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Research Article

MPFL Behavior in Traction Tests after Width Equalization of Patellar and Femoral Insertions

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Abstract

Purpose: The purpose of this study is to search for the biomechanical behavior of the Medial Patellofemoral Ligament (MPFL) after the patellar and femoral insertions were artificially equalized to the same width.

Methods: Thirty-eight knees were obtained from 19 male cadavers. After careful dissection of the MPFL, the medial third of the patella was sawn off longitudinally, as well as the ligament's femoral insertion, creating a bone–ligament–bone unit. Then, a transverse cut was made in the patellar ligament insertion until its patellar width matched that of the femoral insertion. This cut was made proximal in the right knee and distal in the left. Each unit was then submitted to a traction test using the same protocol and method.

Results: Prior to the test, the ligament was measured, and three zones were established: proximal, from the patellar insertion up to 33% of the total length; medial, 37–66%; and distal, 67–100%. Of the 38 ligaments submitted to the traction test, five ruptured in the proximal segment (13.1%), eight (21%) ruptured in the distal segment, and 25 (65%) ruptured in the medial portion, with the proximal transverse cut having no statistical influence on the ligament rupture pattern.

Conclusion: The wider patellar than femoral insertion of the MPFL has little to do with its strength and probably much more to do with the vastus medialis expansion.

Keywords: Ligament strength; MPFL reconstruction; MPFL rupture to traction pattern; MPFL strength; Rupture pattern,

Introduction

Over a thousand papers related to the Medial Patellofemoral Ligament (MPFL) have been written since the first report proposing MPFL reconstruction for patellar instability [1]. This ligament is now well known as an important ligament for stabilising the patella in the femoral groove [2-5]. It is described as a flat triangular shaped structure with a large insertion on the medial patellar facet and a smaller insertion on the medial femoral epicondyle, forming an inverted triangular structure. In spite of this well-known configuration, there are no papers in the medical literature that have tried to correlate this shape to the strength of the ligament, even though some authors explain this shape as an expansion of the vastus medialis and vastus intermedius muscles that extend its patellar medial insertion up to the medial patellofemoral ligament [6-11]. Since all biomechanics studies about the MPFL were done respecting the triangular shape of this ligament, it should be no surprise that the ruptures usually occur in its thinner segment below its midsection from the upper patellar and the lower femoral insertion. Based on what has been reported in the existing literature, the purpose of this paper was to search for the MPFL biomechanical behavior under traction tests after the femoral and patellar insertions were artificially equalized to the same width.

Material and Methods

Between April 2016 and July 2017, a consecutive series of 19 specimens of fresh whole human cadavers were selected, making up a total of 38 knee samples, number calculated by the statistic to support results with evidence. The corpses were obtained from the legal medical department, following the approval protocol of the ethics committee. The inclusion criteria were healthy uninjured joint structures with no degenerative changes, no prior surgery, no evidence of ligament, chondral or meniscal lesions and a minimum range of motion of $0^{-}130^{o}$. In each knee, a longitudinal anterior approach was performed and the MPFL was dissected and left fixed in its original insertion site so that it was the only soft-tissue structure capable of preventing lateral dislocation of the patella (Figures 1 and 2). Every MPFL presented a triangular shape at its patella insertion and a tape-like shape at the femoral insertion. With the aid of an oscillating saw we cut the medial patellar facet longitudinally, preserving the MPFL insertion, and also cut a bone block from its femoral insertion (2 ´ 2 cm^2 area, 1 cm thick). In every knee we measured the size of the patella MPFL insertion. Since there were no data to be use as a guide, it was decided that on the right knees a transversal cut was made on, the distal part of this insertion, meanwhile on the left knees the cut was made on the proximal part until the patellar insertion attained the same width as the femoral insertion, turning the MPFL into a rectangular structure (Figure 3).

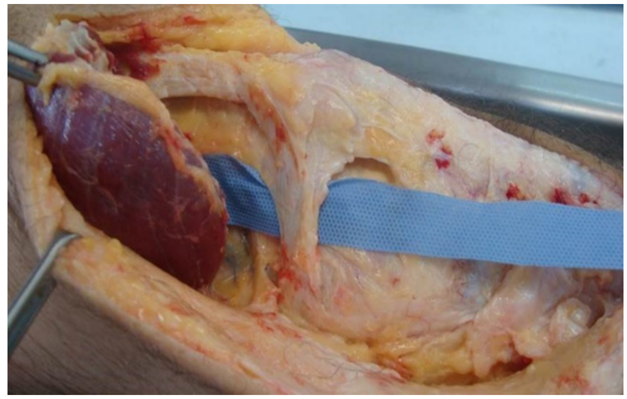

Figure 1: The vastus medialis separated from its insertion on the patella

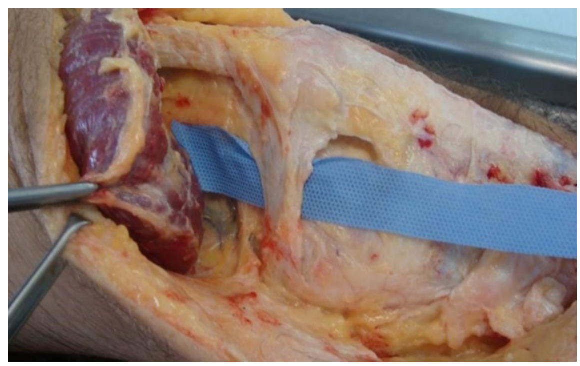

Figure 2: Pulling of the vastus medialis exposes the vastus intermedius expansion to the MPFL.

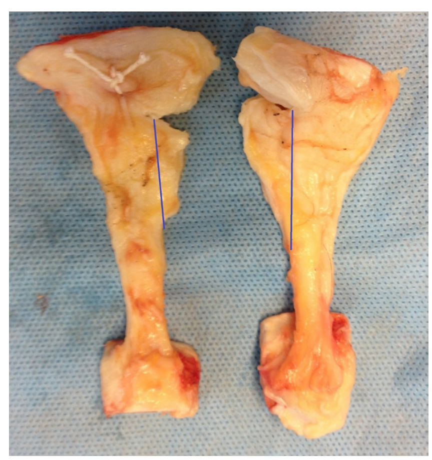

Figure 3: Right and left MPFL with proximal and distal transverse patellar insertion cut to equalise the ligament width in both femoral and patellar insertions.

Following this, we selected two samples from each cadaver consisting of bone–ligament–bone, one corresponding to the right knee and another corresponding to the left knee. In the samples from the right knees, a suture was inserted at the patellar periosteum in order to identify the side being analyzed during the laboratory experimentation. The two samples were placed inside a plastic bag marked with the number of the corresponding cadaver. These were wrapped with surgical gauze soaked in physiological solution (isotonic solution of sodium chloride and distilled water) and then placed in a thermal box with ice. Finally, the samples were transported to the Applied Mechanical Engineering Department of our institution, where the laboratory experimentation took place. Uniaxial traction tests were performed on samples of the MPFL. Sampling was performed in an attempt to reproduce the natural ligament condition, as suggested by various authors [12]. For this purpose, the samples were extracted with cuts of the bone part lying flat in order to maintain alignment. However, it should be noted that this alignment may have changed during testing of some samples due to possible slippage. The test procedures were performed according to the literature and equipment availability. Samples of the MPFL were received on different days, therefore the samples were frozen and stored in a freezer.

Preparation for the Test

The experimentation was performed on each sample individually. The samples were placed on EMIC testing equipment (Instron Brasil Equipamentos Científicos Ltda, São José dos Pinhais, PR, Brazil) and fixed with a pair of compression clamps. The load cell used was 10 kgf and the traction force was applied until the ligament was completely torn. A preload of 2 N was applied for 5 min, according to the literature [12]. After preloading, seven cycles of preconditioning were performed, varying from 0 mm to 2 mm at a speed of 10 mm/min. After this preconditioning and before the final loading, measurement of the minimum width of each specimen was performed. Finally, the sample was loaded until breaking, at a speed of 10 mm/min.

Statistical Analysis

Quantitative variables were expressed as mean (standard deviation) and minimum and maximum values. Categorical variables were expressed as absolute and relative frequencies. An adjusted chi-square test was used to compare the rupture sites. Data were analyzed in SPSS, version 21.0, and the level of significance was set at 5% ($P<0.05$).

Results

The mean age of the donors was 28.42 years (range: 18-47) and all were males. The specimens were fresh (within 18 hours of death) and none had been previously frozen. The MPFL was identified in all individuals. From the 38 ligaments submitted to the traction test, five presented a proximal rupture (13.1%), eight (21%) ruptured in the distal segment and 25 (65%) ruptured in the medial portion. The comparative analysis showed that the proximal transverse cut had no statistical influence on the ligament rupture pattern ($P<0.001$). The average traction force applied until tearing of the MPFL was 188.88 N, with a standard deviation of 48.82 N. Patellar MPFL insertions were an average of 21.68 mm and femoral insertions were 9.8 mm on average. The average length of the MPFL was 60.8 mm.

Discussion

When this study began, it was expected that after the proximal patellar insertion of the MPFL was cut to ensure that both patellar and femoral insertions achieved the same width, turning the MPFL into a functional rectangular rather than triangular structure, a random pattern of ruptures would be obtained when the bone–ligament–bone unit was submitted to the traction test. the cut was made on the proximal part until the patellar insertion attained the same width as the femoral insertion, turning the MPFL into a rectangular structure However, this was not the case. There was a general pattern of ruptures in the midpoint of the ligament, in spite of the proximal cuts performed in the patellar ligament insertion. These probably occur because even being reduced to the same width of the femoral insertion, the patellar insertion was still more thick then the lower two-thirds of the ligament. These results show that the larger insertion of the MPFL, which would be responsible for its triangular shape, was not in fact the ligament alone but the result of mixed fibres of the vastus medialis and vastus intermedium tendons. These findings corroborate previous reports that the vastus medialis extends its patellar insertion up to the MPFL, becoming a mixed-fibre structure at this point. Developed to be an intermediate alternative [1] between the less effective lateral releases alone and the effective but also aggressive proximal or distal realignment, the MPFL reconstruction became such a widespread procedure to deal with patella instability that problems started to occur [3,13,14].

These failures may be due to over-recommendation of a procedure unable alone to overcome a variety of causes and severities of patellofemoral instability, but also can be the result of an underestimation of the importance of the medial capsular and muscular interaction. Our findings suggest us that either a double-bundle [14,15] or a single-bundle reconstruction can better reproduce the anatomy if somehow connected with the vastus medialis muscle fibres, as was proposed by some authors [6-11]. Since the normal MPFL is not a real isometric structure, the muscle insertion to the ligament probably acts as reins whenever the muscle contracts by pulling and tensioning the ligament. In doing so, it turns the ligament into a more functionally effective structure. Our findings are not intended as a new technique but rather as an attempt to better understand the way the MPFL interacts with the surrounding structures. The concept of MPFL reconstruction has nothing to do with the type of graft chosen by surgeons, this being merely a matter of personal preference and skill [16-20]. However, even a strong graft would benefit from a muscular connection because the normal undisrupted MPFL is not a very strong ligament alone and the idea that bigger is always better is not supported by nature. To accomplish an interaction between the reconstructed MPFL and the muscular distal portion of the vastus medialis, a wider dissection would not be necessary, and it can remain a minimally invasive procedure (Figures 4,5).

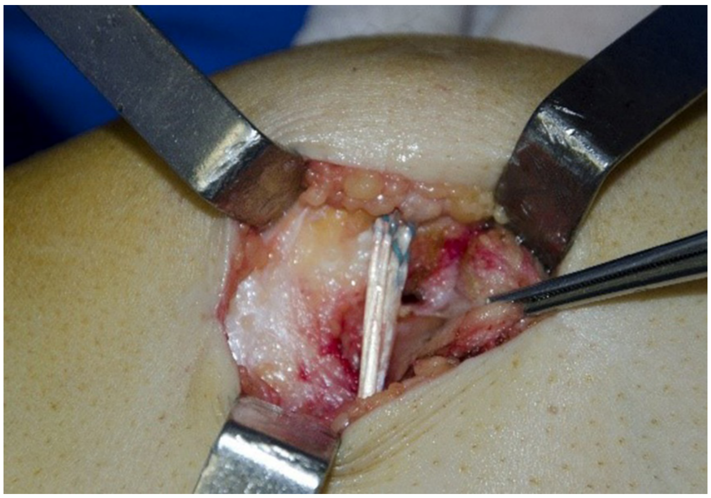

Figure 4: Single-bundle reconstruction of the MPFL.

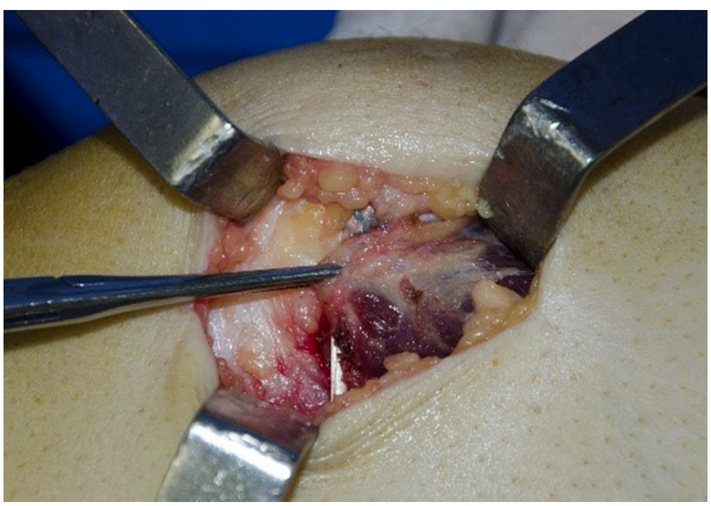

Figure 5: The vastus medialis being attached to the reconstructed MPFL.

Conclusion

This is certainly not a definitive study on the MPFL, and we have no intention of proceeding as such, but it became clear to us that the MPFL's close connection with the vastus medialis should be considered in order to further improve the results of an already well-accepted procedure by reproducing an anatomic interaction that have been undervalued up today in spite of the alert of some papers.

References

1. Gomes JLE (1992) Medial patellofemoral ligament reconstruction for recurrent dislocation of the patella: a preliminary report. Arthroscopy 8: 335-340.
2. Amis AA, Firer P, Mountney J, Senavongse W, Thomas NP (2003) Anatomy and biomechanics of the medial patellofemoral ligament. Knee 10: 215-220.
3. Mistry JB, Bonner KF, Gwam CU, Thomas M, Etcheson JI, et al. (2018) Management of injuries to the medial patellofemoral ligament: a review. J Knee Surg 31: 439-447.
4. Huber C, Zhang Q, Taylor WR, Amis AA, Smith C, et al. (2020) Properties and function of the medial patellofemoral ligament: a systematic review. Am J Sports Med 48: 754-766.
5. Aframian A, Smith TO, Tennent TD, Cobb JP, Hing CB (2017) Origin and insertion of the medial patellofemoral ligament: a systematic review of anatomy. Knee Surg Sports Traumatol Arthrosc 25: 3755-3372.
6. Panagiotopoulos E, Strzelczyk P, Herrmann M, Scuderi G (2006) Cadaveric study on static medial patellar stabilizers: the dynamizing role of the vastus medialis obliquus on medial patellofemoral ligament. Knee Surg Sports Traumatol Arthrosc 14: 7-12.
7. Zaffagnini S, Dejour D, Grassi A, Bonanzinga T, Muccioli GMM, et al. (2013) Patellofemoral anatomy and biomechanics: current concepts. Joints 1: 15-20.
8. Tanaka MJ, Chahla J, Farr II J, LaPrade RF, Arendt EA, et al. (2019) Recognition of evolving medial patellofemoral anatomy provides insight for reconstruction. Knee Surg Sports Traumatol Arthrosc 27: 2537-2550.
9. Tanaka MJ (2017) The anatomy of the medial patellofemoral complex. Sports Med Arthrosc Rev 25: e8-e11.
10. Placella G, Tei MM, Sebastiani E, Criscenti G, Speziali A, et al. (2014) Shape and size of the medial patellofemoral ligament for the best surgical reconstruction: a human cadaveric study. Knee Surg Sports Traumatol Arthrosc 22: 2327-2333.
11. Mochizuki T, Nimura A, Tateishi T, Yamaguchi K, Muneta T, et al. (2013) Anatomic study of the attachment of the medial patellofemoral ligament and its characteristic relationships to the vastus intermedius. Knee Surg Sports Traumatol Arthrosc 21: 305-310.
12. Kim KE, Hsu SL, Woo SL (2014) Tensile properties of the medial patellofemoral ligament: the effect of specimen orientation. J Biomech 47: 592-595.
13. Tompkins MA, Arendt EA (2015) Patellar instability factors in isolated medial patellofemoral ligament reconstructions - what does the literature tell us? A systematic review. Am J Sports Med 43: 2318-2327.
14. Kang H, Zheng R, Dai Y, Lu J, Wang F (2019) Single- and double-bundle medial patellofemoral ligament reconstruction procedures result in similar recurrent dislocation rates and improvements in knee function: a systematic review. Knee Surg Sports Traumatol Arthrosc 27: 827-836.

15. Li J, Li Z, Wang K, Liu C, Wang Y, et al. (2019) Medial patellofemoral ligament reconstruction: a comparison of single-bundle transpatellar tunnel and double-anchor anatomic techniques for the treatment of recurrent lateral patellar dislocation in adults. Arthroscopy 35: 845-854.

16. Vavalle G, Capozzi M (2016) Isolated reconstruction of the medial patellofemoral ligament with autologous quadriceps tendon. J Orthop Traumatol 17: 155-162.

17. Fink C, Steensen R, Gfoller P, Lawton R (2018) Quadriceps tendon autograft medial patellofemoral ligament reconstruction. Curr Rev Musculoskelet Med 11: 209-220.

18. Gomes JL (2008) Medial patellofemoral ligament reconstruction with half width (hemi tendon) semitendinosus graft. Orthopedics 31: 322-326.

19. Gomes JE (2008) Comparison between a static and a dynamic technique for medial patellofemoral ligament reconstruction. Arthroscopy 24: 430-435.

20. Monllau JC, Masferrer-Pino A, Ginovart G, Pérez-Prieto D, Gelber PE, et al. (2017) Clinical and radiological outcomes after a quasi-anatomical reconstruction of medial patellofemoral ligament with gracilis tendon autograft. Knee Surg Sports Traumatol Arthrosc 25: 2453-2459.