Introduction: It has been reported that total meniscectomy increases the risk of developing osteoarthritis radiographically by 14 times after 21 years [1] and a partial meniscectomy substantially increases by a factor of four the risk of developing radiographic evidence of osteoarthritis within 16 years [2]. One of the explanations for the development of premature osteoarthritis post-meniscectomy is that the cartilage sustains increased stress [3]. It is still unknown why some individuals experience rapid cartilage degradation following meniscectomy while others show a minimal cartilage loss [4]. Differences in gait mechanics offer a possible explanation in which some subjects could sustain uncompensated kinematic shifts following meniscectomy. These kinematic shifts would shift loads to regions of cartilage that cannot sustain altered loads, in a manner similar to the condition seen in ACL deficient patients [5]. Thus kinematic changes following meniscectomy become an important consideration. However, there is a paucity of information on the effects of meniscectomy on gait [6] and no study has looked at the effect of partial meniscectomy. The purpose of this study was to test the hypotheses that the internal-external (IE) rotation, anterior-posterior (AP) translation, and knee flexion of partial medial meniscectomized (PMM) knees during the stance phase of walking are different from contralateral, uninjured knees.

Materials and Methods: Four subjects with partial medial meniscectomies and no ligamentous injury to the knee participated in the study after providing IRB-approved informed consent (age=49±13.3 years, 3 male, 1 female). The subjects were, on average, 100 months post-meniscectomy with a range of 3 to 324 months. Subjects were tested bilaterally for three walking trials at a self-selected speed using an opto-electronic motion capture system (Qualisys) and a force plate (Bertec) for measuring foot-ground reaction force. The uninjured contralateral knees of the meniscectomized population were used as matched controls. AP translation (tibia relative to femur), IE rotation and knee flexion were derived from a previously described point cluster technique that used 21 light-reflective markers placed on the lower limb segments to create two cluster groups: one on the thigh and one on the shank [7]. AP translation and IE rotation during walking trials were normalized to a standing reference trial to minimize errors due to marker placement. Additionally, bilateral knee MR images were obtained for both knees of each subject. The medial and lateral menisci were segmented out and their volumes were calculated [8]. The amount of medial meniscal loss was determined by comparing the volume of the medial menisci of the PMM knee with the volume of the medi- al meniscus of the contralateral knee. Differences between the average knee flexion angles, AP translations, and IE rotations during the stance phase of walking were tested using paired Student’s t-tests (α=0.05) to determine the significance of the differences between the ACL deficient and the contralateral knee.

Results: The results of this study supported the hypothesis that the IE rotation of partial medial meniscectomized knees was significantly different from contralateral knees throughout the stance phase (Figure 1, top), but they did not support the hypotheses that AP translation (Figure 1, bottom) and knee flexion would be different between PMM and contralateral knees. The PMM subjects had knees in which the average tibial rotation during stance phase was significantly (p<0.05) more externally rotated (4.5°) when compared with the contralateral knee. The differences in the average knee flexion angle (0.7°) and average tibial AP displacement (0.16 mm posterior) between PMM knees and contralateral knees during stance phase were not significant. There was substantial variation in the medio-lateral meniscal loss with an average of 48.3% volume loss and a range of 6% to 100%. There were too few subjects to correlate the volumetric loss with the changes in IE rotation.

Discussion: This study has shown that the secondary motion of the knee during walking after partial medial meniscectomy can vary from that of the contralateral uninjured knee. The purpose of a medial meniscectomy is to relieve pain and restore normal function. Although the primary motion of knee (flexion) appears to be normal, the IE rotation is significantly different.

It has been previously shown that there exists an increase in anterior tibial translation following medial meniscectomy [9]. However, this was in a cadaver knee under an applied anterior load which is very different than the dynamic-in vivo loading tested in our study. Yet, a compromised medial meniscus could result in a loss of its ability to prevent anterior translation of the medial plateau of the tibia during walking, thus resulting in the overall externally rotated tibia during stance phase that we see here. This altered motion pattern may result in a rapid change in the loading distribution on the articular cartilage. As the cartilage has likely become conditioned to the previous loading distribution, this change in secondary motion may cause a disruption in the normal cartilage metabolism. These changes may begin a cascade leading to premature OA [10].


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Figure 1. Tibial rotation (top) and tibial displacement (bottom) of PMM knees (red) and contralateral healthy knees (blue) with averages in dashed lines.