

Effect of Fixation Angle and Tension on Knee Kinematics in Medial Meniscus Posterior Root Repair

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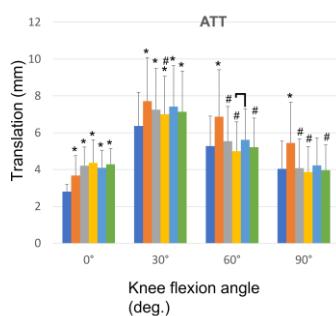
INTRODUCTION: Medial meniscus posterior root tear (MMPRT) is a debilitating knee injury that leads to the loss of meniscal hoop stress and pathological extrusion of the medial meniscus (MM). Transtibial pullout repair has emerged as the gold standard treatment for MMPRT; however, its efficacy in restoring normal knee kinematics when combined with meniscotibial ligament (MTL) lesions remains unclear. This study aimed to evaluate the effects of different initial fixed tension and knee flexion angles on transtibial pullout repair in the presence of both MMPRT and MTL. Furthermore, the optimal initial knee flexion angle and fixation tension for transtibial pullout repair in MMPRT cases remain highly dependent on surgeon preference and experience, with no established consensus. This study aimed to address these gaps in knowledge by evaluating the influence of different tension levels and knee flexion angles on the reduction of MM extrusion and knee kinematics. We hypothesized that increasing the initial fixed tension in the extension position would not only impact knee kinematics but also contribute to the reduction of MM extrusion. Understanding the optimal tension and knee flexion angle for transtibial pullout repair in the presence of both MMPRT and MTL will facilitate improved surgical decision-making and potentially enhance patient outcomes.

METHODS: With Institutional approval, thirteen fresh-frozen human cadaveric knees were tested in four states; (1) intact MM, (2) MMPRT + MTL, (3) MMPRT repair. Both MMPRT and MTL were created arthroscopically and transtibial pullout repair without MTL repair was performed. Fixation of the tibia was classified into four different combinations of fixation tension and fixation angle, respectively (20N@ 0°, 20N@ 90°, 60N@ 0°, 60N@ 90°). The kinematics were analyzed using a six degree of freedom robotic testing system under three knee loads: (a) an 89 N anterior tibial load to test anterior tibial translation (ATT), (b) a 5 Nm external (ER) torque, and (c) a 10 Nm varus torque. MM extrusion was evaluated with ultrasound. ATT and ER were measured at 0°, 30°, 60°, and 90° of knee flexion, and varus at 0° and 30° of knee flexion. Regarding measurements of MM extrusion, Interobserver and intraobserver reliabilities were assessed with the intraclass correlation coefficient (ICC).

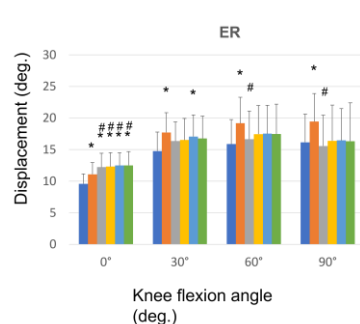
RESULTS SECTION: In knees with both MMPRT and MTL lesions, kinematic parameters such as ATT, ER, varus alignment, and MM extrusion were found to be significantly greater compared to intact knees. Regarding ATT, at 0° knee flexion, none of the fixation methods restored the knee to the intact condition. At 30°, only the Repair 0° 60N fixation method showed significant improvement but did not fully restore the intact knee condition. At 60° and 90° of knee flexion, all fixation methods except for Repair 90° 20N restored the knee to the state of an intact knee (Fig. 1). For external rotation, at 0° knee flexion, none of the fixation methods restored the knee to the intact condition and showed significantly greater values compared to knees with MMPRT and MTL. At 30° the Repair 90°20N fixation method did not restore the knee to the intact condition. At 60° and 90° of knee flexion, all fixation methods restored the knee to the intact condition (Fig. 2). In terms of varus alignment, at both 0° and 30° of knee flexion, none of the fixation methods restored the knee to the intact condition. Regarding MM extrusion, at both 0° and 30° of knee flexion, all fixation methods except for the Repair 90° 20N fixation method restored the knee to the intact condition (Fig.3). The interobserver reproducibility and intraobserver repeatability were considered high, with ICC values of 0.86 and 0.85, respectively.

DISCUSSION: The most important finding of this cadaver study was that transtibial pullout repair did not improve kinematics in the extended knee position when both the MMPRT and MTL lesions. In addition, the fixation at higher tension was the most effective in improving MM extrusion. Our hypothesis that an increase of initial fixed tension in the knee extension position improves extrusion was confirmed but had little effect on knee kinematics.

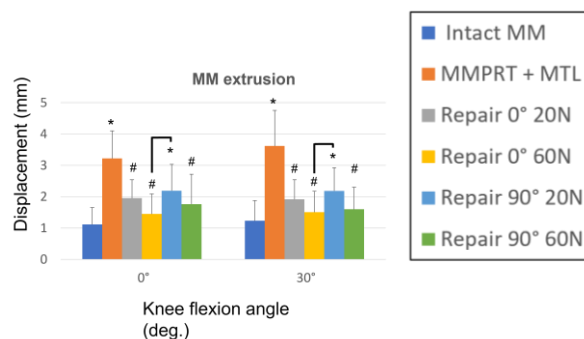
SIGNIFICANCE/CLINICAL RELEVANCE: Transtibial pullout repair did not improve kinematics in the knee extension position when both the MMPRT and MTL were present but did improve meniscal extrusion. When performing surgery for transtibial pullout repair, high tension fixation in the knee extension position is recommended.



(Fig.1)



(Fig.2)



(Fig.3)

Figure 1: Left: Anterior tibial translation (ATT; mm) under an 89 N anterior tibial loading.: * p<.05 vs Intact, #p<.05 vs. MMPRT+MTL

Figure 2: Middle: External rotation under a 5 N-m torque: * p<.05 vs Intact, #p<.05 vs. MMPRT+MTL

Figure 3: Right: MM extrusion under a 10Nm varus torque evaluated with ultrasound: * p<.05 vs Intact, #p<.05 vs. MMPRT+MTL