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Association Between Baseline Meniscal Symptoms and Outcomes of Operative and Nonoperative Treatment of Meniscal Tear in Patients With Osteoarthritis

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Objective. Patients with meniscal tears reporting meniscal symptoms such as catching or locking have traditionally undergone arthroscopy. The present study was undertaken to investigate whether patients with meniscal tears who report meniscal symptoms have greater improvement with arthroscopic partial meniscectomy (APM) than physical therapy (PT).

Methods. We used data from the Meniscal Tear in Osteoarthritis Research (MeTeOR) trial, which randomized participants with knee osteoarthritis (OA) and meniscal tear to APM or PT. The frequency of each meniscal symptom (clicking, catching, popping, intermittent locking, giving way, swelling) was measured at baseline and 6 months. We used linear regression models to determine whether the difference in improvement in Knee Injury and Osteoarthritis Outcome Score (KOOS) pain score at 6 months between patients treated with APM versus PT was modified by the presence of each meniscal symptom. We also determined the percentage of participants with resolution of meniscal symptoms by treatment group.

Results. We included 287 participants. The presence (versus absence) of any of the meniscal symptoms did not modify the improvement in KOOS pain score between APM versus PT by >0.5 SD (all *P* interaction >0.05). APM led to greater resolution of intermittent locking and clicking than PT (locking 70% versus 46%, clicking 41% versus 25%). No difference in resolution of the other meniscal symptoms was observed.

Conclusion. Meniscal symptoms were not associated with improved pain relief. Although symptoms of clicking and intermittent locking had a greater reduction in the APM group, the presence of meniscal symptoms in isolation should not inform clinical decisions surrounding APM versus PT in patients with meniscal tear and knee OA.

INTRODUCTION

Symptomatic knee osteoarthritis (OA) affects an estimated 14 million individuals in the US, with up to 91% of patients with knee OA demonstrating a meniscal tear on magnetic resonance imaging (MRI) (1,2). Knee symptoms such as catching, popping, or locking elicited in young persons with acute injuries have been considered mechanical symptoms. Historically, these mechanical

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SIGNIFICANCE & INNOVATIONS

- We leveraged data from a randomized control trial to evaluate the association between meniscal symptoms and knee pain after surgery versus physical therapy for meniscal tear.
- The presence or absence of meniscal symptoms was not associated with differential pain outcomes after surgery versus physical therapy.
- Knee symptoms such as clicking and catching have historically been ascribed to meniscal pathology. These data cast further doubt on the ability of meniscal symptoms to help direct management of meniscal tear.

symptoms along with symptoms such as pain with twisting have been grouped together as "meniscal symptoms" and attributed to meniscal tear or to other internal derangements. These patients were often referred to orthopedic surgeons for consideration of arthroscopic diagnosis and management. However, in the current era of advanced imaging, meniscal tear can be visualized on MRI, obviating the need for direct surgical visualization.

Middle-aged and older patients with knee OA frequently report meniscal symptoms; clinicians continue to suspect symptomatic meniscal tear in these patients, even though there is little evidence that meniscal symptoms stem from meniscal pathology in older patients with degenerative (rather than traumatic) meniscal tears (3). In fact, prior evidence suggests that meniscal tears were seen in a similar proportion of asymptomatic and symptomatic knees (4).

Randomized trials comparing surgical treatment versus conservative therapy for patients with degenerative meniscal tears have found that both strategies reduce pain (5–8). Although meniscal symptoms may not be specific to meniscal damage, many clinicians feel that patients with meniscal symptoms may represent a subgroup with a favorable response to arthroscopic partial meniscectomy (APM) (9), as resection of the torn meniscus is thought to aid in restoring smooth joint motion. Therefore, there is considerable interest in whether patients with meniscal symptoms might benefit more from surgery than those without these symptoms.

Our group previously developed a more comprehensive list of commonly considered meniscal symptoms based on input from physicians, physical therapists, and patients. While the original list included several pain parameters, here we focus on the traditional mechanical or meniscal symptoms including clicking, catching, popping, intermittent locking, giving way, and swelling of the knee (10). We sought to evaluate whether patients reporting any of these expanded meniscal symptoms had greater improvement with APM than with physical therapy (PT) using data from the Meniscal Tear in Osteoarthritis Research (MeTeOR) trial, a randomized trial of APM versus PT in patients with knee OA and meniscal tear (6). We evaluated the association between these expanded meniscal symptoms, treatment group (APM, PT), and patient improvement. Here, we test the null hypothesis that in patients with OA, the association between treatment group and 6-month change in pain will not be different for those with versus those without baseline meniscal symptoms.

PATIENTS AND METHODS

Study sample. We used data from participants in the MeTeOR trial; details of this trial have been previously published (6,11). Three hundred fifty-one subjects were recruited from 7 academic centers from 2008 through 2011. Participants included males and females age ≥45 years who had at least 4 weeks of knee pain and an MRI with evidence of a meniscal tear extending to the meniscal surface in at least 2 consecutive slices. Included participants also had evidence of mild-to-moderate osteoarthritic change (Kellgren/Lawrence [K/L] grade ≤3) as determined by osteophyte and/or joint space narrowing on plain radiographs, or full-thickness articular cartilage defect on at least 1 tibial or femoral surface on MRI. We excluded patients with a chronically locked knee (e.g., subject unable to flex or extend knee on examination), inflammatory arthritis, prior surgery on the index knee, K/L grade 4 OA, and contraindication to MRI. Participants reporting locking but able to flex and extend the knee on examination were included and are designated as "intermittent locking" in our analyses. Participants were randomized either to PT or to APM followed by the PT regimen. The surgical intervention was APM with resection of the damaged meniscus back to a stable rim. Meniscal repairs were not permitted as part of the trial. All participants provided consent, and the study was approved by the Partners HealthCare Human Research Committee (2005P000440). This trial is registered at ClinicalTrials.gov (NCT00597012).

Data elements. We collected data on age, sex, and body mass index (BMI, kg/m^2) at baseline. The frequency of patient-reported meniscal symptoms was obtained at baseline and 6-month follow-up. Meniscal symptoms included clicking, catching, popping, intermittent locking, giving way, and knee swelling. Questionnaires assessed frequency of each meniscal symptom as follows: none; once/week; 2–6 times/week; 1–2 times/day; and several times/day. Based on the distribution of the

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categorical responses, all meniscal symptoms were dichotomized to "none" versus "any." Radiographic severity of OA was measured at baseline using the K/L grade (12).

Outcome and assessment. The primary outcome of interest was change in patient-reported pain from baseline to 6-month follow-up assessed with the Knee Injury and Osteoarthritis Outcome Score (KOOS) pain scale (13). We transformed KOOS pain score to a 0–100 scale, with 0 being least amount of pain, and 100 the greatest, with negative change indicative of improvement.

Statistical analysis. We described baseline characteristics of the cohort using means and percentages. For the primary analysis, we excluded the participants crossing over from PT to APM prior to 6 months, as these participants could be early in the recovery process at the 6-month assessment, as well as participants randomized to APM who did not undergo the surgery. The participants crossing over from PT to APM after 6 months were included in the PT arm. Participants missing either baseline or 6-month KOOS pain scores were excluded. We built separate multivariable linear regressions for each meniscal symptom (clicking, catching, popping, intermittent locking, giving way, and swelling), with the dichotomous symptom variable as the independent variable, and change in KOOS pain score from baseline to 6 months as the dependent variable. We examined the interaction between each meniscal symptom and treatment type (APM, PT) on change in KOOS pain score. All models were adjusted for age, sex, BMI, and baseline KOOS pain score.

In a second set of models, we also adjusted for K/L grade to account for radiographic OA severity. In another sensitivity analysis, we dichotomized meniscal symptoms as "less than daily" (none; once/week; 2–6 times/week) versus "daily" (1–2 times/day and several times/day) to allow investigation of participants with more frequent meniscal symptoms. The original MeTeOR trial was not powered to detect these interactions; thus, these analyses are intended to be hypothesis generating.

To address potential bias due to the exclusion of crossovers from the primary analysis, we assessed whether including crossovers in the APM arm or the PT arm altered results through 2 sensitivity analyses. In the first, we used an intent-to-treat approach, in which we included participants crossing over from PT to APM prior to 6 months and participants crossing over from PT to APM after 6 months in the PT arm. The second analysis used an as-treated approach including participants crossing over from APM to PT prior to 6 months in the APM arm. (The participants crossing over after 6 months were kept in the PT arm, as the primary outcome was at 6 months.)

As a secondary analysis, we investigated resolution of meniscal symptoms from baseline to 6-month follow-up. From the subset of participants reporting any meniscal symptoms at baseline, we defined "resolution" as those participants reporting "none" at follow-up. We investigated differences in this outcome across each treatment category, APM and PT. In this analysis, we included participants crossing over from PT to APM after 6 months in the PT arm, and excluded patients crossing over between arms during the first 6 months. Participants with missing 6-month meniscal symptom data were considered "non-resolvers" rather than omitted, as this was felt to be the most conservative analytic approach. We used contingency tables and the chi-square test to assess for statistically significant differences in percent improvement among the treatment groups. For all analyses *P* values less than 0.05 were considered statistically significant. All analyses were performed using SAS statistical software, version 9.4.

RESULTS

Of the 351 participants,164 participants (47%) were randomized to and received APM. One hundred nine (31%) were randomized to PT and did not crossover; 14 participants (4%) were randomized to PT but crossed over after 6 months and were therefore included in the PT arm. Ten participants (3%) were randomized to APM but did not have the procedure, and 54 (15%) were randomized to PT but received APM within 6 months and were excluded from analysis. The primary analysis included the 287 participants (82%) who were randomized to and received APM or were randomized to and received PT in the first 6 months. Mean age and BMI were similar among the treatment groups. Clicking, catching, popping, and giving way were present in 48–67% of participants at baseline. Twenty-seven to 31% of participants reported intermittent locking, and 71–75% reported swelling. The percentage of participants reporting each meniscal symptom by treatment group at baseline is outlined in Table 1.

Primary analysis. In the primary analysis, participants randomized to and receiving APM were considered in the APM group (n = 164), and those randomized to PT who remained in the PT group at least until 6 months were considered in the PT group (n = 123). Six-month change in KOOS pain score was missing in 23 participants in the APM group and 20 participants in the PT group; thus, the final analysis included 141 in the APM group and 103 in the PT group. Overall, regardless of meniscal symptoms at baseline, those undergoing APM had slightly greater improvement in KOOS pain scores at 6 months compared to PT. In the individual models for meniscal symptoms after adjustment for age, sex, BMI, and baseline KOOS pain score, participants without clicking, catching, popping, or locking and with giving way and swelling had a small but greater improvement in KOOS pain score after APM than PT. Assuming that the SD of KOOS pain score is 15 (14), the differences correspond to an effect size of 0.3–0.5. Participants with clicking, catching, popping, or locking and without giving way and swelling had minimal

Table 1. Baseline characteristics by treatment group*

Characteristic	Arthroscopic partial meniscectomy (n = 164)	Physical therapy (n = 123)	*P*
Age, mean ± SD years	59 ± 8	58 ± 6	0.08
BMI, mean ± SD	30 ± 6	30 ± 6	0.99
Female	94 (57)	67 (54)	0.63
KOOS pain score, mean ± SD	46 ± 16	46 ± 16	0.74
Kellgren/Lawrence grade			0.29
0	14 (9)	10 (8)	
1	31 (19)	34 (28)	
2	63 (38)	37 (30)	
3	56 (34)	42 (34)	
Meniscal symptoms			
Clicking	106 (66)	80 (67)	0.81
Catching	81 (51)	62 (52)	0.86
Popping	79 (50)	61 (51)	0.85
Intermittent locking	43 (27)	37 (31)	0.42
Giving way	77 (48)	64 (54)	0.27
Swelling	114 (71)	90 (75)	0.49

* Values are the number (%) unless indicated otherwise. Of the 287 participants, data were missing on 0–6% for each baseline characteristic. BMI = body mass index; KOOS = Knee Injury and Osteoarthritis Outcome Score.

differences in KOOS pain score between APM and PT. All interaction *P* values were > 0.09 (Table 2). Further adjusting models for K/L grade did not alter results. The results of this analysis did not change when meniscal symptoms were considered as daily versus less than daily, aside from swelling, where those with daily and less than daily swelling had a 3- and 5-point greater improvement with APM, respectively (see Supplementary Table 1, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24588). As in the primary analysis, the effect of each meniscal symptom on change in KOOS pain score over 6 months was not modified by treatment (*P* value for interaction >0.05 for each symptom).

Sensitivity analyses. In the sensitivity analysis, using an intent-to-treat approach, 177 participants were categorized as PT, and 164 as APM. Change in KOOS pain score over 6 months was missing in 26 participants in the PT group, and 23 in the APM group. At baseline, the crossover group had a higher percentage of female participants at 65%, versus 57% for APM and 54% for PT. Mean baseline KOOS pain score was also greater in the crossover participants at 51, versus 46 for both APM and PT (see Supplementary Table 2, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24588). Results were analogous to the primary analysis, and the presence or absence of each meniscal symptom and

Table 2. Change in Knee Injury and Osteoarthritis Outcome Score (KOOS) pain score for arthroscopic partial meniscectomy (APM) and physical therapy (PT) by presence of meniscal symptom*

	Mean change in KOOS pain score from baseline to 6 months (95% CI)†			Difference (95% CI)‡	*P* for interaction
	PT	APM	*P*		
Clicking	18.9 (14.7, 23.2)	22.2 (18.6, 25.8)	0.24	−3.3 (−8.8, 2.2)	0.58
No clicking	21.9 (16.4, 27.4)	27.8 (22.9, 32.7)	0.11	−5.9 (−13.1, 1.4)	0.58
Catching	20.1 (15.3, 24.8)	21.9 (17.8, 25.9)	0.56	−1.8 (−8.0, 4.3)	0.37
No catching	20.6 (15.9, 25.4)	26.5 (22.2, 30.7)	0.07	−5.8 (−12.1, 0.4)	0.37
Popping	18.9 (13.9, 23.8)	21.2 (17.1, 25.2)	0.47	−2.3 (−8.7, 4.0)	0.41
No popping	21.6 (17.0, 26.1)	27.6 (23.5, 31.6)	0.05	−6.0 (−12.0, 0.04)	0.41
Intermittent locking	21.2 (15.2, 27.1)	21.5 (15.7, 27.3)	0.94	−0.3 (−8.6, 7.9)	0.32
No intermittent locking	19.9 (15.9, 24.0)	25.2 (21.8, 28.5)	0.05	−5.2 (−10.5, −0.02)	0.32
Giving way	17.8 (13.0, 22.5)	25.7 (21.5, 29.8)	0.01	−7.9 (−14.1, −1.7)	0.09
No giving way	22.7 (17.8, 27.5)	22.9 (19.0, 26.9)	0.93	−0.3 (−6.4, 5.9)	0.09
Swelling	19.8 (16.0, 23.7)	25.9 (22.4, 29.3)	0.02	−6.0 (−11.1, −0.9)	0.12
No swelling	22.5 (15.7, 29.3)	20.6 (15.1, 26.1)	0.66	1.9 (−6.7, 10.4)	0.12

* 95% CI = 95% confidence interval.
† Adjusted for age, sex, body mass index, and baseline KOOS pain score.
‡ Negative values favor APM, and positive values favor PT.

Table 3. Proportion of participants with resolution of meniscal symptoms over 6 months by each treatment category*

Resolution	Clicking	Catching	Popping	Locking	Giving way	Swelling
APM	43 (41)†	48 (59)	39 (49)	30 (70)†	44 (57)	43 (38)
PT	20 (25)†	31 (50)	23 (38)	17 (46)†	35 (55)	36 (40)
RR (95% CI)‡	1.62 (1.04, 2.53)	1.19 (0.87, 1.61)	1.31 (0.88, 1.94)	1.52 (1.02, 2.27)	1.04 (0.78, 1.40)	0.94 (0.67, 1.33)

* Values are the number (%) unless indicated otherwise. Resolution reflects participants with any symptom at baseline and none at 6-month follow-up, if data missing at 6 months are regarded as no resolution. APM = arthroscopic partial meniscectomy; PT = physical therapy; RR = relative risk.
† $P < 0.05$ for difference in resolution between APM and PT groups.
‡ RR >1 favors APM.

treatment type did not clinically or statistically significantly modify the change in KOOS pain score at 6 months (see "intention to treat" in Supplementary Table 3, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24588). In the second sensitivity analysis including those crossing over from PT to APM prior to 6 months in the APM arm, 218 were categorized as APM, and 123 as PT. Change in KOOS pain score over 6 months was missing in 29 participants in the APM arm and in 20 participants in the PT arm. Again, the results were similar to the primary analysis (see "as treated" in Supplementary Table 3, available at http://onlinelibrary.wiley.com/doi/10.1002/acr.24588).

Secondary outcome. In this analysis, participants crossing over from PT to APM after 6 months were included in the PT arm, while those crossing over before 6 months were excluded. For each meniscal symptom, 14–32 participants did not provide 6-month data, and missingness did not vary between treatment. At 6 months, the percentage of participants with resolution (reporting any meniscal symptom at baseline and none at 6-month follow-up) for clicking, catching, popping, intermittent locking, and giving way was greater in those undergoing APM. Among those undergoing PT, clicking resolved in 25%, catching in 50%, popping in 38%, locking in 46%, and giving way in 55%. Improvement in swelling was greater in the PT group than in those receiving APM (Table 3). The greater extent of resolution in intermittent locking and clicking in the APM group as compared with the PT group was statistically significant ($P < 0.05$).

DISCUSSION

Our study suggests that, in general, individuals with OA and meniscal symptoms do not have greater clinically meaningful improvement in pain after APM compared with PT. The differences in 6-month change KOOS pain score between APM and PT did not exceed 7.9 points; as the minimum clinically important difference for KOOS pain score is 8–15 points (15,16), these differences are unlikely to be clinically meaningful (15). In separate analyses for each symptom, the presence of clicking, catching, popping, intermittent locking, and swelling at baseline did not demonstrate a statistically significant or clinically greater improvement in 6-month pain outcomes with APM than with PT. Only with presence of giving way did the difference between APM and PT reach an effect size of 0.5, indicating a moderate effect. While a greater proportion of participants undergoing APM reported improvement in clicking, catching, popping, giving way, and intermittent locking over 6 months, only intermittent locking and clicking showed statistically significant differences in improvement among the treatment groups. This suggests that APM may offer greater relief of clicking and intermittent locking meniscal symptoms than PT despite not offering greater relief of pain.

Our findings are comparable to those of 2 recent studies. Sihvonen et al (16) analyzed data from the FIDELITY trial, in which participants with meniscal tear without knee OA were randomized to APM versus sham surgery, to evaluate whether participants with meniscal symptoms (sensation of catching or locking) had greater improvement with APM. Results demonstrated no significant difference in the prevalence of meniscal symptoms after APM versus sham surgery at 2, 6, or 12 months (16). Our study differs in that we found that APM was more likely to relieve intermittent locking and clicking than PT. But, like Sihvonen et al, we also found that relief in overall pain was not influenced by meniscal symptoms (17).

Gauffin et al included patients with meniscal tear and Ahlbäck grade 0 knee OA (<50% joint space narrowing) randomized to exercise versus APM. Secondary analyses of this study showed no effect of meniscal symptoms (catching or locking for >2 seconds) or interaction between meniscal symptoms and treatment on change in KOOS pain score at 3-year follow-up (18). Similar results were seen in the main trial with 1-year follow-up (19). However, the 3-year as-treated data also found that participants with meniscal symptoms had less improvement in KOOS pain score with APM. The 5-year follow-up data from this study again demonstrated a statistically significant greater reduction in KOOS pain score for those without meniscal symptoms in the APM group (20). As noted by Gauffin et al, meniscal symptoms may be nonspecific and not necessarily reflect meniscal pathology (18). Regardless, our study adds to this body of literature by evaluating a broader range of meniscal symptoms and again suggests that traditional meniscal symptoms do not clearly relate to meniscal pathology in patients with OA, as assessed by response to partial meniscal resection.

Orthopedic surgeons generally assert that the decision to refer a patient with meniscal tear for surgical evaluation should

not be based on the presence of meniscal symptoms alone but be grounded in the surgeon's clinical judgement and patient preference. We acknowledge the wide range of views on this important topic and encourage additional research, such as ours, to clarify unresolved questions regarding the nature of meniscal symptoms and their role in selecting patients for treatment (19,21–23). Prior work from our group using MeTeOR data has shown that patients with fewer osteoarthritic changes on MRI (bone marrow lesions and cartilage damage) have greater improvement of pain with APM than with PT, while those with more substantial OA changes have similar outcomes regardless of whether they undergo APM or PT (24). Therefore, clinical features such as extent of underlying OA and tear type may be more salient to the initial surgical decision than the presence or frequency of meniscal symptoms (24,25). In our study, adjusting for K/L grade, a radiographic marker of OA severity, did not alter results. However, it is likely K/L grade is not sensitive enough to capture underlying pathology. Overall, studies on the use of APM for treatment of meniscal tear have not found APM to be superior to PT (6,7,8,26), although Gauffin et al (19) found benefit to APM and PT compared with PT alone. Based on the current evidence, there are no widely accepted criteria for identifying patients more likely to improve from APM than from PT.

Our study has several limitations. Thirty-one percent (n = 54) of the participants randomized to PT crossed over to APM over 6 months. To address bias from excluding these participants, we included them in intent-to-treat and as-treated analyses. The results of these analyses were similar to those of the primary analysis. We excluded participants without complete 6-month KOOS pain score data, which may introduce bias. As this study is a secondary analysis of MeTeOR data, we have limited power to detect interactions. We did not correct for multiple comparisons and thus recommend caution in interpretation. The follow-up period was 6 months; therefore, we are unable to assess if these results are durable. Meniscal symptoms, including intermittent locking, fluctuate over time. We cannot rule out that any observed improvement was due to chance or natural disease course instead of treatment, and additional confirmatory studies are warranted. Last, as all patients had OA changes in addition to meniscal tear, we were unable to ascertain whether the etiology of the meniscal symptoms was indeed the meniscus or other sources such as damage to cartilage or surrounding structures. Finally, we cannot use these data to draw conclusions regarding younger patients with traumatic-type tears.

In conclusion, our results suggest that in our patients with mild-to-moderate knee OA and meniscal tear, the presence of self-reported clicking, catching, popping, intermittent locking, or swelling does not identify a subgroup that is more likely to have pain relief following APM. Although symptoms of clicking and intermittent locking had a greater reduction in the APM group, the presence of meniscal symptoms in isolation is not sufficient to make a clinical decision regarding APM versus PT for the reduction of pain in this patient population, and further clinical data points must be considered, including patient characteristics, physical examination results, and imaging findings.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. MacFarlane had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. MacFarlane, Yang, Collins, Brophy, Cole, Spindler, Guermazi, Jones, Mandl, Martin, Marx, Levy, Stuart, Safran-Norton, Wright, Wright, Losina, Katz.

Acquisition of data. Brophy, Cole, Spindler, Guermazi, Jones, Martin, Marx, Levy, Stuart, Safran-Norton, Wright, Wright, Losina, Katz.

Analysis and interpretation of data. MacFarlane, Yang, Collins, Brophy, Cole, Spindler, Guermazi, Jones, Mandl, Martin, Marx, Levy, Stuart, Safran-Norton, Wright, Wright, Losina, Katz.

ADDITIONAL DISCLOSURES

Author J. Wright is an employee of Johnson & Johnson.

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