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Patellofemoral and tibiofemoral morphology and biomechanical changes following arthroscopic partial medial meniscectomy

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SUMMARY

Individuals who undergo arthroscopic partial meniscectomy have increased risk of developing tibiofemoral osteoarthritis. This study further investigated this and the risk of developing patellofemoral osteoarthritis.

158 patients who had undergone medial APM underwent a MRI and gait testing 3 month, 2 year or 4 years post surgery. Cartilage volume, defects, and bone volume/area were assessed in the tibiofemoral and patellofemoral compartments from MRI. Biomechanical variables such as knee adduction and extension moments were also identified. Regressions were used to identify if surgery and which gait variables were related to early signs of knee joint osteoarthritis.

Medial APM was associated with increased risk of cartilage defects in both compartments (all $p=0.02$), and increased medial tibial plateau area ($p=0.01$). Increased time from medial APM was related to a higher risk of cartilage defects in the medial tibiofemoral ($p=0.09$) and patellofemoral ($p=0.02$) compartments and increased medial tibial plateau area ($p=0.03$). The gait parameters are currently undergoing analysis.

Meniscectomy has adverse impacts on both the tibiofemoral and patellofemoral joints within 5 years post-surgery. Strategies aiming at preventing the development of osteoarthritis should focus on both compartments. Identification of gait variables related to this increased risk will inform these possible strategies.

INTRODUCTION

Meniscectomy is a common surgical procedure used to treat a symptomatic meniscal tear. Meniscectomy has been recognized as an important risk factor for tibiofemoral osteoarthritis [7]. However, whether meniscectomy is associated with adverse effects on the patellofemoral compartment is not clear [3]. To date, the only study investigating this relationship reported increased frequency of patellofemoral osteoarthritis coexisted with tibiofemoral osteoarthritis 15 to 22 years post-surgery in a meniscectomy population free of radiographic knee osteoarthritis at the index surgery compared with controls [3]. However it remains unclear whether this was simply due to the coexistence of patellofemoral osteoarthritis in a knee with tibiofemoral osteoarthritis or whether patellofemoral

osteoarthritis developed as a consequence of the meniscectomy.

In previous MRI studies we showed an increased rate of knee cartilage loss over 2 years, and a greater prevalence and severity of cartilage defects over 3-5 years in tibiofemoral joint following partial meniscectomy when compared with healthy controls [5]. Moreover, changes in gait patterns are present as early as 3 months following a partial meniscectomy [8]. Given the role of biomechanical factors in the pathogenesis of osteoarthritis [6], it may be that tibiofemoral and patellofemoral joint changes related to knee osteoarthritis may both develop early after the initial surgery

Since there is currently very limited literature on the relationship between development patellofemoral osteoarthritis and knee meniscectomy, we used this cross-sectional study to identify if patients who had previously undergone arthroscopic partial medial meniscectomy (APMM) 3 months, 2 years or 4 years prior, exhibited morphological differences in tibiofemoral and patellofemoral joints assessed by MRI compared with healthy controls. We also aimed to identify what gait parameters are related to the development of both tibiofemoral and patellofemoral osteoarthritis.

METHODS

158 patients who had undergone APMM either 3 month, 2 year or 4 years prior were recruited for this study. A further 38 healthy individuals were recruited to act as a control group.

On the day of their testing all participants underwent a MRI and gait testing. MRIs were performed at one of two sites, one in Perth and one in Melbourne, utilizing previously published sequences [5]. Cartilage defects were graded in tibiofemoral and patellofemoral compartments using a classification system previously described where grade 0 represents normal cartilage and grade 4 full-thickness cartilage wear with exposure of subchondral bone [2]. A prevalent cartilage defect was defined as a cartilage defect score of > 2 at any site. Tibial and patellar cartilage volumes were measured using the software ImageJ and Osiris, respectively [10]. Cross-sectional area of tibial plateau was determined using Osiris from axial images [9]. Patellar bone volume was calculated by using the same method as for cartilage volume [4]. All measures were performed by independent trained observers, with independent random

cross checks blindly performed by a different trained observer, all blinded to clinical and group status.

The gait analysis utilized VICON MX cameras, 2 AMIT force plates and electromyography data collected from ten muscles crossing the knee using a Delysis system. The UWA marker set and models were used for the 3-dimensional motion analysis[1]. The following variables were identified during gait – external peak knee adduction and extension moments, adduction moment impulse, knee range of motion, levels of co-contraction, heel strike transient force as well as quadriceps and hamstring strength as assessed using dynamometry.

Multivariate regression models were constructed to explore the relationship between both 1) meniscectomy-related variables and 2) gait variables with knee cartilage and bone, adjusting for potential confounders of age, gender, BMI, MRI resource (Perth or Melbourne scanner), cartilage volume and bone size for cartilage defects, and bone size for cartilage volume. P-values < 0.05 were considered statistically significant. All analyses were performed using the SPSS statistical package.

RESULTS AND DISCUSSION

The analysis of the gait variables is currently being undertaken. As such the results and discussion will focus on the relationship of the meniscectomy variables, having undergone and time from surgery, with the architecture as identified in the MRI analysis. Results will be presented as (Odds ratio (95% confidence interval), P value)

APMM patients had an increased prevalence of medial tibiofemoral (3.17 (1.24, 8.11), $p = 0.02$) and patellar cartilage defects (13.76 (1.52, 124.80), $p = 0.02$) compared with the controls. After adjustment for the confounders, time from APMM was positively associated with the prevalence of patellar cartilage defects (1.04 (1.01, 1.07), $p = 0.02$), and weakly positively, but not significantly, associated with the prevalence of medial tibiofemoral cartilage defects (1.02 (1.00, 1.03), $p = 0.09$).

APMM was not significantly associated with medial tibial (-75.8 (-211.0, 59.4), $p = 0.27$) or patellar cartilage (-11.6 (-256.5, 233.3), $p = 0.93$) volume after adjustment for confounders. Time between APMM and MRI was not significantly related to medial tibial (-1.5 (-4.3, 1.2), $p = 0.27$) or patella cartilage volume (2.0 (-2.9, 6.8), $p = 0.43$) after adjusting for confounders.

After adjusting for confounders, APMM and time from APMM were significantly associated with medial tibial plateau bone area (APMM 143.8 (57.4, 230.2), $p = 0.001$) – time from APMM 2.5 (0.8, 4.3), $p = 0.005$) but not patellar bone volume (APMM 722.5 (-442.1, 1887.1), $p = 0.22$) – time from APMM 9.4 (-14.2, 32.9), $p = 0.43$).

As expected from previous work APMM was related to changes in the medial tibiofemoral compartment, and while non-significant the further away from the time of surgery a participant was the likelihood of them having morphological

changes within this compartment. The results also support those of Englund and Lhomander [3] who identified that those who had undergone a APMM were at increased risk of developing patellofemoral osteoarthritis. The strong relationship to time from surgery further supports the proposition that the developed early signs of osteoarthritis is in some manner related to the surgery. While there were no changes in cartilage volume in either compartment, it would be expected that this would develop as the patients further progressed from their surgery.

What is unclear from the results presented to date is the mechanism by which APMM could affect the patella cartilage. It is hoped that the analysis of the biomechanical variables collected on these patients may be able to shed further light on possible mechanisms.

CONCLUSIONS

MRI evidence of morphological changes appears in both the tibiofemoral and patellofemoral joints in patients with following APMM. Both APMM and increased time from APMM are associated with adverse effect on articular cartilage in both compartments. These findings suggest that meniscectomy plays a role in the pathogenesis of both tibiofemoral and patellofemoral osteoarthritis. However additional prospective longitudinal studies are needed to better understand the influence of APMM on cartilage loss within the knee joint. Strategies will need to be developed that focus on prevention in both the tibiofemoral and patellofemoral compartments following meniscectomy in order to reduce the risk of osteoarthritis. Identification of biomechanical parameters related to the development of osteoarthritis will better inform these interventions.

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