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Cadaveric Study to Define the Anatomy of the Medial Patellofemoral Ligament (MPFL) and Its Variant Patterns

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Abstract

Background: The medial patellofemoral ligament (MPFL) is one of the major soft tissue stabilizers on the medial side of the knee joint, extending from the medial condyle of the femur to the medial aspect of the patella. Different kinds of literature described different sizes and different origins and insertions of MPFL. Injury of MPFL causes patellar instability and dislocation. We reported the anatomy and morphology of MPFL and its implications in the repair of MPFL. The aim of the study was also to look at the variant forms of the MPFL.

Methodology: A total of 40 lower limbs fixed in formalin were dissected to study the MPFL of the knee. After reflecting the deep fascia and retinaculum on the medial side of the knee joint the MPFL was exposed. For better learning the lower medial part of vastus medialis was reflected, so that the part of MPFL undercover was exposed.

Results: Different forms of MPFL were seen like two straps 12.5%, broad rectangle 20%, and triangular shaped 67.5% MPFL. The origin of MPFL was found between the adductor tubercle and medial epicondyle of the femur and insertion was seen extending from the proximal medial half of the patella to the tendinous aponeurosis of vastus medialis obliquus (VMO) and vastus intermedius muscle (VIM).

Conclusions: This is the first study that described three variant patterns of MPFL in accordance with their morphological appearance. This knowledge will be helpful to the surgeons for easy identification and repair of the MPFL.

Categories: Physical Medicine & Rehabilitation, Orthopedics, Anatomy
Keywords: knee joint, ligament tear, knee ligament, patellar dislocation, medial patellofemoral ligament

Introduction

The patella is the largest sesamoid bone, embedded in the tendon of the quadriceps femoris. An expansion from the tendon of the quadriceps femoris blends distally with superficial fibers of the patellar ligament. From the superficial surface of the patella, the patellar retinaculum extends on the medial and lateral sides. A thickened band extending from the medial margin of the patella to the medial condyle of the femur and medial condyle of the tibia is called as medial patellofemoral ligament (MPFL) and medial patello-tibial ligament respectively [1]. These ligaments are important for the stabilization of the patellofemoral joint.

The MPFL is the major medial soft tissue restraint preventing lateral displacement of the distal knee extensor mechanism, contributing an average of 53% of the total force [2]. The MPFL is located within the second layer of the medial soft tissue of the knee, and it has a role in the prevention of lateral excursion of the patella [3]. Its femoral origin lies between the adductor tubercle and the medial epicondyle [4]. The MPFL widens from its narrow origin to the insertion covering approximately half of the proximal medial patella [5]. Numerous reconstructive techniques have been described using a variety of grafts, including hamstring tendons (gracilis or semitendinosus), portions of the quadriceps, or patellar tendons [6-8].

The aim and objectives of the study were to define accurately the anatomical aspect of MPFL and to bring up the different variant patterns of MPFL. The knowledge of MPFL anatomy and its different patterns will be helpful to the surgeons while performing the repair of the MPFL.

Materials And Methods

The study was conducted in the Department of Anatomy, AIIMS Bhopal, India. Forty limbs of cadavers aged between 48 and 90 years, fixed in formalin were used for the study. Permission through letter number IHEC-

LOP/2021/IM0373 from the Institutional Ethical Committee was taken before starting the project. The specimens with pathological deformity, injury, or history of knee surgery were excluded from the study. The skin and superficial fascia on the anterior aspect of the distal part of the thigh, knee, and proximal part of the leg was reflected. The deep fascia of the front of the knee and medial aspect of the thigh was carefully removed to expose the muscles of the front of the thigh and retinaculum of the knee joint. The first layer of the retinaculum of the knee on the medial side was also removed. We traced the distal part of the medial border of vastus medialis muscle. It was carefully retracted to the lateral side to find the shiny fibrous structure extending from the medial condyle of the femur to the upper part of the patella. The adductor magnus tendon was also traced to its distal attachment at the adductor tubercle. The medial attachment of MPFL can be found in between the adductor tubercle and the medial epicondyle of the femur. Once the MPFL was identified, its lateral extent was defined by reflecting or cutting the distal part of vastus medialis muscle. The shape and pattern of fibers in MPFL were noted. The well-dissected specimens showing the variant pattern of MPFL were saved by capturing digital photographs. All 40 limbs after careful dissection showed the presence of MPFL.

Results

Anatomy of MPFL

Origin

Medial epicondyle of the femur (MEF) is a bony prominence found on the medial condyle of the femur and the adductor tubercle (AT) is a bony prominence present on the distal end of a medial supracondylar ridge of the femur. AT is superior and slightly posterior to the MEF. Origin of MPFL was found 10 ± 3 mm of breadth arising in between AT and medial epicondyle MEF as shown in Figure *1*. AT was located closer to the MPFL as compared to MEF. The upper fibers of MPFL were arising very close to the lower part of the AT while the lower fibers of MPFL were 3-7 mm apart from the MEF depending on the breadth of the MPFL.

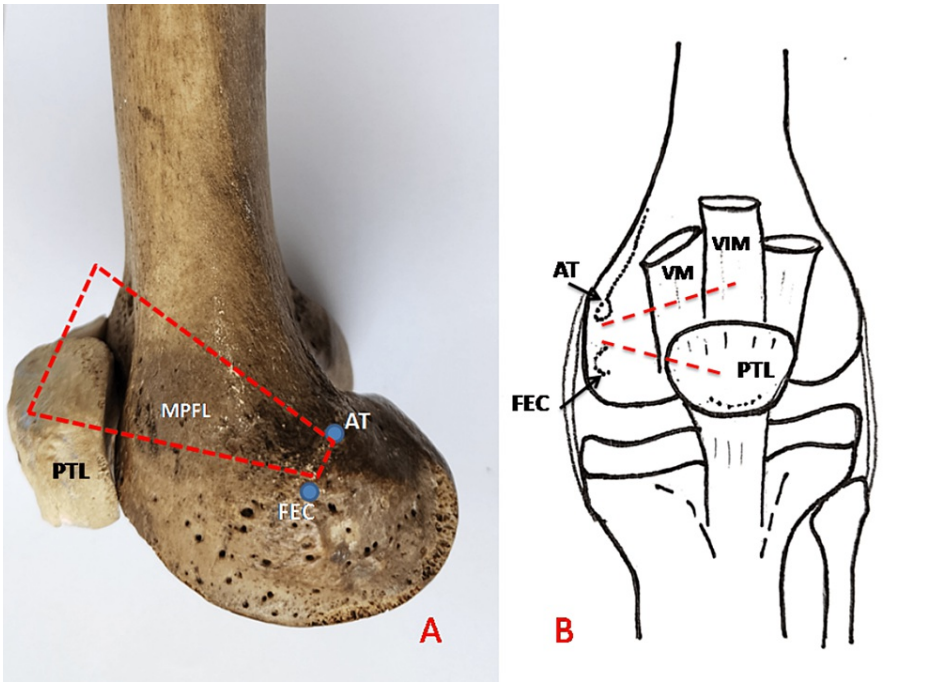

FIGURE 1: (A&B) Origin of MPFL from the area in between AT and FEC of the medial condyle of femur and insertion on proximal half of PTL and tendinous aponeurosis of VM and VIM muscles. Approximate position of MPFL is shown by red dotted lines.

MPFL, medial patellofemoral ligament; AT, adductor tubercle; FEC, femoral epicondyle; PTL, Patella; VM, vastus medialis; VIM, vastus intermedius

Insertion

Typically the fibers were seen directed medially upwards towards the superior medial half part of the patella. The MPFL was found deeper to vastus medialis obliquus (VMO). The fibers of MPFL were seen merging in the aponeurosis of VMO and vastus intermedius muscle (VIM). The insertion of MPFL has two parts, the proximal one merging in the tendinous aponeurosis of VMO and VIM and the distal part on the proximal

medial half of the patella as shown in Figure 1. In the majority of cases, the proximal part was not tightly fixed with the aponeurosis of VMO and was separated by applying moderate force. In a few cases, it was tightly adherent, so it was broken while trying to separate it, as shown in Figure 2.

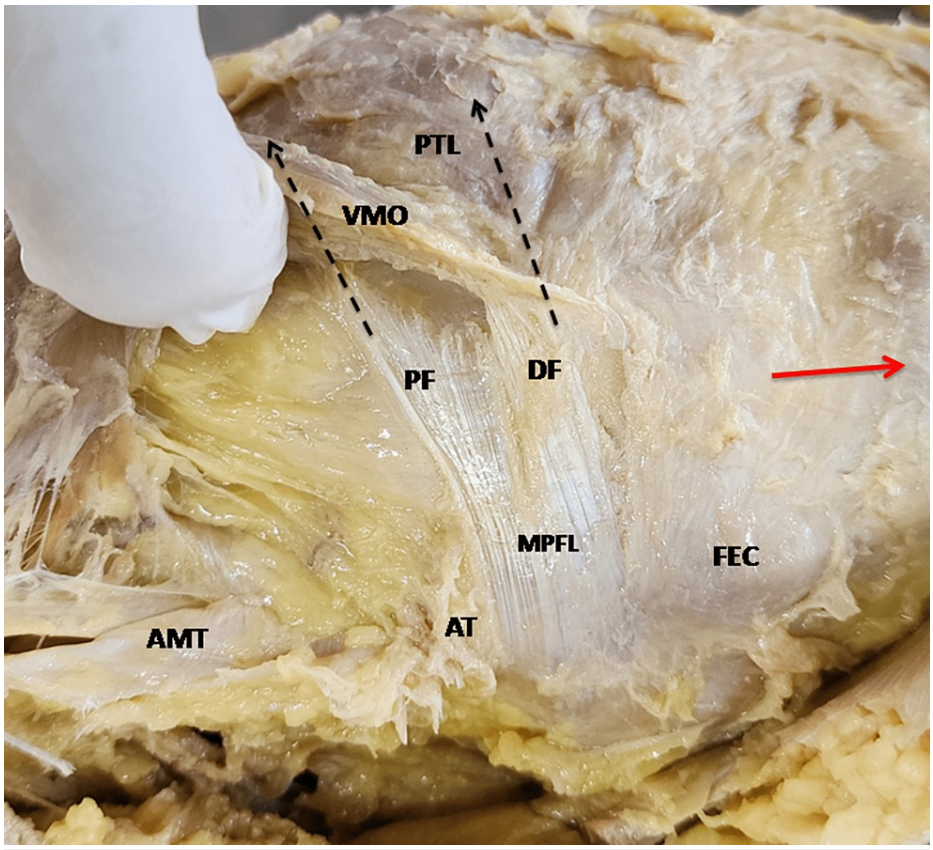

FIGURE 2: Direction of proximal and DF of MPFL. PF were adherent to the aponeurosis VMO, so the fibers broken while separating from VMO.

DF, distal fibers; PTL, Patella; AMT, adductor magnus tendon; AT, adductor tubercle; FEC, femoral epicondyle; MPFL, medial patellofemoral ligament; PF, proximal fibers; VMO, vastus medialis obliquus

The red arrow is directed distally towards the foot (medial side of the left knee).

Variant patterns of MPFL

We found three types of MPFL: typical triangular, rectangular, and two straps variety as shown in Table 1.

S. No.	Type of shape	Number of cases (40)	Number of cases in %
1	Triangular	27	67.5
2	Rectangular	8	20
3	Two straps	5	12.5

TABLE 1: Variant patterns of the MPFL.

MPFL, medial patellofemoral ligament

1. Typical triangular: This is typical shape of MPFL where the apex is located on the medial condyle of the femur and fanning fibres insert on a broad base represented by the upper medial half of the patella and quadriceps tendon as shown in Figure 3. At the femoral end, the mean width of MPFL is 11 mm and at the patellar end, it is 28 mm. The average length was 55.7 mm. We noticed 67.5% of MPFL of this variety.

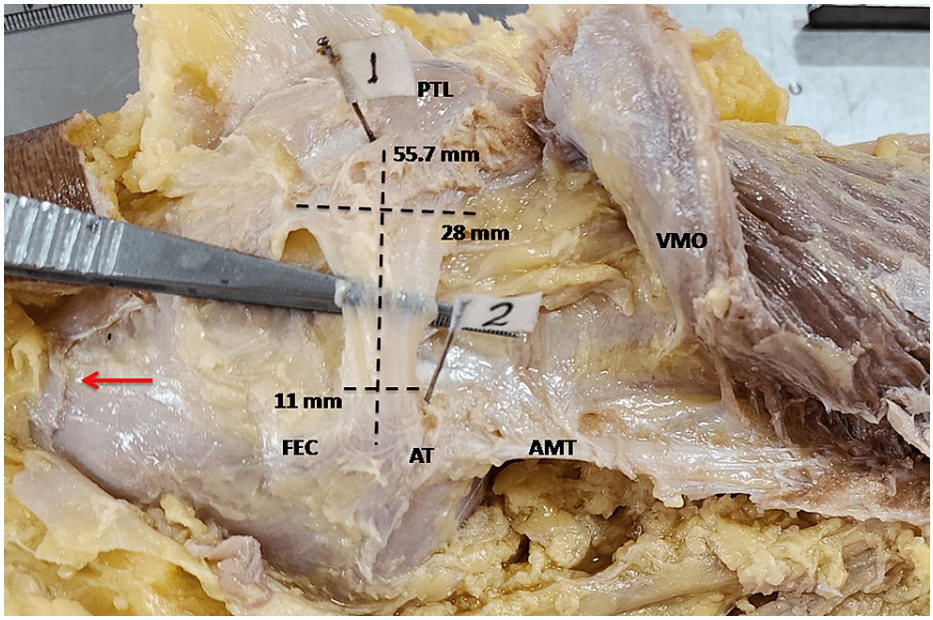

FIGURE 3: Typical triangular MPFL which had a length of 55.7 mm, width at origin lying between FEC and AT was 11 mm and width at PTL end 28 mm. For better exposure VMO was reflected.

The red arrow is directed distally towards foot (medial side of the right knee).

MPFL, medial patellofemoral ligament; FEC, femoral epicondyle; AT, adductor tubercle; PTL, Patella; VMO, vastus medialis obliquus

2. Rectangular: In this variety, the broad sheet of fibers having an average width of 18 mm was seen extending from medial condyle of the femur to the medial border of the patella as shown in Figure *4*. The upper and lower borders were roughly parallel to each other. This rectangular variant type of MPFL was found in 20% of knees.

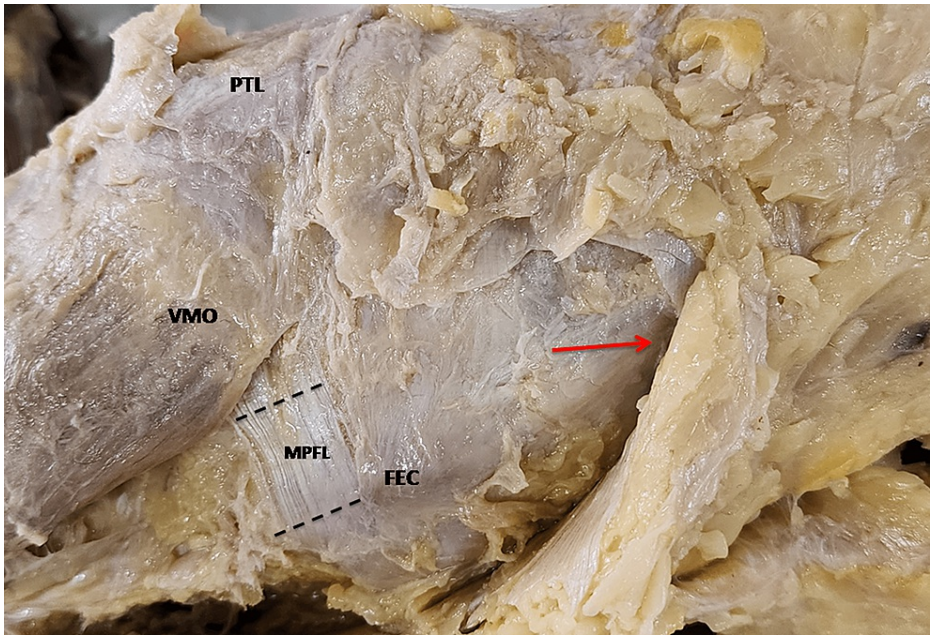

FIGURE 4: Rectangular variety of MPFL where width at medial and lateral end was roughly same and upper and lower borders seem to be parallel.

MPFL, medial patellofemoral ligament; PTL, Patella; VMO, vastus medialis obliquus; FEC, femoral epicondyle.

The red arrow is directed distally towards foot (medial side of left knee).

3. Two straps: The MPFL was in the form of two straps as shown in Figure *5*. The average width of the two-striped MPFL was 15 mm in the middle. Slightly broadening was observed at the patellar end. This variant pattern was seen in 12.5% of limbs.

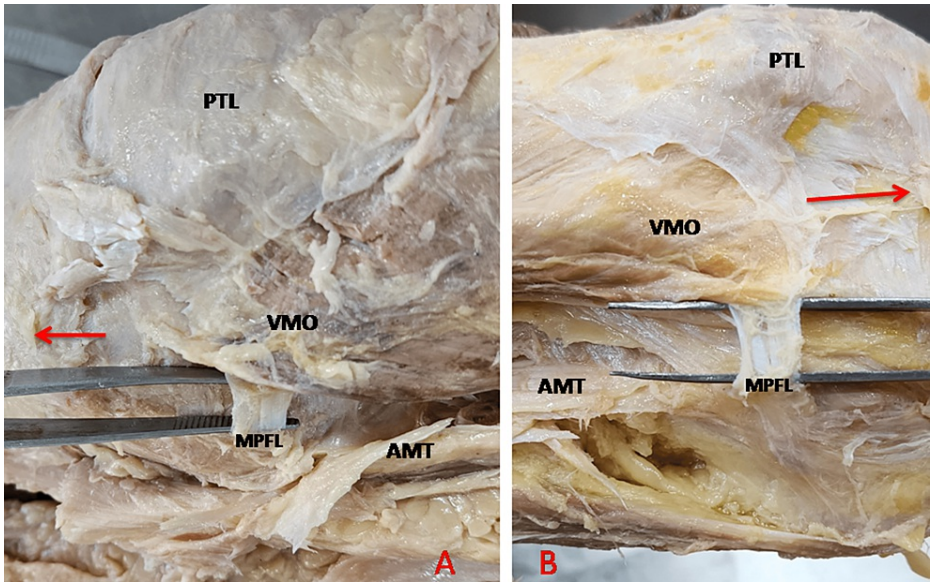

FIGURE 5: Two straps variety of MPFL.

A: medial side of the right knee; B: medial side of the left knee

MPFL, medial patellofemoral ligament; AMT, adductor magnus tendon; PTL, Patella; VMO, vastus medialis obliquus

A red arrow is directed distally toward the foot

Discussion

Patellofemoral dislocations are common and occur due to quadriceps contraction across a flexed, valgus knee with the externally rotated weight-bearing tibia compared to the femur [9]. Conservative management focuses on concentric exercises to strengthen the quadriceps muscles and especially the vastus medialis to prevent further instability. Even after the attempts of rehabilitation, if the dislocation recurs; then operative intervention is needed with the aim of restoring the soft tissue anatomy of the medial side of the knee to normal. In all, 94% of patients suffer a tear to the MPFL following a patellar dislocation particularly on the lateral side [10].

In this study, we defined the different shapes of the MPFL which was traditionally considered triangular only. An attempt was also done to explain the exact location of origin and insertion of MPFL. Weber brothers were the first to describe the anatomy of the knee in 1836 and had no consensus on the anatomy of MPFL or its existence in the knee joint [11]. Nowadays there are multiple studies including this study, where 100% of knees showed the presence of MPFL [12-13].

Different studies described the different origins of MPFL, some from adductor tubercle [2-3, 14], and some from MEF [15]. Some authors reported the origin of MPFL was between the adductor tubercle and MEF and the same findings were noticed by us [4, 12]. Patellar insertion was found on the proximal half of the medial border [2, 5], and the proximal two third of the medial border [16-17]. Tuxøe et al. [17] reported that the MPFL was attached to the deeper part of the aponeurosis of VMO and the proximal two-third border of the patella. Baldwin [18] in his study found that the conjoint attachment of MPFL, first layer of retinaculum, and VMO tendon occupies the medial aspect of the patella corresponding to the articular surface of the patella which is present on the posterior aspect. They also concluded that the AT provided exclusively attachment to the adductor magnus tendon and MEF provided attachment to the medial collateral ligament. The origin of MPFL was from the groove in between AT and MEF. Mochizuki et al. [19] reported that the proximal fibers of MPFL were attached to the tendon of VIM without tight adhesions to VMO and distal fibers attached to the medial border of the patella. We also found the same results but in a few cases, there were tight adhesions between the proximal fibers of MPFL and VMO.

Amis et al. [5] mentioned MPFL as a thin band of fascia extending from the area of MEF to the proximal part of the medial border of the patella. The appearance of the MPFL and its bulk varies from person to person and it may be very thin to identify. Mainly the researchers described the shape of the MPFL as triangular [20], but some named it ‘sail shaped’ [21] or hourglass-shaped [22]. We had not found any article which morphologically classified MPFL into three categories: triangular, rectangular, and two straps. We

reported here 67.5% triangular, 20% rectangular, and 12.5% two-strap variant patterns of MPFL.

Conclusions

This study added knowledge about the exact origin and insertion of MPFL. The origin lies between the adductor tubercle and the medial epicondyle of the femur. For the insertion fibers of MPFL extended to the proximal medial half of the patella and the tendinous aponeurosis of VMO and VIM. The three variant patterns: triangular, rectangular, and two straps of MPFL are reported for the first time in this study. This knowledge will be helpful to the surgeons involved in the repair of the MPFL.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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