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Brief Report

Importance of patellofemoral and tibiofemoral cartilage lesions on trajectory of self-reported outcomes in patients at high risk of knee OA: 4–6 years follow-up of patients undergoing meniscal surgery

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SUMMARY

Objective: We evaluated whether patient-reported outcome trajectories (i.e., changes over time) differed by intraoperative compartmental cartilage lesion pattern over 4–6 years following arthroscopic meniscal surgery.

Methods: In this ancillary study of the Knee Arthroscopy Cohort Southern Denmark cohort, we intraoperatively categorized cartilage lesions as isolated patellofemoral, isolated tibiofemoral, or combined patellofemoral/tibiofemoral. Participants completed the Knee injury and Osteoarthritis Outcome Score (KOOS) pre-operatively, at 3 and 12 months, and at 4–6 years post-operatively and reported overall satisfaction at final follow-up. Our main outcome was $KOOS_4$ (grand mean of four subscale means). We evaluated whether $KOOS_4$ scores changed over time according to cartilage lesion patterns using adjusted mixed linear regression. We also estimated probability of treatment satisfaction using logistic regression.

Results: Of 630 participants with complete cartilage scores, 280 (44%) were women, mean (standard deviation) age was 49 (13) years, and BMI was 27.3 (4.4) kg/m^2. $KOOS_4$ scores at baseline were slightly lower in all lesion groups compared to the no lesion group, yet only the combined group was statistically significantly lower. $KOOS_4$ trajectories were similar across cartilage lesion patterns, but by final follow-up, adjusted mean $KOOS_4$ scores were 6.8 (95% CI 2.2, 11.4) to 9.8 (1.1, 18.5) points lower in groups with cartilage lesions compared to the no lesion group. Probability of patient-reported satisfaction did not differ statistically by group.

Conclusions: Though $KOOS_4$ scores were slightly lower in groups with arthroscopically assessed cartilage lesions compared to the no lesion group, trajectories were similar across all groups.

Introduction

Meniscal lesions are associated with knee osteoarthritis (OA), hence it is common to see knee OA-related structural abnormalities in individuals treated for meniscal lesions, regardless of whether or not surgery is performed[1–3]. Therefore, while arthroscopic meniscal surgery is not recommended as first-line intervention for

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meniscal lesions[4], individuals who have undergone such surgery likely have, or are at risk of developing, knee OA. Both prevalence and greater severity of cartilage lesions are associated with worse clinical outcomes following meniscal surgery[2,3,5,6].

The prevalence and progression of knee OA has focused largely on the tibiofemoral joint, though patellofemoral OA is also common in populations with meniscal lesions[2]. The few studies that have evaluated the association between patellofemoral joint cartilage lesions at the time of surgery and clinical outcomes have been somewhat conflicting[3,5]. For example, one study found no relationship between intraoperative patellofemoral cartilage lesions and clinical outcomes one year after arthroscopic partial meniscectomy[3], while another showed patellofemoral lesions to be associated with worse outcomes 2–5 years after surgery[5]. These conflicting findings may be explained by the different follow-up periods, meaning it is possible that such a relationship develops or changes over time. No studies have compared both patellofemoral and tibiofemoral lesions with longer-term clinical outcomes. This is particularly relevant because patients with patellofemoral OA may differ clinically from those with tibiofemoral OA, reporting symptoms at least as severe or worse than those with tibiofemoral OA[7,8].

We therefore evaluated whether trajectories (i.e., changes over time) of patient-reported outcomes differed by intraoperative compartmental pattern of cartilage lesions over 4–6 years in patients following arthroscopic meniscal surgery and thus at high risk of knee OA.

Methods

Study design and participants

This is an ancillary study of the prospective Knee Arthroscopy Cohort Southern Denmark (KACS) cohort[9]. This cohort includes 641 participants (mean age 49 years (range 18–77; 43% women) who underwent arthroscopic meniscal surgery (resection or repair), and who had no previous or planned surgeries for the anterior or posterior cruciate ligaments. Study and participant details have been published (ClinicalTrials.gov identifier NCT01871272)[9].

Exposure: cartilage lesions

At the index surgery, surgeons intraoperatively identified cartilage lesions in the medial tibiofemoral, lateral tibiofemoral, and patellofemoral compartments using the International Cartilage Repair Society (ICRS) scoring system (0 = normal, 4 = very severe), a method with good inter-rater reliability (ICC 0.83)[10]. Based on ICRS scores, we defined prevalence of a cartilage lesion as ICRS Grade ≥2, and subsequently classified participants into one of four categories of compartmental patterns: no cartilage lesions (ICRS < Gr. 2 throughout the knee); isolated patellofemoral cartilage lesions (ICRS ≥ Gr. 2 in the patellofemoral compartment only); isolated tibiofemoral cartilage lesions (ICRS ≥ Gr. 2 in the tibiofemoral compartments only); or combined cartilage lesions (ICRS ≥ Gr. 2 in both the patellofemoral and tibiofemoral compartments).

Outcome: Knee injury and Osteoarthritis Outcome Score

Study participants completed the Knee injury and Osteoarthritis Outcome Score (KOOS) pre-operatively, and at 3 months, 12 months, and 4–6 years post-operatively. The KOOS is a 42-item patient-reported outcome measure consisting of five subscales: Pain, Symptoms, Activities of Daily Living (ADL), Function in Sport and Recreation (Sport/Rec), and Quality of Life (QoL)[11]. Participants rate each item on five graded adjectival response options, then mean subscale scores are calculated and converted to a standardized score ranging from 0 to 100, with 100 representing 'no problems'.

We reported the aggregated $KOOS_4$ – the grand mean of four KOOS subscale score averages (excluding KOOS ADL) – as our main outcome, in order to simplify interpretation[9]. Our secondary outcomes were the five individual KOOS subscales, plus two patient-reported global assessment scores assessed at final follow-up. The patient acceptable symptom state (PASS) determines whether a participant is satisfied with their current knee function[12]. The participant was asked to answer 'yes' or 'no' to the question, "*When you think of your knee function, do you consider your current condition as satisfactory? By knee function, you should take into account your activities of daily living, sport and recreational activities, your pain and other symptoms and quality of life*." If participants answered 'no' to this question, they responded to a second question (with 'yes' or 'no') to determine if the participant felt the treatment had failed, "*Would you consider your current state as being so unsatisfactory that you think the treatment has failed*?"

Statistical analyses

To evaluate whether $KOOS_4$ scores differed over time according to baseline compartmental patterns of cartilage lesions, we performed mixed effects linear regression, which is capable of handling unbalanced (i.e., missing) data and thus provides unbiased estimates when data are missing at random. We fit a random intercept at the participant level to account for repeated measures over time. As fixed effects, we included compartmental pattern, the interaction of pattern*time (to evaluate whether changes over time differed by pattern), and covariates age, sex, and body mass index (BMI). Pattern, time and sex were all treated as dummy variables. We repeated these methods for each individual KOOS subscale. After creating each model, we performed post-estimation statistics to confirm normal distribution of residuals and homoscedasticity, then used each model to estimate adjusted KOOS scores (95% CI) for each group at each time point.

At the final follow-up visit, we evaluated differences in proportions of individuals who reported being satisfied (PASS), according to compartmental patterns of cartilage lesions, using logistic regression adjusted for age, sex and BMI. Among the subgroup who did not report being satisfied at the final follow-up visit, we conducted similar analyses for proportions of individuals who reported treatment failure. After running each model, we estimated probabilities (95% CI) of PASS and treatment failure responses, as well as relative risks (95% CI), by group, using Stata's *margins* and *adjrr* commands.

For sensitivity analysis we repeated all analyses in a subgroup of individuals who underwent arthroscopic partial meniscectomy only (i.e., we excluded those who underwent repair) and who were at least 40 years old. All analyses were performed using Stata/SE 15.1 (StataCorp, TX).

Results

Of 630 participants from the KACS cohort with complete cartilage lesion scores at surgery, 280 (44%) were women, mean (standard deviation) age was 49 (13) years, and BMI was 27.3 (4.4) kg/m^2 (Table I, Supplementary Fig. 1). Meniscal resection was performed in 590 (94%) individuals, meniscal repair in 33 (5%), and both were performed in 7 (<1%) cases. For those with cartilage lesions at surgery (n = 349, 55%), the most common pattern was combined patellofemoral and tibiofemoral lesions (n = 207, 33%), followed by isolated tibiofemoral (n = 119, 19%) and isolated patellofemoral (n = 23, 4%). By 4–6 years follow-up, 26% of the sample was lost to

	None (n=281)	Isolated PFJ (n=23)	Isolated TFJ (n=119)	Combined PFJ/TFJ (n=207)
Women, n (%)	97 (35%)	7 (30%)	49 (41%)	119 (57%)
Age	42 (13)	49 (10)	52 (10)	56 (10)
BMI	26.4 (3.4)	26.1 (3.4)	26.8 (4.1)	28.8 (5.3)
Symptom onset, n(%)*				
Slowly	70 (24.9)	4 (17.4)	42 (35.3)	87 (42.0)
Semi-traumatic	115 (40.9)	11 (47.8)	48 (40.3)	81 (39.1)
Traumatic	96 (34.2)	8 (34.8)	29 (24.4)	39 (18.8)
ICRS – medial tibiofemoral n (%)				
0	160 (57%)	11 (48%)	6 (5%)	4 (2%)
1	121 (43%)	12 (52%)	5 (4%)	9 (4%)
2	.	.	52 (44%)	68 (33%)
3	.	.	45 (38%)	94 (45%)
4	.	.	11 (9%)	30 (14%)
ICRS – lateral tibiofemoral % (n)				
0	186 (66%)	16 (70%)	37 (31%)	29 (14%)
1	95 (34%)	7 (30%)	51 (43%)	55 (27%)
2	.	.	17 (14%)	77 (37%)
3	.	.	12 (10%)	33 (16%)
4	.	.	2 (2%)	12 (6%)
ICRS – patellofemoral % (n)				
0	186 (66%)	.	45 (38%)	.
1	95 (34%)	.	74 (62%)	.
2	.	15 (65%)	.	93 (45%)
3	.	5 (22%)	.	85 (41%)
4	.	3 (13%)	.	29 (14%)
$KOOS_4$	48.1 (15.6)	45.7 (17.2)	46.7 (15.0)	41.9 (14.4)
KOOS Pain	58.4 (18.6)	59.2 (20.7)	55.3 (17.8)	49.3 (17.2)
KOOS Symptoms	62.1 (18.9)	52.5 (21.9)	60.4 (18.7)	57.5 (17.5)
KOOS ADL	67.9 (19.0)	65.2 (22.1)	65.2 (18.8)	57.1 (18.4)
KOOS Sport Rec	29.9 (22.7)	26.3 (22.6)	28.3 (21.9)	20.5 (19.9)
KOOS QoL	42.1 (15.1)	44.8 (16.9)	43.0 (15.2)	40.2 (15.7)

All reported values are unadjusted mean (SD) values unless otherwise specified.

* Symptom onset: slowly = symptoms evolved slowly; semi-traumatic = symptoms began with a specific incident such as kneeling, sliding or twisting of the knee; traumatic = symptoms began with a violent incident such as sport-related crash or collision. KOOS = Knee injury and Osteoarthritis Outcome Score; PFJ = patellofemoral joint; TFJ = tibiofemoral joint; BMI = body mass index; ICRS = International Cartilage Repair Society; ADL = activities of daily living; Sport Rec = function in sports and recreation; QoL = quality of life.

Table I Demographics and baseline KOOS scores, by compartmental location of cartilage lesions

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follow-up, however missingness was not correlated with participant characteristics.

$KOOS_4$ scores were similar across groups at baseline, with slightly lower scores for all groups with cartilage lesions, but only the combined lesion group was statistically significantly lower (Table I, Fig. 1, Supplementary Table 1). Changes in $KOOS_4$ scores over time were similar across groups (pattern*time interaction, $P = 0.16$), with slightly higher scores in the group with no cartilage lesions at all time-points (Fig. 1, Supplementary Table 1). Within-group improvements (95% CI) from baseline to final follow-up ranged from 21.2 (13.0, 29.5) for the isolated patellofemoral group to 27.4 (25.0, 29.8) for the no lesion group. At the final follow-up, all three groups with cartilage lesions had statistically significantly lower adjusted mean $KOOS_4$ scores compared to the no lesion group, with worse mean $KOOS_4$ ranging from 6.8 (2.2, 11.4) in the isolated tibiofemoral group to 9.8 (1.1, 18.5) points lower in the isolated patellofemoral group.

Changes in KOOS subscale scores over time were similar to $KOOS_4$, though three of the five subscales (ADL, Sport Rec, and QoL) had statistically significant interaction terms (Supplementary Fig. 2). Mean between-group differences were slightly larger at final follow-up in the Sport Rec and QoL subscales (Supplementary Table 1).

Probability of patient-reported satisfaction (PASS) was 75% (0.75 [95%CI 0.68, 0.81]) for the no lesion group. While not statistically significant, the probability of PASS was on average 10–15% lower in the groups with cartilage lesions, resulting in mean relative risks of 13–19% lower chance of being satisfied for groups with cartilage lesions (Supplementary Table 2). Among those who were not satisfied with their outcomes ($n = 149$), very imprecise estimates of Treatment Failure (i.e., wide confidence intervals) precluded any clear interpretation.

In sensitivity analyses, results did not differ substantially (Supplementary Tables 3 and 4).

Discussion

Changes in $KOOS_4$ scores over time were similar across all patterns of cartilage lesions. Though these trajectories were similar, by final follow-up all three cartilage lesion groups had significantly worse mean $KOOS_4$ scores of approximately 7–10 points lower than the no lesion group, suggesting these differences may be clinically meaningful[9]. These results extend previous work[3,5,6] with longer follow-up periods in a large cohort where both patellofemoral and tibiofemoral cartilage lesions were assessed at baseline, offering more insight into how symptoms change over time.

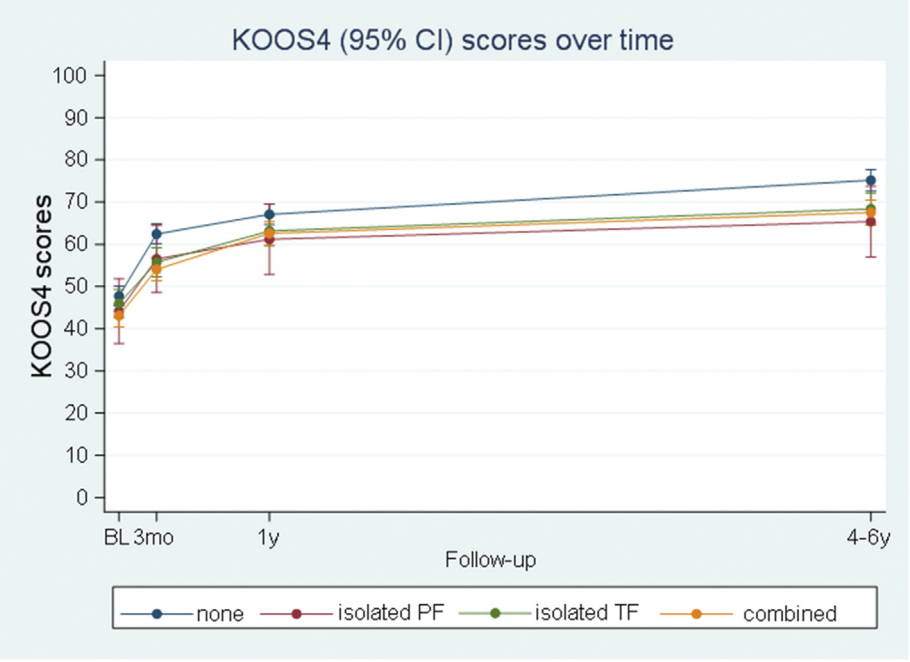

Fig. 1 Adjusted $KOOS_4$ (95% CI) scores according to baseline cartilage lesion compartment pattern, over time. BL = baseline (pre-operative $KOOS_4$ scores); PFJ = patellofemoral joint; TFJ = tibiofemoral joint. See Supplementary Table 1 for sample sizes for each pattern at each follow-up time.

The proportion of individuals in our study with patellofemoral lesions (37%, regardless of tibiofemoral status) can be compared to other meniscal cohorts (49%)[3], asymptomatic cohorts of at least 40 years old (33% [95% CI 20, 48])[13], and to other symptomatic cohorts (43% [95% CI 32, 55])[14]. The proportion of tibiofemoral lesions (52%, regardless of patellofemoral status) can be compared to meniscal cohorts (52%)[3], similarly aged asymptomatic cohorts (38%, [95% CI 24, 54])[13] and knee OA cohorts (27% [95% CI 26, 28] in men, 37% [95% CI 36, 38] in women)[15].

We did not find any specific pattern of intraoperative cartilage lesions to be uniquely prognostic of patient-reported outcomes in the present study. The literature suggests that post-surgically identified patellofemoral OA may still contribute to worse symptoms compared to tibiofemoral OA alone, ten or more years after arthroscopic procedures such as meniscectomy or anterior cruciate ligament reconstruction[7]. While this is beyond the aim of the present study, it does highlight that longer-term outcomes or the further progression of OA after surgery may contribute to symptoms in a compartment-specific way. Further work is needed to clarify the role of different patterns of OA as contributors to symptoms over time, and to evaluate the clinical relevance of these changes. This is particularly important given evidence suggesting relatively weak correlations between structural features and symptoms[13].

Limitations

The sample size of the isolated patellofemoral lesion group was small in the present study ($n = 23$), which resulted in less robust and precise estimates of patient-reported outcomes. Consequently, the study may have been underpowered to detect a statistically significant difference in trajectories. In addition, had we acquired imaging such as MRI in this cohort study, we would have been able to monitor changes in prevalence or severity of cartilage lesions and other joint structure features over time, and compared this to patient-reported outcomes.

To conclude, in this prospective observational study over 4–6 years, neither the presence nor compartmental pattern of cartilage lesions assessed arthroscopically at the time of meniscal surgery markedly impacted the changes in patient-reported outcomes over time. Those with a cartilage lesion (irrespective of location) did tend to have worse patient-reported outcomes at 4–6 years follow-up.

Author contributions

Study coauthors contributed substantially to the conception or design of the work (EMM, KP, AC, JBT, ME, LSL, CV, RK), data acquisition (JBT, KP, LSL, ME, CV, RK), data analysis (EMM, KP, JBT), interpretation of results (EMM, KP, AC, JBT, ME, LSL, CV, RK); drafting the work (EMM), revising the work critically and providing final approval of the manuscript (EMM, KP, AC, JBT, ME, LSL, CV, RK). EMM takes responsibility for the integrity of the work as a whole.

Conflict of interest

JBT has received research funding from Pfizer, not related to the present study. ME has received consultancy fees from Pfizer, not related to the present study.

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.joca.2021.06.002.

References

1. Englund M, Guermazi A, Roemer FW, Aliabadi P, Yang M, Lewis CE, *et al*. Meniscal tear in knees without surgery and the development of radiographic osteoarthritis among middle-aged and elderly persons: the Multicenter Osteoarthritis Study. Arthritis Rheum 2009;60:831–9.
2. Englund M, Lohmander LS. Patellofemoral osteoarthritis coexistent with tibiofemoral osteoarthritis in a meniscectomy population. Ann Rheum Dis 2005;64:1721–6.
3. Cleveland Clinic Sports Health. Predictors of successful treatment 1 Year after arthroscopic partial meniscectomy: data from the OME cohort. JBJS Open Access 2020;5. e19.00044.
4. Thorlund JB, Juhl CB, Roos EM, Lohmander LS. Arthroscopic surgery for degenerative knee: systematic review and meta-analysis of benefits and harms. Br Med J 2015;350:h2747.
5. Ferkel RD, Davis JR, Friedman MJ, Fox JM, Del Pizzo W, Snyder SJ, *et al*. Arthroscopic partial medial meniscectomy: an analysis of unsatisfactory results. Arthrosc J Arthrosc Relat Surg 1985;1:44–52.
6. MacFarlane LA, Yang H, Collins JE, Guermazi A, Jones MH, Spindler KP, *et al*. Influence of baseline magnetic resonance imaging features on outcome of arthroscopic meniscectomy and physical therapy treatment of meniscal tears in osteoarthritis. Am J Sports Med 2019;47:612–9.
7. Culvenor AG, Lai CC, Gabbe BJ, Makdissi M, Collins NJ, Vicenzino B, *et al*. Patellofemoral osteoarthritis is prevalent and associated with worse symptoms and function after hamstring tendon autograft ACL reconstruction. Br J Sports Med 2014;48:435–9.
8. Duncan R, Peat G, Thomas E, Wood L, Hay E, Croft P. How do pain and function vary with compartmental distribution and severity of radiographic knee osteoarthritis? Rheumatology 2008;47:1704–7.
9. Thorlund JB, Englund M, Christensen R, Nissen N, Pihl K, Jørgensen U, *et al*. Patient reported outcomes in patients undergoing arthroscopic partial meniscectomy for traumatic or degenerative meniscal tears: comparative prospective cohort study. Br Med J 2017;356:j356.
10. Smith GD, Taylor J, Almqvist KF, Erggelet C, Knutsen G, Portabella MG, *et al*. Arthroscopic assessment of cartilage repair: a validation study of 2 scoring systems. Arthrosc J Arthrosc Relat Surg 2005;21:1462–7.
11. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee injury and osteoarthritis outcome score (KOOS)–development of a self-administered outcome measure. J Orthop Sports Phys Ther 1998;28:88–96.
12. Tubach F, Ravaud P, Baron G, Falissard B, Logeart I, Bellamy N, *et al*. Evaluation of clinically relevant states in patient reported outcomes in knee and hip osteoarthritis: the patient acceptable symptom state. Ann Rheum Dis 2005;64:34–7.
13. Culvenor AG, Øiestad BE, Hart HF, Stefanik JJ, Guermazi A, Crossley KM. Prevalence of knee osteoarthritis features on magnetic resonance imaging in asymptomatic uninjured adults: a systematic review and meta-analysis. Br J Sports Med 2019;53:1268–78.
14. Hart HF, Stefanik JJ, Wyndow N, Machotka Z, Crossley KM. The prevalence of radiographic and MRI-defined patellofemoral osteoarthritis and structural pathology: a systematic review and meta-analysis. Br J Sports Med 2017;51:1195–208.
15. Pereira D, Peleteiro B, Araujo J, Branco J, Santos RA, Ramos E. The effect of osteoarthritis definition on prevalence and incidence estimates: a systematic review. Osteoarthritis Cartilage 2011;19:1270–85.