# ON THE INFLUENCE OF THE MEDIAL MENISCOTIBIAL LIGAMENTS INTEGRITY IN THE REACTION FORCE OF THE POSTERIOR ROOT OF THE MEDIAL MENISCUS

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**DISCLOSURES:** The authors have no disclosures regarding connection to any products evaluated in this study.

**INTRODUCTION**: Several techniques have been developed to repair the posterior root of the medial meniscus (PRMM) tear and recover the ability of the knee to withstand arch strain. Although there are several treatment options, the current trend is to repair the PRMM tear with suture or pullout anchors with the aim of restoring the main function of the normal meniscus and recovering the pullout strength of the refixed root. The effectiveness of these procedures to prevent meniscus extrusion is controversial (1). The existence of a correlation between medial meniscus (MM) extrusion and injury to the medial meniscotibial ligaments (MMTL) has been defended based on clinical findings based on magnetic resonance (2, 3) and experimental measurements in human cadavers (4, 5). In this sense, we hypothesized that the stabilizing function of the MMTL have an important role in the resulting tension force exerted on the PMMR during valgus knee movement. In view of our findings, MMTL repair should be considered for a better PMMR tear treatment strategy. This work aims to investigate whether the magnitude of the resultant reaction force acting on the PRMM is affected by the integrity of the MMTL when the knee collapses inwards during weight-bearing activity (knee valgus).

**METHODS:** Tridimensional models for the femur, tibia, menisci and cartilages of a 29-year-old female patient were downloaded (https://simtk.org/projects/mb_knee) (6) (Figure 1). The fixation sites of the deep medial collateral ligament (MCL) and the meniscal roots were determined according to (7, 8, 9) and modeled by spring elements using the stiffness parameters provided by (10, 11). Bones were defined as rigid bodies, while cartilages and menisci were represented by linear elastic and transversely isotropic material models, respectively, with material properties of (12, 13). A compressive force of 690 N was applied on the femoral head, while a valgus rotation of 8º was defined on the femoral condyles; moreover, all tibial degrees of freedom were restricted. The boundary conditions of the finite element (FE) simulations were set to simulate an inward movement of the knee and applied progressively to provide an understanding of the relationship between the valgus angle and the mechanical response of different knee structures. To simulate the presence of ligaments that were not modeled, such as the cruciate ligaments, additional displacement restrictions were placed on the femur, focusing the simulations entirely on the valgus rotation and the inferior translation. A bonded contact condition was applied to join the cartilages to the bones and the medial meniscus to the central part of the deep MCL, while between the menisci and the cartilages, as well as between the femoral and tibial cartilages, a frictionless contact was chosen to represent the low coefficient of friction that characterizes joint contact. Ultimately, with the aim of understanding the influence of the integrity of the deep MCL on the reaction force exerted on the PRMM, different degrees and types of injuries to this structure were modeled for comparison with the healthy joint through the inclusion of an initial gap in the force-displacement curves that define the meniscotibial and meniscofemoral spring elements, representing a state of laxity in which the ligament does not produce reactive forces to prevent deformation. The multibody model of the knee was then imported into Ansys Mechanical 2022 R1, in which all mesh generations and FE simulations were performed. The mesh was composed of 20,532 elements, with an average size of 3 mm for the bones and 2,5 mm for the other bodies (Figure 2).

**RESULTS:** For isolated MCL meniscotibial injuries, the reaction force acting on the PRMM increases much more rapidly with the valgus angle when compared to the healthy joint as well as to the meniscofemoral injury (Figure 3). In addition, larger gaps in the meniscotibial portion also increase the reaction force, with complete rupture being the critical scenario in which the values are 8 times greater when compared to the healthy knee for an 8º valgus rotation. These results indicate that meniscotibial injuries in the deep MCL can promote an increase in tension in the PRMM during a valgus movement of the knee, which was observed due to an excessive movement of superior displacement of the medial meniscus from the tibial plateau, which is restricted in the last resistance by the meniscal roots, until their fatigue and rupture. The MCL is loose or torn and is also responsible for the phenomenon of meniscal extrusion.

**DISCUSSION:** The main result found in this study indicates that the demand on the PRMM during valgus rotation is much greater when there is an isolated lesion in the MMTL, which supports the hypothesis that there is a correlation between lesions in these structures, as well as being an indication that lesions in the MMTL can precede and promote those in the PRMM, as pointed out by (3). In addition, it has been shown that the mechanical demand on the PRMM during valgus is due to the marked detachment of the MM from the tibial plateau, which is possible when there is laxity in the MMTL. This phenomenon has already been noticed in other studies and was associated precisely with the diagnosis of injuries to the MMTL, but not with overload of the PRMM (5). to our best knowledge, this is the first finite element computational analysis to demonstrate this effect.

**SIGNIFICANCE/CLINICAL RELEVANCE:** The loss of MMTL integrity may result in significant overload on the PRMM contributing to meniscal extrusion. Therefore, the MMTL repair must be considered for a better PRMM tear treatment strategy.

**IMAGES AND TABLES:**

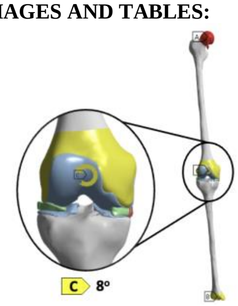


Figure1 – Computational model

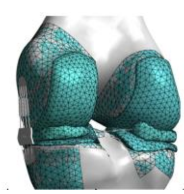

Figure 2- Knee joint discretization

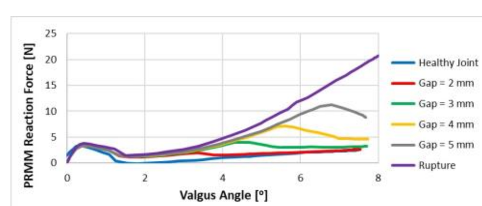


Figure 3- Reaction forces on the PRMM

**REFERENCES:** 1. Chung KS, Ha JK, Ra HJ, Kim JG. A meta-analysis of clinical and radiographic outcomes of posterior horn medial meniscus root repairs. Knee Surgery, Sports Traumatology, Arthroscopy. 2015 Oct 22;24(5):1455–68.

2. Krych AJ, Bernard CD, Leland DP, Camp CL, Johnson AC, Finnoff JT, et al. Isolated meniscus extrusion associated with meniscotibial ligament abnormality. Knee Surgery, Sports Traumatology, Arthroscopy. 2019 Jul 22;28(11):3599–605.
3. Krych AJ, LaPrade MD, Hevesi M, Rhodes NG, Johnson AC, Camp CL, et al. Investigating the Chronology of Meniscus Root Tears: Do Medial Meniscus Post\erior Root Tears Cause Extrusion or the Other Way Around? Orthopaedic Journal of Sports Medicine. 2020 Nov 1;8(11):232596712096136.
4. Paletta GA, Crane D, Konicek J, Piepenbrink M, Higgins LD, Milner J, et al. Surgical Treatment of Meniscal Extrusion: A Biomechanical Study on the Role of the Medial Meniscotibial Ligaments with Early Clinical Validation. Orthopaedic Journal of Sports Medicine. 2020 Jul 1;8(7):232596712093667-232596712093667.
5. Farivar D, Knapik DM, Vadhera AS, Condron NB, Hevesi M, Shewman E, et al. Medial Meniscal Extrusion of Greater Than 3 mm on Ultrasound Suggests Combined Medial Meniscotibial Ligament and Posterior Medial Meniscal Root Tears: A Cadaveric Analysis. Arthroscopy. 2023 Feb 1.
6. Guess TM, Razu S. Loading of the medial meniscus in the ACL deficient knee: A multibody computational study. Medical Engineering & Physics. 2017 Mar; 41:26–34.
7. Liu F, Yue B, Gadikota HR, Kozanek M, Liu W, Gill TJ, et al. Morphology of the medial collateral ligament of the knee. Journal of Orthopaedic Surgery and Research. 2010;5(1):69.
8. Wilmes P, Pape D, Kohn D, Seil R. The Reproducibility of Radiographic Measurement of Lateral Meniscus Horn Position. Arthroscopy. 2007 Oct 1;23(10):1079–86.