

Osteoarthritis and Cartilage



Changes in knee joint load indices from before to 12 months after arthroscopic partial meniscectomy: a prospective cohort study

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SUMMARY

Objective: Patients undergoing arthroscopic partial meniscectomy (APM) are at increased risk of knee osteoarthritis (OA). Meniscal damage and/or surgery may alter knee joint loading to increase OA risk. We investigated changes in knee joint loading following medial APM surgery, compared with the contra-lateral leg.

Methods: We estimated indices of knee joint loading (external peak knee adduction moment (KAM), KAM impulse and peak knee flexion moments (KFMs)) normalized to body size (i.e., body mass (BM) and height (HT)) using 3D gait analysis in 23 patients (17 men, mean (SD) 46.2 (6.4) years, BMI 25.8 (3.4) kg/m²) without radiographic knee OA before and 12 months after medial APM. Static alignment was assessed by radiography and self-reported outcomes by Knee injury and Osteoarthritis Outcome Score (KOOS).

Results: Peak KAM and KAM impulse increased in the APM leg compared to the contra-lateral leg from before to 12 months after surgery (change difference: 0.38 Nm/BM*HT% 95% CI 0.01 to 0.76 ($P = 0.049$) and 0.20 Nm*s/BM*HT% 95% CI 0.10 to 0.30 ($P < 0.001$)). Patients self-reported improvements on all KOOS subscales (KOOS pain improvement: 22.8 95% CI 14.5 to 31.0 ($P < 0.01$)).

Conclusions: A relative increase in indices of medial compartment loading was observed in the leg undergoing APM compared with the contra-lateral leg from before to 12 months after surgery. This increase may contribute to the elevated risk of knee OA in these patients. Randomized trials including a non-surgical control group are needed to determine if changes in joint loading following APM are caused by surgery or by changes in symptoms.

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Introduction

Biomechanical factors play an important role in the initiation and progression of knee osteoarthritis (OA)¹. One such factor is dynamic loading during walking. The external knee adduction moment (KAM), calculated from gait analysis, is considered a valid and reliable estimate of medial tibiofemoral compartment loading^{2,3} and studies have shown that increased KAM is related to disease severity⁴, disease progression^{5–7} and structural joint changes⁸ in patients with knee OA.

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Meniscectomized patients have a high risk of developing knee OA⁹ and have knee arthroplasty at a younger age compared to patients without prior knee surgery¹⁰. Arthroscopic partial meniscectomy (APM) is one of the most frequently performed orthopedic procedures¹¹, even though surgery is not superior to non-operative interventions in relieving pain in middle-aged and older patients¹². Patients who have undergone medial meniscectomy show increased KAM, indicative of an increase in the medial tibiofemoral compartment loading compared to healthy controls^{13,14}. Furthermore, a higher KAM is predictive of structural knee joint changes in these patients¹⁵. Collectively, these findings indicate that increased knee joint loading may contribute to the increased risk of knee OA in meniscectomized patients.

The KAM is primarily determined by the magnitude of the ground reaction force vector and the degree of varus alignment⁸, and removal of medial meniscus tissue could increase joint loading via an increase in the varus alignment of the knee. Indeed, one cross-sectional study reported increased varus alignment 5 years after medial meniscectomy, with the increase in varus alignment dependent on the amount of meniscus tissue resected¹⁶. On the other hand, change in gait speed, which is often affected by pathology or symptoms, could also affect the ground reaction force and elicit changes in the KAM^{17,18}. To our knowledge, no studies have investigated *in vivo* changes in medial compartment knee joint loading from before to after arthroscopic partial medial meniscectomy.

The aim of this study was to investigate changes in indices of medial compartment knee joint loading in the leg undergoing surgery from before to 12 months after medial APM, as compared with the contra-lateral leg. We hypothesized that indices of knee joint loading would increase in the leg undergoing surgery compared to the contra-lateral leg.

Method

The “Strengthening the Reporting of Observational Studies in Epidemiology” (STROBE) Statement was used as guideline for reporting this observational study¹⁹.

Patients

Patients aged 35–55 years at time of enrollment and assigned for partial meniscectomy by an orthopedic specialist on suspicion of a medial meniscal tear were recruited. We included patients from April 2012 to September 2013 from two public hospitals (Odense University Hospital, Odense and Lillebaelt Hospital, Kolding) and one private clinic in the city of Odense with self-reported gradual symptom onset or symptom onset caused by a minor incident like bending/twisting of the knee during daily activities (i.e., tears of degenerative origin). Exclusion criteria were: clear traumatic symptom onset (i.e., caused by a sports injury, crash or collision); tibiofemoral and/or patellofemoral OA defined as having Kellgren and Lawrence (K/L) grades 2 or higher in either knee; previous knee surgery in either knee; back pain within last 30 days limiting physical activity; other injuries limiting physical activity within last 30 days; BMI above 36 kg/m²; very low physical activity level (indoors walking only). After meniscectomy, patients were given a leaflet with standard rehabilitation exercises, which they were encouraged to perform at home. Information on compliance with the exercise recommendation was not collected. All patients gave their written informed consent and the Ethics Committee for the Region of Southern Denmark approved the study (ID: 20120006).

Radiographs

Standardized fixed-flexion posteroanterior and skyline X-ray examinations were made at baseline prior to surgery to assess degree of radiographic tibiofemoral and patellofemoral OA according to Kellgren and Lawrence²⁰. For standardization of X-ray examinations of the tibiofemoral compartments the Synflexer frame was used²¹. Anatomical knee alignment was estimated from the short film X-ray examinations at both baseline and 12 months follow-up using a conversion of anatomical femorotibial axis to mechanical axis²² with lower values representing varus alignment. All X-ray images were scored by a resident specializing in radiology (GMJ) (ICC_{3,1} 0.99 for assessment of alignment).

Gait analysis

Gait analysis was performed before and 12 months after APM. A six-camera (100 Hz) 3D motion analysis system (Nexus version 1.8.5, Vicon, Oxford, UK) was used to estimate the knee joint moments during walking. The standard plug-in-gait marker set was used and ground reaction forces were measured (1000 Hz) in synchrony with the kinematic data using two force plates (AMTI, OR6-7 Series Inc., Watertown, MA, US) imbedded in the floor. Patients walked barefoot at self-selected speed. If patients walked more than 5% faster or slower at the follow-up assessments we collected data from additional trials matching the baseline speed ($\pm 5\%$) as walking speed is known to affect joint moments¹⁷. Knee joint moments were estimated using inverse dynamics and normalized to body mass (BM) and height (HT). Subsequently, the following variables of interest were extracted: external peak KAM (Nm/BM*HT%), KAM impulse (Nm*s/BW*HT%) and peak knee flexion moment (KFM; Nm/BM*HT%). We included the KFM since it has been reported to contribute to medial compartment contact force²³. Variables were calculated for individual trials and averaged over five trials. Test–retest reliability in our laboratory for peak KAM, KAM impulse and peak KFM is 0.84, 0.95 and 0.77 (ICC_{3,1}), respectively.

Knee injury and Osteoarthritis Outcome Score (KOOS)

Patient reported symptoms, pain, function and quality of life were collected using the KOOS questionnaire prior to meniscectomy and at the 12 month follow-up. A normalized score was calculated for each subscale (0 indicating extreme symptoms and 100 indicating no symptoms). The KOOS score has been validated for meniscectomy patients and has shown high test–retest reproducibility^{24,25}.

Collection of surgery information

All surgeries were carried out under general anesthesia. Information regarding the location of tear within the medial compartment (anterior, mid body or posterior) and amount of tissue resected (in %) was collected using the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine – Classification of meniscal tears questionnaire (ISAKOS) filled out by the operating surgeon. We report amount of resection as 0–25%, 26–50%, or more than 50%. The ISAKOS questionnaire has moderate reliability for reporting of such structural/surgical features²⁶.

Statistical analysis

The main outcomes were change in peak KAM, KAM impulse and peak KFM from before to 12 month after APM. All outcomes

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