

Structural pathology is not related to patient-reported pain and function in patients undergoing meniscal surgery

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ABSTRACT

Background The relationship between meniscal tears and other joint pathologies with patient-reported symptoms is not clear. We investigated associations between structural knee pathologies identified at surgery with preoperative knee pain and function in patients undergoing arthroscopic meniscal surgery.

Methods This study included 443 patients from the Knee Arthroscopy Cohort Southern Denmark (KACS), a prospective cohort following patients 18 years or older undergoing arthroscopic meniscal surgery at 4 hospitals between 1 February 2013 and 31 January 2014. Patient-reported outcomes, including the Knee Injury and Osteoarthritis Outcome Score (KOOS), were obtained by online questionnaires prior to surgery. Knee pathology was assessed by the operating surgeons using a modified version of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification of meniscal tears questionnaire, supplemented with information extracted from surgery reports. Following hypothesis-driven preselection of candidate variables, backward elimination regressions were performed to investigate associations between patient-reported outcomes and structural knee pathologies.

Results Regression models only explained a small proportion of the variability in self-reported pain and function (adjusted $R^2=0.10-0.12$) and this association was mainly driven by age, gender and body mass index.

Conclusions Specific meniscal pathology and other structural joint pathologies found at meniscal surgery were not associated with preoperative self-reported pain and function in patients with meniscal tears questioning inferences made about a direct relationship between these. Our findings question the role of arthroscopic surgery to address structural pathology as a means to improve patient-reported outcomes in patients having surgery for a meniscal tear.

INTRODUCTION

Arthroscopic meniscal surgery is one of the most commonly performed orthopaedic procedures.¹ Diagnosis of meniscal tears involves clinical history and physical examination and is often confirmed by MRI, which has high accuracy in diagnosing meniscal tears.²⁻⁴ MRI-based studies have reported that meniscal tears are common in the contralateral asymptomatic knee in patients sustaining a knee trauma⁵ and in middle-aged and older individuals *without* symptoms and/or signs of radiographic knee osteoarthritis.⁶⁻⁸ In combination with recent evidence challenging the effect of knee arthroscopy

for meniscal tears,⁹ the theoretical framework for meniscal surgery has been questioned: that the meniscus tear is responsible for the patient perceived pain and other symptoms, and that dealing with the meniscal tear by surgery will lead to resolution of symptoms.¹⁰

Meniscal tears often present in combination with other knee pathology at arthroscopy. Thus, it is plausible that knee symptoms may be caused by factors other than meniscal tears per se,¹¹ or some types of meniscal tears could be symptomatic while others are not. Arthroscopy can provide information about meniscal tear pattern and coexisting pathologies potentially related to knee symptoms, such as cartilage damage, synovial changes and inflammation.¹²

The aim of this study was to investigate the association between structural knee pathologies identified at surgery with preoperative pain and function in patients with a verified meniscal tear at surgery.

MATERIALS AND METHODS

Study design

Cross-sectional study investigating the association between preoperative patient-reported knee pain and function and pathological findings at knee arthroscopy.

Participants

Participants from the Knee Arthroscopy Cohort Southern Denmark (KACS)¹³ with baseline assessment of patient-reported outcomes and a verified meniscal tear at surgery. KACS is a prospective cohort study following patients recruited between 1 February 2013 and 31 January 2014 undergoing knee arthroscopy for a meniscal tear at four different public hospitals in Denmark. Patients were informed about the KACS cohort study by a study nurse and asked to sign the consent form after being referred to surgery for a meniscal tear by an orthopaedic surgeon. For logistical reasons, participants at one study site were presented with information about the study prior to seeing the orthopaedic surgeon but signed the consent form after being referred to surgery.

Inclusion criteria were: ≥ 18 years of age, referred to knee arthroscopy on suspicion of a meniscus tear based on clinical examination by an orthopaedic surgeon and MRI (if considered necessary), able to read and speak Danish and having an email address.

Exclusion criteria were: no meniscal tear found at surgery, previous or planned ACL or posterior



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cruciate ligament reconstruction surgery in either knee, fracture (s) to the lower extremities within the past 6 months prior to recruitment or not able to reply to the questionnaire because of mental impairment. Patients with missing data on any structural pathology were excluded from this study.

Informed consent to the use of personal data was obtained from all included patients, even though the Regional Scientific Ethics Committee of Southern Denmark waived the need for ethical approval after reviewing the outline of KACS.¹³

Patient-reported outcomes

Patient-reported outcomes were collected using online questionnaires prior to surgery (median 7 days, IQR 3–11 days). The patient-reported outcomes (ie, dependent variables) of interest for this analysis were: pain, function in sport and recreation (Sport/Rec) and function in daily living (ADL) assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS).¹⁴ These domains were selected, based on their inclusion as primary outcomes to study the effectiveness of meniscal surgery in previous studies.^{9–15} KOOS is a knee-specific questionnaire used to assess patient-reported outcomes of knee injury consisting of five subscales in total: pain, symptoms, ADL, Sport/Rec and quality of life. Each domain ranges from 0 to 100 points with 0 being extremely symptomatic and 100 being asymptomatic. The inclusion of subscales of physical function relating to daily life and sport and recreation enhances KOOS's validity for patients within a wide age range and range of current and expected physical activity levels,¹⁶ such as patients undergoing meniscus surgery since these range from young to old. KOOS is valid for patients undergoing arthroscopic meniscal surgery,^{14–18} and has been used to assess self-reported outcomes in this group of patients.^{19–20}

Structural pathology at arthroscopy

Objective findings of knee pathologies pertaining to the meniscus and cartilage were recorded by the operating surgeon at arthroscopy using a modified version of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification of meniscal tears questionnaire²¹ (ie, including scoring of cartilage using the International Cartilage Repair Society (ICRS) grading system).²² This information was supplemented with additional pathological findings extracted from the patients' surgery reports. Information registered by surgeons on the modified ISAKOS questionnaire was transferred from paper format to electronic format using automated forms processing. This method is a valid alternative to double entry of data.²³

The following variables were included in the analysis: tear location (ie, medial and/or lateral tear), tear depth, circumferential location of tear, radial location of tear, tear pattern, meniscus tissue quality, length of tear, cartilage grade, presence of plica and knee joint laxity assessed by the surgeon at surgery. ACL rupture (only on non-reconstructed patients) and grade of inflammation/synovitis were retrieved from surgery reports. Synovitis was generally well described, especially when present, therefore missing descriptions of synovitis were considered as no synovitis present.

Variable grouping

To improve interpretability of statistical models, we grouped the selected independent variables into blocks of variables of similar construct. For example, all variables concerning structural change of the meniscus were grouped together in a single block. Thus, all selected variables were entered into one of five blocks:

previous surgery, meniscal pathology, cartilage pathology, other findings at arthroscopy and patients characteristics (ie, age, sex and body mass index (BMI) as they are considered traditional confounders; see online supplementary appendix table S1).

Statistical analysis

No power calculation was conducted due to the exploratory nature of the study. Before exclusion of patients with missing data, we conducted a drop out analysis to test for differences between patients with and without missing data. Continuous data were tested using student's unpaired t-test and categorical data using either the χ^2 or Fischer's exact test.

Prior to analysis, collinearity was investigated by calculating variance inflation factors (VIFs) for all independent variables. The level of collinearity was not considered problematic if mean VIF was below 4 and individual VIFs were <10 .²⁴ For each outcome (ie, pain, Sport/Rec and ADL), we performed a linear backward elimination regression analysis on prespecified blocks of variables to investigate which pathological factors that were related to the three different outcomes, respectively. Additionally, we assessed the magnitude and direction of associations between outcome measures and variables included in the models. At first, all candidate blocks were included in the model. At each step, the least significant block of variables was removed by backward elimination using a cut-off of $p \leq 0.10$.

R^2 and adjusted R^2 were examined to describe how well the models explained the overall variance. In addition, hierarchical regressions were performed for blocks reaching statistical significance (ie, $p \leq 0.10$). Significant blocks were entered in order from lowest to highest p value to assess individual R^2 for each block. This method was also used to assess R^2 values for individual variables within each significant block. Finally, distribution of residuals and level of heteroskedasticity were checked for each backward elimination regression model to determine how well a linear regression described the data. Distribution of

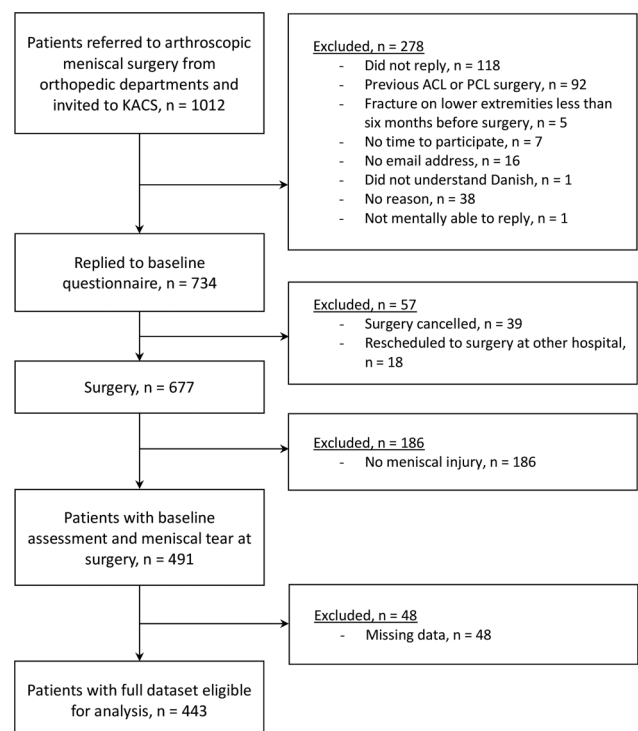


Figure 1 Flow chart of inclusion.

Table 1 Characteristics of patients

Variables	N=443	
		Range
Age, years (SD)	49.7 (12.8)	18–76
Sex, female, n (%)	195 (44.0)	
Height, cm (SD)	174.9 (9.5)	152–201
Weight, kg (SD)	83.7 (15.6)	48–149
BMI, kg/m ² (SD)	27.3 (4.3)	19.5–47.2
KOOS, (SD)		
Pain	54.5 (18.7)	0–97
Sport and recreation	25.8 (21.5)	0–100
ADL	63.6 (19.5)	3–100
Previous meniscus surgery on index knee, n (%)	79 (17.8)	
Tear location		
Medial	329 (74.3)	
Lateral	74 (16.7)	
Both	40 (9.0)	
Tear pattern, n (%)		
Longitudinal–vertical (bucket handle)	84 (19.0)	
Horizontal	32 (7.2)	
Radial	29 (6.6)	
Vertical flap	105 (23.7)	
Horizontal flap	24 (5.4)	
Complex	118 (26.6)	
Root tear	2 (0.5)	
More than one tear type	49 (11.1)	
Tissue quality, n (%)		
Non-degenerative	168 (37.9)	
Degenerative	261 (58.9)	
Undetermined	14 (3.2)	
Tear length, mm (SD)	16.9 (8.7)	2–50
Tear depth, n (%)		
Partial	164 (37.0)	
Complete	279 (63.0)	
Radial location, n (%)		
Posterior	288 (65.0)	
Mid body	44 (9.9)	
Posterior+mid body	73 (16.5)	
Anterior	15 (3.4)	
Anterior+mid body	4 (0.9)	
Posterior+anterior	1 (0.2)	
All	18 (4.1)	
Circumferential location, n (%)		
Zone 1	139 (31.4)	
Zone 2	230 (51.9)	
Zone 3	74 (16.7)	
Medial cartilage grade, n (%)		
Grade 0	111 (25.1)	
Grade 1	107 (24.2)	
Grade 2	89 (20.1)	
Grade 3	101 (22.8)	
Grade 4	35 (7.9)	
Lateral cartilage grade, n (%)		
Grade 0	166 (37.5)	
Grade 1	153 (34.5)	
Grade 2	78 (17.6)	
Grade 3	35 (7.9)	
Grade 4	11 (2.5)	
Patellofemoral cartilage grade, n (%)		
Grade 0	155 (35.0)	

Continued

Table 1 Continued

Variables	N=443	
		Range
Grade 1	114 (25.7)	
Grade 2	77 (17.4)	
Grade 3	70 (15.8)	
Grade 4	27 (6.1)	
Plica, n (%)	165 (37.3)	
Synovitis, n (%)		
None	247 (55.8)	
Irritation/redness	37 (8.4)	
Light synovitis	100 (22.6)	
Moderate synovitis	41 (9.3)	
Severe synovitis	18 (4.1)	
ACL, n (%)		
Intact	394 (89.0)	
Partial rupture (non-reconstructed)	17 (3.8)	
Total rupture (non-reconstructed)	32 (7.2)	
Knee joint laxity (surgeon assessed), n (%)		
No laxity	384 (86.7)	
Slight laxity	44 (9.9)	
Pronounced laxity	15 (3.4)	

Continuous variables are reported as means±SD and categorical variables as frequencies and percentages.

Percentages may not add up to 100% due to rounding.

ADL, function in daily living; BMI, body mass index; KOOS, Knee Injury and Osteoarthritis Outcome Score.

residuals was inspected visually using histograms and qq-plots. Level of heteroskedasticity was inspected visually by plotting standardised residuals against fitted values.

RESULTS

Participant characteristics

In total, 1012 patients were invited to participate in the study. Three hundred and thirty-five of these were excluded prior to surgery, and 186 out of the 677 patients who underwent arthroscopic surgery were excluded because no meniscal tear was found (ie, corresponding to 18%, 12%, 30% and 16% of patients at the four recruitment sites, respectively; [figure 1](#)). The majority (71%) of the remaining 491 patients had a preoperative MRI to confirm the presence of a meniscal tear. The 491 arthroscopic surgeries were performed by 42 different surgeons, with 15 surgeons being responsible for 86% of the surgeries. Subsequent to surgery, 48 patients with missing values on the modified ISAKOS questionnaire were excluded after no difference was found between patients with and without missing data (see online supplementary appendix table S2). After exclusions, a total of 443 patients were included for analysis ([figure 1](#)).

The majority of patients were male and the study sample on average middle-aged and slightly overweight. Most patients had medial meniscal tears and many patients had concomitant cartilage damage ([table 1](#)).

Regression analyses

In general, no association between structural pathology and self-reported outcomes was found for pain or ADL function ([tables 2](#) and [3](#)). For Sport/Rec function, <5% of the variability in this score could be attributed to the ‘other findings at arthroscopy’, which was driven by increasing levels of synovitis being

Table 2 Backward stepwise regression in blocks for associations with KOOS pain

Variables	Adjusted R ²	Regression			p Value
		R ²	coefficient (β)	95% CI	
KOOS pain	0.100	0.107			
Person characteristics		0.107			<0.001
Age		0.014	-0.18	(-0.31 to -0.05)	0.008
Sex, female		0.037	-6.69	(-10.06 to -3.33)	<0.001
BMI		0.055	-0.96	(-1.34 to -0.57)	<0.001
Model intercept			92.4	(80.4 to 104.3)	

Elimination criteria $p \leq 0.10$.

Stepwise elimination of blocks of independent variables: Previous meniscus surgery ($p=0.908$), other findings at arthroscopy ($p=0.441$), meniscal pathology ($p=0.308$), cartilage pathology ($p=0.372$).

Individual R² values may not add up to total R² due to rounding.

BMI, body mass index; KOOS, Knee Injury and Osteoarthritis Outcome Score.

Table 3 Backward stepwise regression in blocks for associations with KOOS ADL

Variables	Adjusted R ²	Regression			p Value
		R ²	coefficient (β)	95% CI	
KOOS ADL	0.116	0.122			
Person characteristics		0.122			<0.001
Age		0.044	-0.30	(-0.43 to -0.16)	<0.001
Sex, female		0.021	-5.77	(-9.24 to -2.30)	0.001
BMI		0.056	-0.97	(-1.37 to -0.58)	<0.001
Model intercept			107.4	(95.0 to 119.7)	

Elimination criteria $p \leq 0.10$.

Stepwise elimination of blocks of independent variables: previous meniscus surgery ($p=0.926$), other findings at arthroscopy ($p=0.353$), meniscal pathology ($p=0.157$), cartilage pathology ($p=0.308$).

Individual R² values may not add up to total R² due to rounding.

ADL, function in daily living; BMI, body mass index; KOOS, Knee Injury and Osteoarthritis Outcome Score.

associated with poorer Sport/Rec function (table 4). The 'other findings at arthroscopy' block was the only significant structural pathology block across models.

Overall, the adjusted R² values indicated that the variables in the regression models could explain only 10%, 11% and 12% of the variability in Pain, Sport/Rec and ADL, respectively, and this was mainly explained by the patient characteristics age, gender and BMI (tables 2–4).

Collinearity and model assumptions

No collinearity was detected between independent variables included in the regression analyses. Visual inspection of relevant plots and appropriate statistical tests showed normal distribution of residuals and no signs of heteroskedasticity for the pain and ADL model, confirming that a linear regression described the models well. The Sport/Rec model showed obvious flooring effect, slight heteroskedasticity and a less perfect distribution of residuals than the other models, however the linear regression model still described the data sufficiently.

DISCUSSION

We found no relevant association between structural knee pathology and self-reported pain and function prior to arthroscopic meniscal surgery in this study. Synovitis was the only variable to explain a very small part of the variability in the self-reported Sport/Rec function of the KOOS questionnaire. In all models, the patient characteristics of age, female gender and greater BMI were consistently but weakly associated with poorer self-reported outcomes.

MRI-based studies have reported that the presence of meniscal tears is common in patient knees in the absence of patient-reported symptoms,^{5–8} challenging the classical tenet of meniscal injuries being a main cause of knee symptoms in patients with meniscal pathology. The menisci are mainly innervated in the peripheral, vascular zone, represented by the outer one-third of the menisci and the anterior and posterior horns.²⁵ No nerve fibres are seen in the avascular intermediate or inner third of the menisci.²⁵ Sensation of pain in the non-anaesthetised human knee has been reported to be markedly higher from the outer than the inner rim of the menisci, investigated by instrumented arthroscopic palpation.²⁶ Thus, it is plausible that factors such as size, location and type of meniscal tear could be important for patient perceived pain. Hypothetically, a small radial tear in the avascular zone should not cause pain, whereas a tear in the outer third part presumably would. However, in the present study we found no association between any of the investigated structural pathologies related to the meniscal tear and self-reported pain.

Synovitis has been reported to be associated with preoperative pain and dysfunction in patients with traumatic meniscal injury undergoing partial meniscectomy.¹² The results of the present study are in line with this, as increasing levels of synovitis were somewhat associated with poorer function during strenuous tasks (ie, Sport/Rec function). However, this result should be interpreted with caution as the association was not consistent across models and only explained about 3% of the variability in KOOS Sport/Rec function score.

Implications of findings

Inferences about a clear relationship between structural knee pathology and patient perceived symptoms as part of a rationale for the indication for arthroscopic meniscus surgery are not supported by results of the present study. Further, the results of our study do not support a construct of specific subgroups of patients, based on meniscal and other structural pathology, which may have particular benefit of surgery compared with others. The lack of association between structural pathology on the one hand, and pain and physical function on the other hand, may partially explain the reported lack of efficacy of arthroscopic surgery for knee pain in middle-aged and older adults.⁹

Limitations

The analysis was based on stepwise regression procedures, which are data driven and known to produce selection bias and optimism as a result of overfitting.^{27–28} However, models with small sample sizes are most prone to overfitting,²⁸ and selected variables with very small p values (for instance $p < 0.001$) are much less prone to selection bias and overfitting than variables with p values near the chosen significance level.²⁷ Yet, no internal validation procedure was performed in this study, and the extent of overfitting due to the use of predictor selection strategies is therefore unaccounted for.²⁸ Given the general lack

Table 4 Backward stepwise regression in blocks for associations with KOOS Sport/Rec

Variables	Adjusted R ²	R ²	Regression coefficient (β)	95% CI	p Value
KOOS Sport/Rec	0.113	0.137			
Person characteristics		0.094			<0.001
Age		0.027	−0.23	(−0.39 to −0.07)	0.005
Sex, female		0.058	−8.98	(−12.89 to −5.07)	<0.001
BMI		0.009	−0.40	(−0.84 to 0.05)	0.081
Other findings at arthroscopy		0.043			0.013
Synovitis		0.030			0.011
None			Reference		
Irritation/redness			−3.50	(−10.63 to 3.63)	
Mild synovitis			−6.05	(−10.85 to −1.25)	
Moderate synovitis			−9.00	(−15.99 to −2.01)	
Severe synovitis			−11.21	(−21.04 to −1.39)	
ACL rupture		0.001			0.800
Intact			Reference		
Partial rupture (non-reconstructed)			−3.43	(−14.29 to 7.43)	
Total rupture (non-reconstructed)			0.38	(−9.48 to 10.24)	
Plica		0.001			0.493
No			Reference		
Yes			1.40	(−2.61 to 5.42)	
Knee joint laxity (surgeon assessed)		0.010			0.259
No laxity			Reference		
Slight laxity			−5.61	(−12.98 to 1.76)	
Pronounced laxity			−7.48	(−20.64 to 5.68)	
Model intercept			54.9	(40.8 to 69.0)	

Elimination criteria $p \leq 0.10$.

Stepwise elimination of blocks of independent variables: previous meniscus surgery ($p=0.575$), cartilage pathology ($p=0.407$), meniscal pathology ($p=0.339$).

Individual R² values may not add up to total R² due to rounding.

BMI, body mass index; KOOS, Knee Injury and Osteoarthritis Outcome Score; Sport/Rec, sport and recreation.

of relationship between structural pathology and self-reported outcomes in this study, we do not consider overfitting of models a problem. To accommodate for possible variable selection bias, we narrowed the list of candidate variables prior to backward elimination regressions based on literature and likely hypotheses, making the models hypothesis driven. Such preanalysis selection is considered a good alternative to plain data-driven variable selection.²⁸ To avoid biased selection of variables prior to analysis, no statistical tests were conducted on the data in advance of the selection procedure.

In the present study, we used validated methods^{21 22} to systematically collect information about knee joint pathology at arthroscopy supplemented with information from surgery reports. Even though such methods have shown moderate-to-good reliability, some misclassification of joint pathology may have occurred, which potentially could attenuate an association with self-reported pain and function. However, we consider it unlikely that such misclassification may have caused the complete lack of association observed in the present study.

In the present study, 186 of 677 patients who underwent surgery on suspicion of a meniscal tear did not have a meniscal tear at arthroscopy leading them to being excluded from our present analysis. This may partly be explained by the absence of MRI to verify the presence of a meniscal tear in all patients. However, we believe the results are generalisable to Danish patients undergoing meniscal surgery as the average age of patients in the present study was 49.7 years and 44% were female. This is similar to nationwide data from the Danish National Patient Registry showing that in 2011 patients

undergoing meniscal surgery on average were 47 years old and 41% were female.²⁹

CONCLUSION

Specific meniscal pathology and other structural joint pathologies found at arthroscopic meniscal surgery were not associated with preoperative self-reported pain and function in patients with meniscal tears, suggesting that inferences about a direct relationship between these are questionable. Increasing age, female gender and greater BMI were consistently associated with poorer self-reported outcomes, although the variability explained was modest. Our findings question the role of arthroscopic surgery to address structural pathology as a means to improve patient-reported outcomes in patients having surgery for a meniscal tear.

What are the findings?

- ▶ Meniscal pathology features such as tear type, tear size and tear location identified at arthroscopy were not associated with preoperative self-reported knee pain and function in patients undergoing arthroscopic meniscal surgery.
- ▶ Other structural knee joint pathologies found at surgery, such as cartilage damage, were not associated with preoperative self-reported knee pain and function.
- ▶ Increasing age, female gender and greater body mass index were modestly associated with poorer self-reported outcomes.

How might it impact on clinical practice in the future?

- ▶ These findings question inferences made about relationships between structural knee pathology and patient perceived symptoms.
- ▶ Our findings question the role of arthroscopy to address structural pathology as a means to improve patient-reported outcomes and the construct of specific subgroups of patients, based on meniscal and other structural pathology, who may benefit from meniscal surgery.

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