PATELLOFEMORAL JOINT FORCES DURING RUNNING IN MENISCECTOMISED KNEES

Chelsea Starbuck[1,2,3], Vanessa Walters[2,3], Lee Herrington[2], Bilal Birtakli[4], Richard Jones[2,3]

[1] Faculty of Science and Engineering, Swansea University, UK
[2] School of Health and Society, University of Salford, Salford, UK
[3] The Manchester Institute of Health and Performance, Manchester, UK
[4] Salford Royal NHS Teaching Foundation Trust, Salford, UK

Meniscal injuries in sports are common and often require surgical treatment. Individuals who undergo a partial meniscectomy often complain of patellofemoral pain and later develop degenerative changes in the patella. This study compared peak patellofemoral joint (PFJ) stresses during running in those who have had a meniscectomy (both affected and contralateral limbs) with healthy individuals. Kinematic and kinetic data were collected during running and used to estimate PFJ stresses. Peak hip, knee, ankle angles and moments were calculated. PFJ stresses were lower in the affected limb compared to the contralateral limb and healthy group. The affected limb also demonstrated reduced knee and ankle moments compared to the healthy group. Reduced PFJ stresses following a meniscectomy are likely to be a result of a quadriceps avoidance strategy which is likely to be used to compensate for the quadriceps weakness and atrophy often reported following a meniscectomy. Reduced PFJ stresses, if prolonged, could lead to tissue atrophy and a greater risk of injury.

KEYWORDS: meniscal injury, kinetics, patellofemoral joint

INTRODUCTION: Meniscal injuries are common in sports (Mitchell et al., 2016). Arthroscopic partial meniscectomies are often performed if the injury occurs where there is limited blood supply or if there is a mechanical block (Abram et al., 2019). Individuals continue to experience pain and poor knee function following a meniscectomy despite returning to sport. Patellofemoral pain (PFP) is a common complaint following arthroscopic knee surgery and in those who have had a meniscectomy (Amestoy et al., 2021). Degenerative changes in the knee including the patella are also common in those who have had a meniscectomy (Eichinger et al., 2016; Pengas et al., 2019).

Quadriceps dysfunction has been reported in individuals who develop PFP following a meniscectomy compared to those who do not develop PFP (Amestoy et al., 2021). It is unclear how these deficits reported following a meniscectomy affect movement patterns and PFJ loading. Previous studies have assessed knee loading during jogging (Hall et al., 2017) and treadmill running (Willy et al., 2016) rather than overground running which could give altered results. Furthermore, these studies did not assess PFJ loading in individuals following a meniscectomy. This study aims to compare peak PFJ stresses during running between the affected and contralateral limbs in those who have had a meniscectomy. This study also aims to compare peak PFJ stresses during running between individuals who have had a meniscectomy and healthy individuals.

METHODS: Individuals who had undergone a meniscectomy (3 to 12 months post-surgery) were recruited from clinics (NHS and private orthopaedic). Healthy individuals were recruited from sports clubs and fitness centres. Participants who competed or participated in sport at least twice a week were included in this study. Ethical approval was given from the UK NHS Regional Ethical Committee and informed consent was obtained from each participant before data collection.

Participants were included if they were aged between 18 and 40 years and competed/ participated in sport at least twice a week. For the meniscectomy group, individuals were included in the study if they sustained their meniscal injury during a sporting movement (e.g. change of direction, landing or running) indicating a traumatic meniscal injury. Participants were excluded if they had a history of lower extremity surgeries, except a meniscectomy, previous lower limb traumatic injury, other than the sustained meniscal injury, inflammatory or infectious pathology in the lower limb or ligament laxity.

Participants were asked to run at self-selected speed over a 60-m running track. Kinematic (200 Hz; 27 Qualisys Oqus, Gothenburg, Sweden) and kinetic (1000 Hz; 4 AMTI force plates located 20 m, Advanced Mechanical Technology, Inc, Newton, MA) data were collected. The CAST marker set technique was used. Retro-reflective markers were placed on the participant's lower limbs and thorax. To track motion, rigid clusters that had four non-orthogonal markers were attached to the thighs and shanks (Cappozzo et al., 1995; Starbuck et al., 2021). Visual3D was used to create a six-degree of freedom model and calculate kinematic and kinetic curves normalised to the stance phase. Motion and force data were filtered using a 4^{th} order Butterworth filter with a cut off frequency of 15 Hz. Inverse dynamics were used to calculate hip, knee, and ankle joint moments. Internal joint moments were calculated and normalised to body mass. Hip, knee and ankle sagittal joint angles and moments during stance were used to estimate PFJ and account for forces acting across the knee from both hamstrings and gastrocnemius. A custom-written MATLAB code was used to estimate PFJ stresses as previously reported (Starbuck et al., 2021). Peak PFJ stress and loading rates were calculated. Peak angles and moments were taken for ankle, knee, and hip during stance. Outcomes were obtained for the healthy group and meniscectomy group (both affected and contralateral limbs). Paired t-tests were used to compare between the affected limb and contralateral limb. Independent t-tests were used to compare between the affected limb and the healthy limb. Effect sizes were determined using Hedge's *g*.

RESULTS: Data were collected on 30 individuals following a meniscectomy (20 males and 10 females, age 29.7 ± 6.6 years, height 175.6 ± 9.6 cm, mass 82.3 ± 13.9 kg) and 20 healthy individuals (12 males and 8 females, age 24.7 ± 5.0 years, height 175.1 ± 8.6 cm, and mass 74.5 ± 11.8 kg). The meniscectomy group had greater body mass compared to the healthy group (p = .044). No differences in height were observed between groups (p = .877). Running speed did not differ between groups (healthy group – 3.7 ± 0.6 m/s, meniscectomy group 3.6 ± 0.7 m/s, p=.693).

Peak PFJ stresses were lower in the affected knee compared to the contralateral knee (p < .001, g = .808) and healthy knee (p = .009, g = .769; Table 1). The affected knee had lower peak PFJ loading rates compared to the contralateral knee (p < .001, g = .888). No differences in peak PFJ loading rates were observed between the affected and healthy knee (p = .062, g = .543). Peak knee flexion angles were lower in the affected knee compared to the contralateral knee (p = .012, g = .484). No differences in peak knee flexion angles between the affected knee and healthy knee (p = .140, g = .427). Peak knee extension moments were lower in the affected limbs compared to both healthy (p = .001, g = .908) and contralateral limbs (p < .001, g = .872). The affected limb had lower peak ankle dorsiflexion angles compared to the contralateral limb (p = .003, g = .596). No differences in peak ankle dorsiflexion angles were observed between the affected limb and healthy limb (p = .940, g = .022). Peak ankle plantarflexion moments was lower in the affected limb compared to the healthy limb (p = .003, g = .909). No differences in peak ankle plantarflexion moments were observed between the affected limb and contralateral limb (p = .512, g = .121). The affected limb had greater peak hip angles compared to the healthy limb (p = .026, g = .664). No differences in peak hip angles were observed between the affected and contralateral limbs (p = .379, g = .161). The affect limb had greater peak hip extension moments compared to the contralateral limb (p = .010, g = .494). No differences in peak hip extension moments were observed between the affected and healthy limbs (p = .833, g = .060).

Table 1: Mean (SD) ankle, knee, and hip kinematic and kinetic outcomes during running for both healthy individuals and both affected and contralateral limbs for meniscectomy individuals

		Meniscectomy		Mean difference (CI 95%)	
	Healthy	**Affected**	**Contralateral**	**Healthy vs Affected**	**Affected vs Contralateral**
Peak PFJ stress (MPa)	0.63 (0.18)	0.49 (0.18)	0.62 (0.17)	0.14 (0.04 to 0.25)*	-0.13 (-0.19 to -0.07)*
Peak PFJ stress loading rate (MPa/s)	10.47 (2.81)	8.82 (3.10)	10.38 (2.72)	1.65 (-0.09 to 3.38)	-1.56 (-2.20 to -0.91)*
Peak angles (°)					
Ankle dorsiflexion	21.72 (3.69)	21.80 (3.44)	23.86 (3.39)	-0.08 (-2.13 to 1.97)	-2.05 (-3.34 to -0.77)*
Knee flexion	37.11 (5.06)	34.69 (5.96)	37.72 (5.48)	2.44 (-0.83 to 5.70)	-3.04 (-5.35 to -0.72)
Hip flexion	36.19 (6.25)	40.48 (6.58)	41.11 (6.82)^h	-4.29 (-8.03 to -0.54)*	-0.63 (-2.06 to 0.81)
Peak joint moments (N.m/kg)					
Ankle plantar flexion	0.24 (0.06)	0.19 (0.05)	0.19 (0.06)	0.05 (0.02 to 0.09)*	0.00 (-0.01 to 0.00)
Knee extension	0.17 (0.06)	0.12 (0.05)	0.16 (0.04)	0.05 (0.02 to 0.08)*	-0.04 (-0.06 to -0.02)*
Hip extension	0.13 (0.05)	0.13 (0.05)	0.12 (0.04)	0.00 (-0.2 to 0.03)	0.01 (0.00 to 0.02)*

*** denotes statistical difference (*p*<.05).**

DISCUSSION: Following a meniscectomy, individuals demonstrated reduced PFJ stresses in their affected limb compared to their contralateral limb and healthy individuals. Reduced PFJ stress in the affected knee was likely to be due to a combination of reduced ankle plantar flexion moments and reduced knee extension moments resulting in lower muscle forces through the quadriceps.

Our findings suggest that following a meniscectomy, individuals are employing a quadriceps avoidance strategy. This compensatory strategy to offload the knee and PFJ is likely to be a result of the associated quadriceps muscle weakness, atrophy and dysfunction commonly reported following a meniscectomy (Amestoy et al., 2021; Hall et al., 2013).

The consequence of decreased PFJ stresses and loads at the knee could be two-fold. Firstly, by unloading the tissue there is a risk of tissue atrophy where tissues adapt to being able to only cope with lower loads and therefore are at greater risk of future injury. Secondly, having decreased knee extension moment reduces the demand on the quadriceps, which could lead to muscle atrophy and weakness which are associated with degenerative changes at the knee. Further research is needed to better understand the strategies adopted in the affected knee following a meniscectomy which result in reduced PFJ stresses and the potential long-term consequences.

CONCLUSION: Following a meniscectomy, individuals alter their movement patterns during running which lead to reduced PFJ stresses compared to the contralateral limb and healthy individuals.

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