and 5-years post procedure [6–8].

In contrast, Roos and colleagues randomized 44 subjects to APM or sham surgery and observed that the APM group improved more than the sham group on the KOOS-5 (a summary measure of all five KOOS subscales) by 8.2 points (95% CI [−3.4, 19.8]), approaching the minimal clinically important difference (MCID) of 10 points [17]. Secondary outcomes also favored APM including KOOS Pain (greater improvement in APM than in sham treated subjects by 9.9 points on 100-point scale, 95% CI [−2.1, 21.9]) and the KOOS ADL subscale (greater improvement in APM by 9.0 points, 95% CI [−1.4, 19.4]) [17]. The findings of this study should be viewed cautiously because the investigators encountered difficulty recruiting subjects and only randomized 44 of an intended 72 subjects. To our knowledge, these are the only two published trials designed to compare APM to a sham procedure.

We note, however, that no trial data are available to guide the decision of whether to recommend APM or continue nonoperative therapy in those who fail to improve after an initial course of PT. Thus, an RCT designed to compare the efficacy of surgery vs. continued nonoperative therapy in those who fail a rigorous course of PT would provide valuable evidence to guide treatment decisions.

Complications: The risks of surgical complications following APM are small. In a retrospective analysis of 699,965 APM cases identified from the UK National Health Service (NHS) and Office for National Statistics (ONS) databases, Abram et al. found that 0.08% (95% CI [0.07%, 0.09%]) of those who undergo APM suffered from a pulmonary embolism within 90-days after surgery, a 13-fold greater risk (95% CI [10.35, 16.31]) than observed in the general UK public [23]. Similarly, 0.14% (95% CI [0.13%, 0.15%]) developed septic arthritis following APM, 110-fold more (95% CI [81.19, 149.60]) than in the general public [23]. In a retrospective cohort study of 314,578 Medicare recipients who underwent APM, 0.4% (95% CI [0.38%, 0.42%]) developed septic arthritis, 0.8% (95% CI [0.77%, 0.83%]) developed deep vein thrombosis, and 0.3% (95% CI [0.28%, 0.32%]) developed pulmonary embolism [24]. The higher risks in Medicare recipients than in the UK public likely stems from the older age of Medicare recipients. A recent study found that 5%

of pyogenic knee arthritis cases may be attributed to knee arthroscopy [25]. The literature suggests that mortality from APM is low at less than 0.1% [26,27]. The data are insufficient to estimate whether subchondral insufficiency fractures or rapidly progressing knee OA occur more frequently following APM versus nonoperative therapy. Adverse effects of PT are generally infrequent and mild. In the larger trials that compared APM with PT, musculoskeletal adverse events (knee pain, pain from falls, tendonitis, knee bursitis, etc.) occurred in 0–5.6% of the participants in the PT groups [10,15,19].

Prognostic factors regarding clinical outcomes: Several investigators have sought to identify subgroups of patients who benefit most from initial APM. MacFarlane et al. reported that subjects in the MeTeOR trial who had the fewest intra-articular abnormalities (of cartilage, bone, and synovium) documented on MRI benefitted more from APM than from PT (15 points greater improvement on KOOS Pain scale), while those with the greatest number of abnormalities on MRI benefitted equally from APM and from PT [28]. Consistent with this finding, a meta-analysis of randomized trials by Abram and colleagues noted that patients without concomitant OA may receive more benefit from APM than from PT [18]. Their analysis of participants with knee OA (KL 2–4) found a pooled mean difference of 4.10 points (95% CI [0.74, 7.46]) favoring APM on the KOOS pain scale, compared to a pooled mean difference of 6.91 points (95% CI [2.87, 10.94]) favoring APM in an analysis of those without knee OA (KL 0–1) [18]. An analysis of 641 patients in the Knee Arthroscopy Cohort of Southern Denmark (KACS) who underwent APM reported that more severe knee pain at baseline and an absence of prior meniscal surgery were associated with greater improvement in patient reported pain and function 1 year after surgery [29]. Another study of 665 prospectively enrolled patients with meniscal tear at the Cleveland Clinic found that patients with medial meniscal root tears (OR = 0.27; 95% CI [0.11, 0.66]), lateral tears (OR = 0.42; 95% CI [0.2, 0.9]), and worse baseline KOOS Pain scores (OR = 0.96; 95% CI [0.94, 0.97]) were less likely to achieve clinically meaningful improvements after APM [30]. One review including 32 studies found that a longer duration of symptoms (>1 year), the presence of radiological knee OA at baseline, and resecting >50% of the meniscus are associated with worse clinical outcomes following APM [31]. While physicians are traditionally taught that mechanical symptoms (e.g. clicking, locking) reflect the presence of symptomatic meniscal tear, patients who present with mechanical symptoms appear to have similar outcomes following APM to subjects without mechanical symptoms [10,32–34].

3.2. Association of APM with total knee replacement

A high-quality observational study and a randomized clinical trial have examined the association of APM with total knee replacement (TKR). In a 2017 observational study, Rongen et al. assessed 335 OAI participants who had APM and a group of 1:1 propensity-matched controls according to their likelihood of undergoing APM [35]. Over 9 years of follow-up, 63 (19%, 95% CI [15%, 23%]) APM patients subsequently underwent TKR in the same knee compared to 11% (95% CI [8%, 14%]) of controls (hazard ratio (HR) 3.0, 95% [CI 1.7, 5.3]) [35]. The presence of meniscal tear in the control knees was unknown in this study, precluding distinction between the risk of TKR imposed by APM and the risk imposed by underlying meniscal tear. Furthermore, the authors acknowledge that TKR

represents a decision and not a health status, and therefore is not an ideal proxy for advanced OA [35].

Katz and colleagues observed that 1.8% (95% CI [0%, 4.4%]) of MeTeOR trial subjects randomized to PT who did not cross over to APM underwent total knee replacement (TKR) over five years [20]. In contrast, 9.8% (95% CI [5.2%, 14.3%]) of those who were randomized to and received APM and 10.3% (95% CI [3.1%, 17.5%]) of those randomized to PT who crossed over to APM underwent TKR over five years of follow-up [20]. These data suggest that receiving APM may increase the risk of subsequent TKR, although this finding must be interpreted with caution as individuals who had the experience of APM may simply be more willing to undergo surgery than participants who did not have APM.

3.3. Studies investigating structural outcomes associated with APM

3.3.1. Observational findings—Biomechanical cadaver studies show that greater load is transmitted to the underlying subchondral bone in knees with partial resection than in knees with unresected, torn menisci [36]. These data lead to the hypothesis that APM may give rise to more rapid progression of joint damage than nonoperative therapy. For many years clinicians relied on observational data to address this question. Fauno et al. assessed the incidence of radiographic changes after an average of 8.5-years of follow-up in 136 knees that underwent APM as compared with the subjects' unoperated, contralateral knees [37]. The authors observed at least one Fairbanks [38] change, defined as alterations in joint space width and bone morphology, in 53% (95% CI [45%, 61%]) of the knees that had APM, compared to 22% (95% CI [15%, 29%]) of control knees [37]. A retrospective study with follow-up intervals ranging from 19 to 25 years by Hulet et al. reported that 45% (95% CI [35%, 55%]) of knees that had APM of the lateral meniscus developed radiographic OA changes, as compared to 19% (95% CI [11%, 27%]) of contralateral knees [39].

Using data from the Osteoarthritis Initiative (OAI) longitudinal cohort, Roemer and colleagues performed a case-control study investigating the association between APM and radiographic OA and/or advancement in cartilage damage over 12 months [40]. The authors showed that 31 (8.8% (95% CI [6%, 12%])) of 360 knees with incident radiographic knee OA underwent APM the year prior, while none of the 354 matched controls without incident OA underwent APM. This suggests a greater association of APM with radiographic OA in the first 12 months following surgery [40]. This paper also showed that subjects who had APM in the prior year had a higher odds of advancement in cartilage damage over one year than subjects who did not have APM (adjusted OR 4.21 (95% CI 1.41,12.63)).

A recent retrospective cohort study with 72 months of follow-up by Jones et al. compared the rates of joint space narrowing (JSN) between subjects who underwent APM, control subjects with a meniscal tear who did not undergo surgery (non-surgical group), and control subjects without a meniscal tear (no-tear group). These groups were matched with respect to subjects' gender, age, KL-grade, and follow-up interval [41]. The inclusion of a group with meniscal tear but no surgery helps to isolate the effect of surgery from that of the underlying meniscal tear. Knees exposed to APM had substantially greater rates of joint space narrowing in the first 12 months of observation (−0.083 mm/month, 95% CI [−0.093, −0.073]) than both knees with meniscal tears managed nonoperatively (−0.003 mm/month,

95% CI [-0.013, 0.006]) and knees without a tear (-0.015, 95% CI [-0.024, -0.006]) [41]. The authors acknowledged that the clinical importance of these differences in rate of JSN is unclear [41].

3.3.2. Randomized controlled trial (RCT) findings—Three of the RCTs examined earlier assessed structural changes associated with subjects receiving APM and controls. In these studies, the controls all had underlying meniscal tear, enabling investigators to isolate the effect of APM independent of the effect of underlying meniscal tear. The 5-year follow-up of the FIDELITY study from Sihvonen et al. compared 67 subjects randomized to APM and 74 randomized to placebo surgery [6]. Seventy-two percent (95% CI [61%, 83%]) of the APM group experienced KL progression of at least one grade over five years, compared to 60% (95% CI [49%, 71%]) of the placebo group (RR = 1.21, 95% CI [0.95, 1.53]) [6]. The APM group experienced significantly greater increases in OARSI tibiofemoral osteophyte and joint-space narrowing scores compared to the placebo surgery group (absolute OARSI sum score difference = 0.7, 95% CI [0.1,1.3]) [6]. Sonesson and colleagues conducted a 5-year follow-up analysis of 146 subjects randomized to APM or PT [11]. In an as-treated analysis, 60% (95% CI [50%,70%]) of those who received APM experienced radiographic OA progression (KL grade 2) from baseline to five years, versus 37% (95% CI [25%, 49%]) of the non-surgical group (P = 0.06) [11]. The greater risk of structural progression in both trials may be clinically meaningful.

Using MeTeOR trial data, Collins et al. used MRI to assess structural sequelae of APM versus nonoperative care [42]. MRI assessment allows for detailed examination of changes in cartilage, synovitis, bone marrow lesions, and other structures, many of which are not apparent on radiographs. These authors examined baseline and 18-month follow-up MRIs using the semi-quantitative MRI Osteoarthritis Knee Score (MOAKS) assessment in 103 subjects randomized to APM and 72 randomized to PT who did not cross over to APM. As compared to subjects only receiving PT, those who were randomized to and underwent APM demonstrated significantly greater changes in the number of subregions with advancements in cartilage surface area (adjusted odds ratio (OR) 4.2, 95% CI [2.0, 9.2]) and osteophytes OR 2.6, 95% CI [1.3,5.6]), and in worsening of effusion synovitis (OR 5.0, 95% CI [1.8,13.9]) [42]. Progression in bone marrow lesions, Hoffa-synovitis, and cartilage thickness was greater in the APM group, though these differences were not statistically significant [42]. Similar results were seen in ITT and as-treated sensitivity analyses including cross-overs. A five-year follow-up of the MeTeOR trial cohort suggested that from 18 to 60 months, the APM and PT groups progressed at a very similar rate [43]. Thus, the more rapid progression following APM appears to occur in the first 18 months after surgery [43].

The observational studies and RCTs noted above suggest that individuals receiving APM may experience a greater risk of progression in degenerative changes on radiographs and MRI than persons treated nonoperatively. A critical clinical question is whether these long-term imaging changes following APM are clinically important. Indeed, the loose correlation between structure and symptoms is well recognized [44,45]. MeTeOR trial investigators observed negligible correlation between changes in MRI cartilage surface area damage from baseline to 18 months and subsequent changes in KOOS pain from 18 to 60 months

($r = -0.12$, 95% CI $[-0.27, 0.028]$) [46]. The authors documented similarly negligible associations between changes in osteophytes, bone marrow lesions, and effusion synovitis between baseline and 18 months and subsequent changes in pain from 18 to 60 months. These findings suggest that in the first five years of follow-up, greater structural worsening does not appear to portend subsequent worsening in pain.

4. Discussion

In summary, evidence from several RCTs suggests that initial treatment with either APM or PT is associated with substantial pain relief, with little difference in pain relief between these two strategies. However, up to 30% of subjects receiving PT as initial treatment crossed over to undergo APM [18]. The FIDELITY data warn that the improvement associated with APM may be due largely to placebo effect [6–8]. Whether improvements following PT are due largely to the regression to the mean or placebo effects is not known at this point. Based on this information, it is sensible to recommend physical therapy as the first line treatment for patients with knee pain and meniscal tear, and to consider offering APM to only those who do not experience relief from PT and in whom other sources of pain are unlikely. Indeed, that is the recommendation of several internationally based professional societies [47–49].

Because there are no published randomized studies of treatments for those who did not improve following initial PT, recommendations to opt for surgery in this setting should be viewed cautiously. Indeed, an RCT of APM vs. enhanced PT (e.g., more rigorous, more focused on adherence, in conjunction with corticosteroid injections) in those who fail an initial course of nonoperative therapy would be a valuable addition to the literature and would help guide clinical treatment.

We note that other factors may influence a patient's choice to pursue APM or PT for their meniscal tear. These include socioeconomic factors like income and type of occupation that may limit a patient's ability to afford or spend time attending PT appointments over several months. Many patients have no knee-related activity restrictions four weeks after APM, while physical therapy typically takes longer to restore function and relieve pain [50]. Thus, persons with physically demanding jobs may opt for surgery to relieve symptoms faster and return to work earlier. Other factors that may influence treatment decisions include co-pays for physical therapy or for APM and the potential for post-operative complications that may confer additional costs to patients [51].

To date, research has been conducted to determine whether certain factors are associated with better outcomes from APM. Based on the current evidence, it seems that the presence of radiographic OA, meniscal tear type, pain at baseline, and history of prior meniscal surgeries may influence how much benefit patients receive from APM. The risk of complications following APM, while minimal, are an important consideration for patients weighing its potential adverse outcomes against the musculoskeletal risks of PT. Notable complications of surgery include infection, pulmonary embolism, deep vein thrombosis, septic arthritis, and pyogenic knee arthritis [23–25]. Further research is needed to explore additional complications that may accelerate osteoarthritic changes in the knee.

The evidence from the observational and trial studies investigating the association of APM with TKR suggests that patients who undergo APM are at greater risk of undergoing subsequent TKR in the same knee compared to control knees [20,35]. These findings in conjunction with evidence from longer-term follow up studies imply that APM exacerbates structural changes in the knee. Confounding by indication may have limited such findings from observational studies. Individuals in the APM groups may differ in unmeasured meniscal morphology or may be more open to undergoing surgery compared to non-surgical groups. Rongen and colleagues acknowledge this limitation in their observational study, despite the use of propensity-matched controls [35]. Finally, TKR is a treatment decision rather than a health status. We urge caution in interpreting the association of APM and subsequent TKR.

Combined findings from additional observational studies also demonstrate an association between APM and radiographic OA change. However, the data are derived from multiple investigations with varied follow-up ranges, urging caution in interpretation. Long term follow-up of subjects treated for knee pain and meniscal tear indicate that APM may be associated with greater risk than nonoperative therapy of osteoarthritic changes on radiographs and MRI. However, recent data suggest that these structural changes may not be associated with worse symptoms over the first five years of follow up [46].

Further research focused on elucidating the relationship between these structural changes and clinical outcomes is needed. An additional area to examine more closely is the influence of tear morphology on structural changes, though in middle age and older persons, tears are typically horizontal and/or complex in nature [1,52]. MRI imaging enables researchers to examine tear morphology and may continue to be used in future studies. Current MRI assessments involve standard semi-quantitative techniques, though more advanced assessment techniques are available today and others are under development. Future investigations may benefit from using enhanced quantitative MRI techniques (such as T2 mapping) to shed light on structural changes and progression of knee OA following APM [53].

A multi-faceted approach to future explorations of this topic that involves an investigation of the structural and clinical implications of the APM in the short and long-term, supported by radiographic imaging and quantitative compositional assessments, would provide key insights that clinicians may use to inform middle-aged and older patients considering management options for meniscal tear.

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At the end of the text, under a subheading “Conflict of interest statement” all authors must disclose any financial and personal relationships with other people or organisations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and research grants or other funding.

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Table 1

Randomized trials of arthroscopic partial meniscectomy vs. comparators.

Author, year	Country	Age, KL	N	Intervention	Comparator	Outcome, time point	in surgical arm (ITT)	in comparator arm (ITT)	Between group difference (ITT)	Crossover
Gauffin, 2014, '17, '20 [9–11]	Sweden	45–64 KL 0-2	150	Exercise + APM	Exercise	KOOS Pain, 12 mo.	29.4 pts	18.8 pts	10.6 pts favoring APM *	21% by 12 mo.
Herrlin, 2007, '12 [12, 13]	Sweden	45–64 Allback 0-1	97	Exercise + APM	Exercise	KOOS Pain, 6 mo.	33 pts	24 pts	9 pts favoring APM (NS)	28% by 14 mo.
Katz, 2013, '20 [19, 20]	US	45+ KL 0-3	351	Exercise + APM	Exercise	KOOS Pain, 6 mo.	24.2 pts	21.3 pts	2.9 pts favoring APM (NS)	30% by 6 mo.
Kise, 2016 [14]	Norway	35–60 kL 0-2	140	APM	Exercise	KOOS-4, 24 mo.	24.4 pts	25.3 pts	0.9 points favoring PT (NS)	19% by 16 mo.
Van de Graaf, 2018 [15]	Netherlands	45–70 kL 0-3	321	APM	Exercise	VAS Pain, 24 mo.	41.5 pts	33.8 pts	7.7 pts favoring APM (non-inferior)	29% by 24 mo.
Yim, 2013 [16]	S. Korea	43–62 kL 0-1	108	APM	Exercise	VAS Pain, 6 mo.	37 pts	28 pts	9 pts favoring APM (NS)	None
Roos, 2018 [17]	Denmark	35–55 kL 0-2	44	APM	Sham APM	KOOS-5, 24 mo.	21.8 pts	13.6 pts	8.2 pts favoring APM *	36% by 24 mo.
Sihvonen, 2013, '18, '20 [6–8]	Finland	35–65 kL 0-1	146	APM	Sham APM	VAS Pain, 12 mo.	31 pts	33 pts	2 pts favoring APM (NS)	None

KL = Kellgren-Lawrence Grade; PT = physical therapy; APM = arthroscopic partial meniscectomy; IKDC (Intl Knee Documentation Committee), KOOS (Knee Injury and Osteoarthritis Outcome Score), 100 = best; Visual Analog Scale (VAS) scores transformed to 0–100, 100 = worst;

* = $p < 0.05$; NS = $p > 0.05$.

Table 2
Follow-up Radiographic assessment of APM and comparator groups in cohort studies and RCTs.

Author, year	Sample size ^a / design	Follow-up range (years)	Baseline radiographic status	Primary outcome variable	Findings	P-Value	Conclusion
Fauno, 1992 [37]	136/Cohort	8-12	Not reported	1 pt Fairbank change	APM: 53% Control knee: 22%	P < 0.001	APM associated with increased Fairbanks changes
Herrlin, 2012 [13]	88/RCT	5	Ahlback grade 1	1 pt Ahlback change	APM: 4.7% PT-only: 4.4%	P = 1.0 ^c	APM not associated with osteoarthritic changes
Yim, 2013 [16]	102/RCT	2	KL grade 1	KL grade 2	APM: 4% Non-operative: 5.8%	P = 0.44	Did not find differences in OA changes between groups
Hulet, 2015 [39]	89/Cohort	19-25	IKDC§ grade 4	OA on objective IKDC score (B, D) ^b	APM: 45% Contralateral: 19%	P = 0.0004 ^c	APM associated with OA changes.
Sihvonen, 2020 [6]	146/RCT	5	KL 2	1 KL grade change	APM: 72% Sham: 60%	P = 0.16 ^c	APM associated with greater risk radiographic OA than sham
Sonesson, 2020 [11]	146/RCT	5	Ahlback grade 0	KL grade 2	APM + Exercise: 60% Exercise-only: 37%	P = 0.06	Greater incidence OA changes, though P > 0.05.

KL = Kellgren-Lawrence grades 0-4 scale of knee OA presence 0 = absence of osteoarthritic changes, 1 = doubtful/possible, 2 = minimal, 3 = moderate, 4 = severe [54]. Ahlback grades 0-5, 0 = no radiographic OA changes, 1 = joint space narrowing (<3 mm), 2 = obliterated or partially obliterated joint space, 3 = minor bone attrition (<5 mm), 4 = moderate bone attrition (5-15 mm), 5 = severe bone attrition (>15 mm) [55].

APM = arthroscopic partial meniscectomy; IKDC = International Knee Documentation Committee, ROA = radiographic knee osteoarthritis.

^a = Sample size with available radiograph at follow-up.

^b = Participants were categorized into grades A (healthy), B (asymptomatic with ROA), C (symptomatic, no ROA), and D (symptomatic, with ROA) using the objective §IKDC score with grades 0-3, 0 = normal, 1 = articular modeling, 2 = joint space narrowing (< 50%), 3 = joint space narrowing (> 50%) [39].

^c = We calculated crude p-values for these results as they were unreported in the original paper.