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Menisco-fibular ligament — an overview: cadaveric dissection, clinical and magnetic resonance imaging diagnosis, arthroscopic visualisation and treatment

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Background: *Injury to the menisco-fibular ligament (MFiL) is not commonly recognised. The anatomy of the lateral meniscus is complex and structure-function relationships are only partly understood. The purpose of the present study was to evaluate the MFiL, an anatomic structure rarely discussed that stabilises the lateral meniscus at the level of the hiatus popliteus and may have a crucial role in pathology of lateral meniscus injury.*

Materials and methods: *The MFiL was dissected from its attachment at the lateral meniscus to its insertion on fibular head in 12 human normal cadaver knees. The dimensions were determined and its anatomic position visualised throughout a 90° range of motion. Findings were documented on digital photographs and on video. Results were compared against the magnetic resonance imaging (MRI) appearance of the injured MFiL in 20 patients. Concomitant knee injuries in those patients were also analysed to determine the most frequent pattern of injuries.*

Results: *The normal MFiL showed an inverted trapezoid-shape with a mean width proximally of 13 mm, mean width distally of 8.5 mm and a mean length of 18.4 mm. MRI visualisation of the ligament was possible even in regular sequences; however, additional radial plane sequences were also used. Arthroscopic visualisation and manipulation was optimal when the camera was inserted into the postero-lateral gutter with full knee extension.*

Conclusions: *The MFiL stabilises the postero-lateral knee in concert with the menisco-femoral ligaments. Injury to the MFiL can be a cause of chronic postero-lateral pain syndrome with associated instability. Further anatomical and biomechanical studies are needed in order to fully evaluate its importance.* (Folia Morphol 2021; 80, 3: 683–690)

Key words: menisco-fibular ligament, lateral meniscus, anatomy, knee, arthroscopy, postero-lateral corner

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INTRODUCTION

A thorough understanding of anatomic structure-function relationships is necessary for optimal surgical repair following injury. The purpose of the present study was to evaluate the menisco-fibular ligament (MFiL) — a stabilising structure that maintains the lateral meniscus at the level of hiatus popliteus. This ligament is a relatively unknown ligament and there are only a few studies describing it. On the other hand injuries to lateral meniscus at the level of hiatus popliteus are common, but also hard to handle. Results of suturing lateral meniscus in that area are not always favourable. And failing to save lateral meniscus inevitably leads to early osteoarthrosis [6].

Comparative anatomy in mammals offers insight into structure-function relationships in the human knee. The fruit bat (Pteropus), for example, which has only flexion and extension capability with no rotational movement of the knee joint, has no menisci. On the other hand, lower monkeys (ex. Rhesus, Capuchin), have greater rotational movement in the knee than man, and has a medial meniscus that is similar to man. However, the lateral meniscus is not attached to tibia, but continues obliquely, posterior to posterior cruciate ligament and finds its insertion on femur (similarly to posterior menisco-femoral ligament, Wrisberg's ligament in humans) [10]. Therefore, logically the human lateral meniscus (Fig. 1) anatomy and biomechanics are somewhere between the fruit bat and the monkey and is characterised by both medial and lateral menisci and rather rigid fixation with its posterior root attachment to tibia.

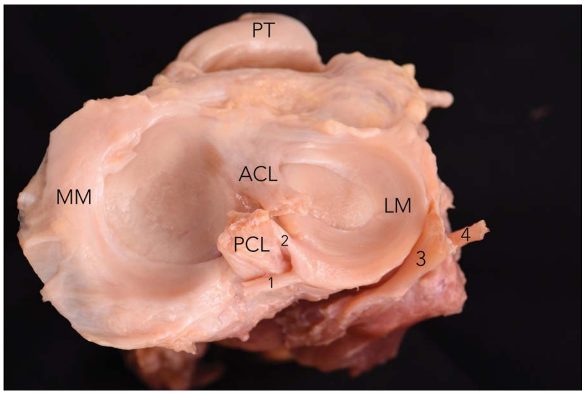

Figure 1. Cadaveric dissection of human right knee; MM — medial meniscus; LM — lateral meniscus; ACL — anterior cruciate ligament; PCL — posterior cruciate ligament; PT — patellar tendon; 1 — posterior menisco-femoral ligament (Wrisberg ligament); 2 — anterior menisco-femoral ligament (Humphrey ligament); 3 — popliteus tendon; 4 — lateral collateral ligament.

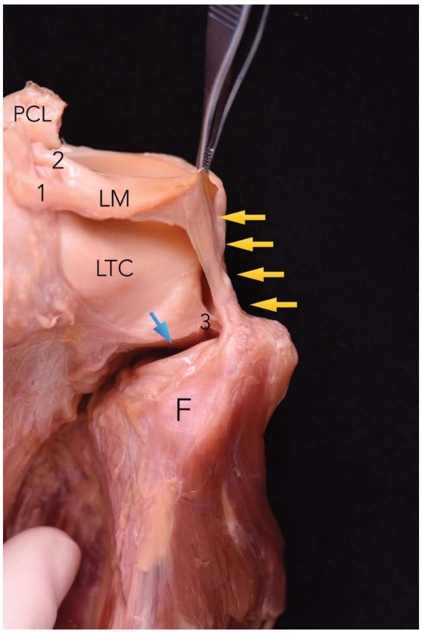

Figure 2. Cadaveric dissection of human right knee; posterior view; LM — lateral meniscus; PCL — posterior cruciate ligament; LTC — lateral tibial condyle; 1 — posterior menisco-femoral ligament; 2 — anterior menisco-femoral ligament; 3 — superior joint capsule of proximal tibio-fibular joint (marked with blue arrow). Menisco-fibular ligament is marked with yellow arrows.

Development of menisco-fibular ligament

In lower vertebrates, as well as during human embryonic development, both the tibia and fibula (with attached popliteus tendon) articulate with the femur. However, at 7–8 weeks gestation, the fibula moves distally and the popliteus tendon forms a new attachment to the femur, concomitantly retaining its original insertion to fibula, which later is called the popliteo-fibular ligament. As a result, humans have an intra-articular popliteus tendon and a hiatus popliteus [3, 5]. At 11 weeks of embryonic development, a direct connection between fibula and lateral meniscus is formed: the MFiL (Fig. 2) [1]. The MFiL is a thick fibrous band connecting inferior edge of posterior part of lateral meniscus with the head of fibula, and to a limited extent, provides reinforcement of the coronary ligament (menisco-tibial ligament). According to Bozkurt et al. [1] the mean thickness of MFiL is 3.84 mm (including the capsule to which it adheres).

The coronary ligament attaches just below articular margin of proximal lateral tibial condyle, while the distal attachment of MFiL is on fibular head [8]. This relatively large ligament is believed to stabilise the lateral meniscus and thus have a significant impact on the biomechanics of the lateral meniscus and play a role in lateral meniscal tears. The presence of the MFiL may biomechanically explain lateral meniscus longitudinal tears at the level of hiatus popliteus. While the knee moves from flexion to extension and the lateral meniscus moves anteriorly following the femoral condyles and being pulled by menisco-femoral ligaments, the MFiL, together with menisco-popliteal fascicles acts to limit that movement (Fig. 3). If that balance gets interrupted by an external force for example, meniscal injury can occur.

In this study we are investigating anatomy and pathology of this unknown MFiL from three different perspectives: anatomical dissection, magnetic resonance imaging (MRI) and arthroscopic appearance.

MATERIALS AND METHODS

Twelve cadaver knees, 9 right and 3 left, were dissected. Ten of the knees were in males and two in females. The mean age was 67 years with a range of 52 to 74 years. Knees with severe osteoarthritic changes (grade IV according to Outerbridge classification of osteochondral injuries) were excluded from the study. Classical anatomical dissection was conducted with careful layer by layer removal of tissue within the postero-lateral corner until the MFiL was clearly identified in all specimens. The length and the width of the ligament was measured and the anatomical findings were documented with digital photographs and video recordings.

The present study also included retrospective evaluation of the MRI of an injured MFiL in 20 patients. These patients included 13 males and 7 females, with a mean age of 37 years and a range of 18 to 53 years. These MRI included 12 left and 8 right knees. All MRI were performed in 1.5 T Signa HDxt 1.5T, GE Medical Systems, in 8chHD Knee Array Coil. The following sequences were performed: sagittal PD FSE, sagittal PD FSE Fat Sat (slice thickness 2.0 mm); coronal PD FSE (slice thickness 3.0 mm) and axial STIR (slice thickness 3.5 mm).

RESULTS

Anatomic dissection

The MFiL in 12 cadaveric knees was an inverted trapezoid-shaped structure, with a mean width proximally of 13 mm (range: 9–17 mm), a mean width distally of 8.5 mm (range: 4.3–12 mm) and a mean length of 18.4 mm (range: 14–26 mm) (Fig. 4). The proximal attachment of the MFiL began at the inferior edge of posterior part of lateral meniscus. At the level of the articular surface of lateral tibial condyle: the medial, vertical edge of ligament began at about the level where popliteus tendon crosses the lateral meniscus, however its lateral

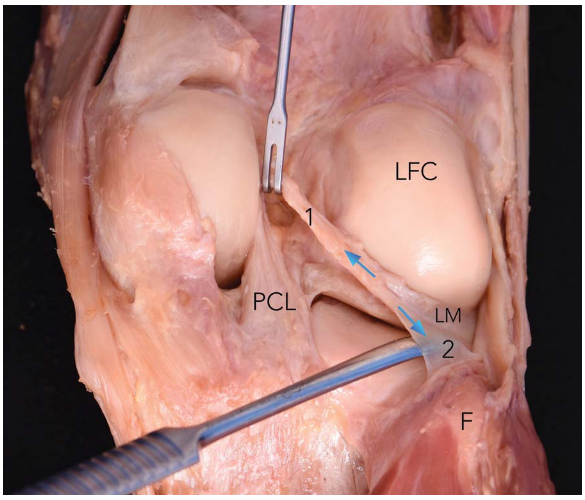

Figure 3. Cadaveric dissection of human right knee; posterior view; LM — lateral meniscus; LFC — lateral femoral condyle; PCL — posterior cruciate ligament; F — fibula; 1 — posterior menisco-femoral ligament (Wrisberg ligament); 2 — menisco-fibular ligament. Notice the way in which menisco-femoral ligament works against menisco-fibular ligament — marked with blue arrows.

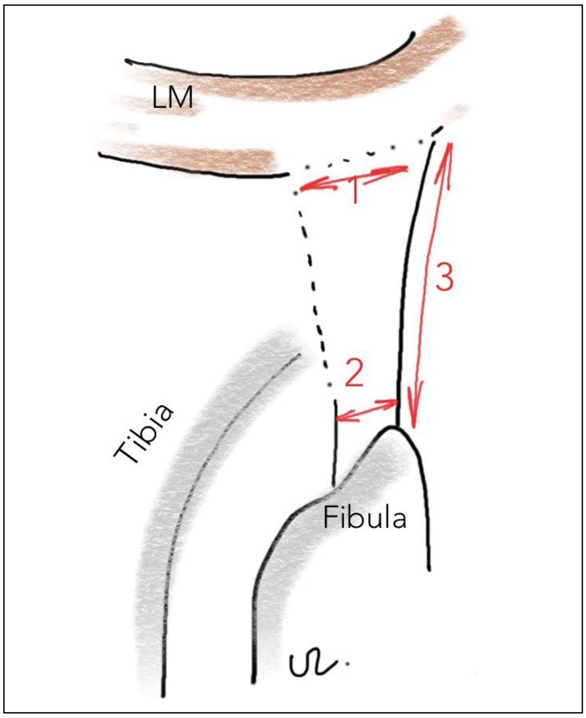

Figure 4. Schematic drawing of measurements taken of menisco-fibular ligament; 1 — proximal width; 2 — distal width; 3 — length; LM — lateral meniscus.

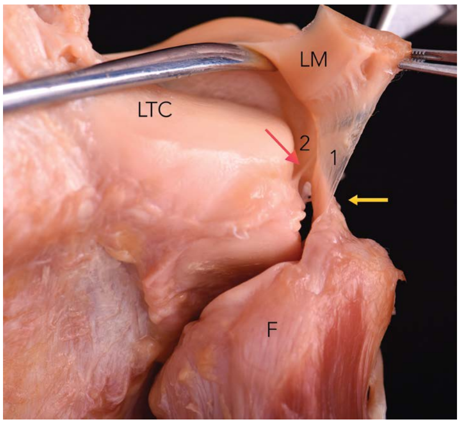

Figure 5. Cadaveric dissection of human right knee; posterior view; LTC — lateral tibial condyle; LM — lateral meniscus, being elevated from tibial plateau; F — fibula; 1 — menisco-fibular ligament, notice its distal, fibular attachment (marked with yellow arrow); 2 — menisco-tibial (coronary) ligament, notice its distal (tibial) attachment (marked with red arrow). Menisco-fibular ligament on its lateral margin becomes menisco-tibial ligament, and only way to distinguish those two, is by observing its distal attachment.

edge could be distinguished from the coronary ligament only by observing its distal attachment (coronary ligament attached to tibia, while MFiL to fibula) (Fig. 5). Stated differently, the ligaments are confluent proximally and are separate and distinct structures distally.

The distal attachment of the MFiL on fibular head is deeper than the distal attachment of fibular collateral ligament. The MFiL attaches just behind the cartilage margin of articular surface of fibular head at the proximal tibio-fibular joint.

In 4 of the 12 knees the MFiL was positioned superficial to the coronary ligament. While flexing the knee, the posterior margin of MFiL is positioned more horizontal, while extension of the knee results in more vertical and tense positioning of the ligament.

Magnetic resonance (MR) evaluation

We retrospectively evaluated 20 patients with injury to MFiL. We also analysed other concomitant knee injuries in those patients.

The 12 patients with MFiL injury showed a variety of different injury patterns: oedema, partial and complete tears. There was only 1 of the 20 patients with isolated MFiL injury. All remaining patients had complex, multiligament injuries (Table 1). The most common knee injury associated with MFiL injury was a complete anterior cruciate ligament tear.

The ligament may be best visualised in sagittal PD FSE sequence, especially if there is contrast or haemarthrosis (Fig. 6). In acute cases, local oedema may be the only indicator of MFiL injury. Radial plane images (often used in hip, but also knee MRs [11]) (Fig. 7A, B) can facilitate visualisation of MFiL injury. Proton density weighted radial sequences are planned on the axial image of the knee. The centre of the radial plane is set at the middle of the joint on the tibial eminence. Three-dimensional volumetric reconstruction in the plane of the ligament may also give excellent visualisation.

Arthroscopic evaluation

Findings of the present study were used to develop a protocol for arthroscopic visualisation and treatment of the MFiL. The knee is positioned in full extension and the camera is placed in the postero-lateral gutter of the knee joint, anteriorly to intraarticular part of popliteus tendon, through superior-lateral portal. The "working portal" is standard antero-lateral portal (Fig. 8A–C). In this position the MFiL may be easily evaluated and treated (Fig. 9A, B). The MFiL maybe also visible from anterior, beneath the lateral meniscus (Fig. 10). Suturing of the ligament is best performed with a small pig-tail device.

DISCUSSION

The anatomy of the lateral meniscus is complex and structure-function relationships are only partly understood. Injury to the MFiL is not commonly recognised. The purpose of the present study was to evaluate the MFiL, an anatomic structure rarely discussed that stabilises the lateral meniscus at the level of the hiatus popliteus and may have a crucial role in pathology of lateral meniscus injury.

According to Seebacher et al. [12] and Davies et al. [4], the lateral compartment of the knee joint consists of three layers:
- I — superficial layer is formed by iliotibial band and biceps femoris tendon;
- II — middle layer consists of fibres to lateral patellar retinaculum (patello-femoral ligament and patello-meniscal ligament);
- III — deep layer, being the most complex one, which may be further divided into superficial (with lateral collateral ligament and fabello-fibular ligament) and deep (with coronary ligament and arcuate ligament) lamina.

Although not described in above mentioned studies: the MFiL would be a part of the deep lamina of the third layer of the lateral compartment.

Obaid et al. [9] evaluated the MFiL in 160 MRI studies of 152 patients. He described the MFiL as a curvilinear or straight hypointense structure, an-

Table 1. Patients with menisco-fibular ligament (MFiL) injuries confirmed in magnetic resonance. Different concomitant injuries are presented in the table

Patient	Sex	Age	Side	MFiL	MM	LM	ACL	PCL	MCL	FCL	HL	WL	MPF	PFL	AL	PT	FPML
1	Male	43	Left	Partial injury	B	B	+		PI		PI					0	+
2	Male	53	Left	Partial injury and oedema	BuH	B	+		PI		PI	PI		PI		PI	+
3	Female	23	Right	Partial injury and oedema	B	B	+		+		PI	PI	B				+
4	Female	32	Left	Oedema	B	B	PI		PI			PI					
5	Female	46	Right	Partial injury and oedema	B	B	+	PI		PI				PI	PI	0/PI	
6	Male	18	Right	Partial injury and oedema	B	PI	+					PI	PI				+
7	Male	34	Left	Partial injury	PostM	+	+			PI				PI		PI	
8	Male	37	Left	Partial injury and oedema	B	+	+				PI						+
9	Female	21	Left	Partial injury and oedema			+		PI		PI	PI					+
10	Male	19	Right	Partial injury			+						PI	PI			
11	Male	42	Right	Complete injury		D											
12	Male	39	Left	Scar			+					Sc					
13	Male	31	Right	Partial injury and oedema	PostM	D	PI		PI	PI		PI	0	0		0	+
14	Female	34	Right	Partial injury and oedema	PostM	Rad	ACLr+		PI	PI	0					Sc	
15	Male	53	Right	Complete injury	D	PostM+						+	+				
16	Male	47	Right	Partial injury	PI		ACLr/PI		PI	PI			PI		PI	PI	
17	Male	34	Right	Partial injury	0/+		+		PI	PI		PI	PI	PI		PI	
18	Female	48	Left	Complete injury	0	+	PI		+	PI	PI		PI			PI	
19	Male	48	Right	Complete injury	+	+	PI		PI	PI				PI	PI		
20	Female	43	Right	Partial injury	PI	+	PI		PI	PI	PI					0	

+ — complete injury; ACL — anterior cruciate ligament; ACLr — anterior cruciate ligament reconstruction; AL — arcuate ligament; B — bruising; BuH — bucket handle tear; D — degenerative changes; FCL — fibular collateral ligament; FPML — fracture of posterior margin of lateral tibial condyle; HL — Humphrey ligament; LM — lateral meniscus; MCL — medial collateral ligament; MM — medial meniscus; MPF — menisco-popliteal fascicles; 0 — oedema; PCL — posterior cruciate ligament; PFL — popliteo-fibular ligament; PI — partial injury; PostM — postmeniscectomy; PT — popliteus tendon; Ra — radial tear; Sc — scar; WL — Wrisberg ligament

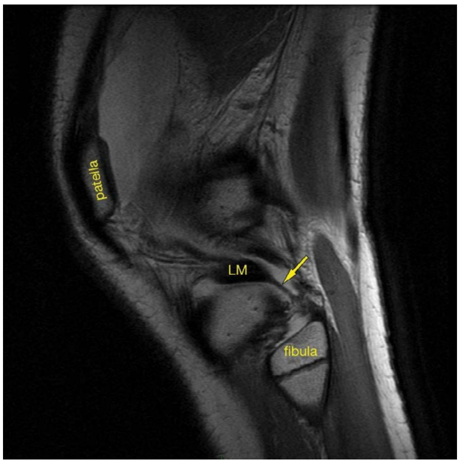

Figure 6. Magnetic resonance imaging scan in sagittal plane: intact menisco-fibular ligament (marked with yellow arrow); LM — lateral meniscus.

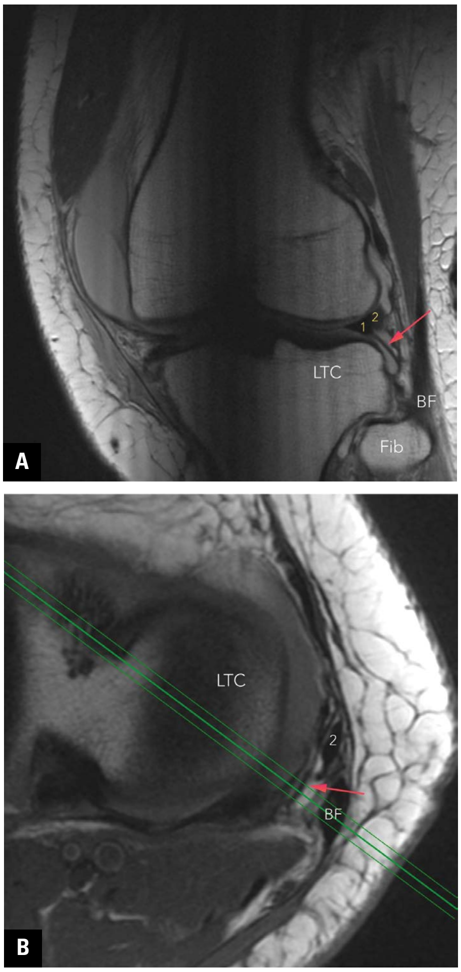

Figure 7. Magnetic resonance imaging scan in special radial plane; **A.** Intact menisco-fibular ligament (marked with red arrow); 1 — lateral meniscus; 2— popliteus tendon; LTC — lateral tibial condyle; BF — biceps femoris tendon; Fib. — Fibula; **B.** Magnetic resonance imaging axial image showing the way in which radial plane was planned, perpendicular to the plane of menisco-fibular ligament (also marked with red arrow).

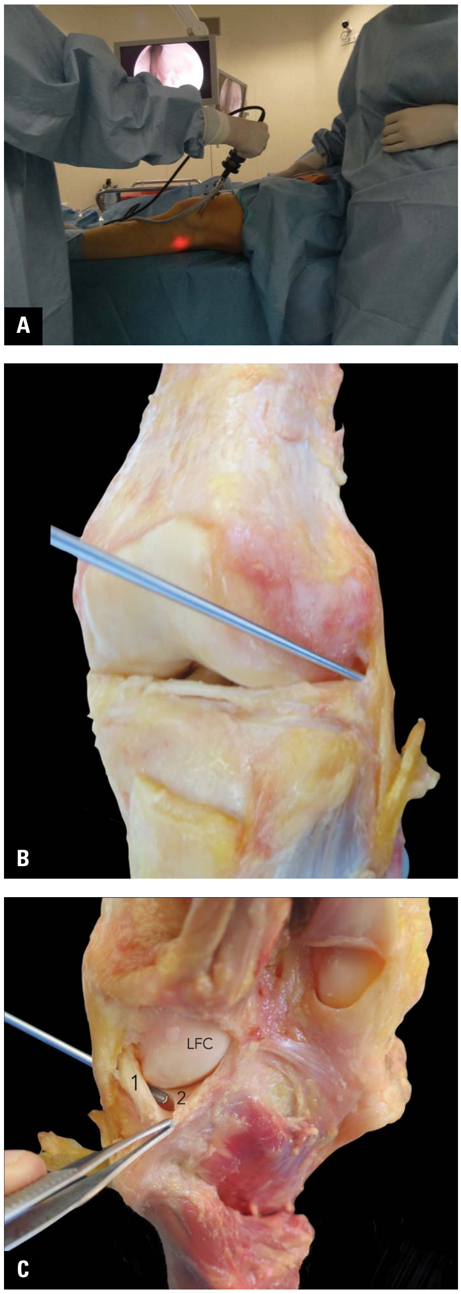

Figure 8. A. Arthroscopic visualisation of menisco-fibular ligament. The knee is in full extension. Camera is placed in the postero-lateral gutter of the knee joint, anteriorly to intraarticular part of popliteus tendon, through superior-lateral portal; Panels **B** and **C** demonstration of camera's positioning on cadaver specimen; LFC — lateral femoral ligament; 1 — popliteus tendon; 2 — menisco-popliteral superior fascicles.

terior and lateral to popliteus tendon, running from inferior margin of lateral meniscus to the apex of fibular head. The visualisation of the ligament was determined by the presence or absence of joint fluid. In his study the presence of the MFiL was confirmed in approximately half of the cases. Lee et al. [7] performed MR arthrography with 70 degrees of knee

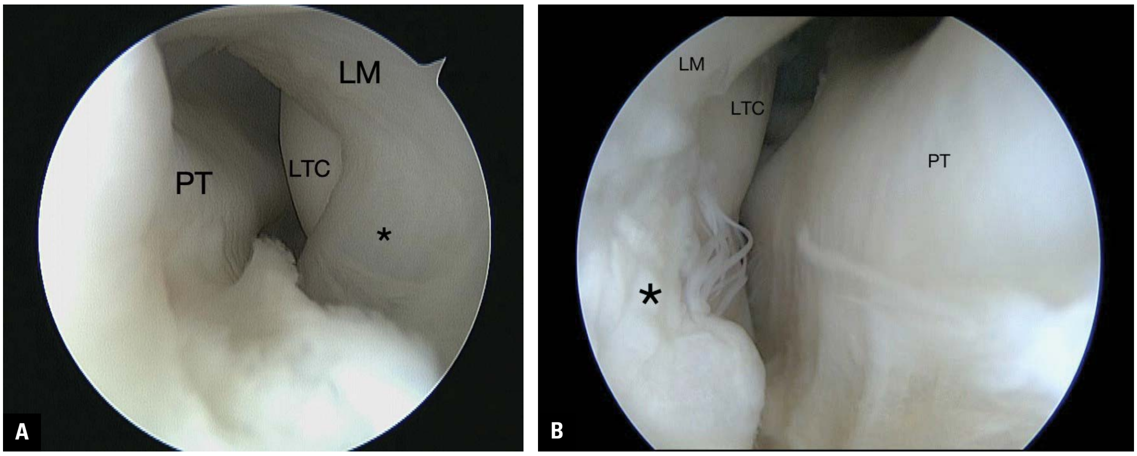

Figure 9. Arthroscopic view of postero-lateral gutter. The knee is in full extension. Camera is placed in the postero-lateral gutter of the knee joint, anteriorly to intraarticular part of popliteus tendon, through superior-lateral portal — see details on Figure 8. **A.** (*) — intact menisco--fibular ligament of the right knee; **B.** (*) — complete rupture of menisco-fibular ligament of the left knee; LM — lateral meniscus; PT — popliteus tendon; LTC — lateral tibial condyle.

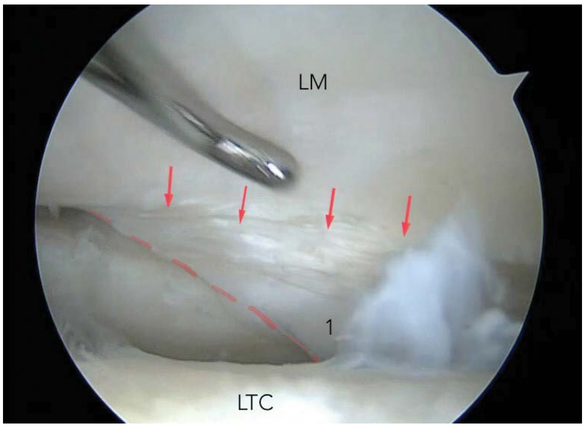

Figure 10. Arthroscopic appearance of torn menisco-fibular ligament (marked with red arrows) in the left knee joint. Camera is placed through standard antero-lateral portal, arthroscopic hook through standard antero-medial portal. Arthroscopic hook is elevating lateral meniscus (LM); LTC — lateral tibial condyle; 1 — menisco-fibular ligament.

flexion in 19 patients. Adding intraarticular contrast and knee flexion increased detectability of the MFiL up to almost 90% of cases. Aforementioned study by Ciszkowska et al. [2] correlated MRI images with gross anatomic dissection of MFiL in 25 cadaver knees. The presence of the MFiL was confirmed in both MRI and gross anatomic dissections of knees. With MRI, the linear, hypointense line of thin ligament extending between the posterior third of the lateral meniscus and the apex of the fibula was best defined on sagittal images. The ligament could be also visualised on axial and coronal images. The mean thickness of the ligament in the midsubstance was 1.37 mm (min 0.71 mm; max 2.15 mm). The length and width were difficult to define in MRI because of the small size and spatial shape of the ligament. The gross anatomic dissections confirmed the trapezoid shape of flat ligament. The mean length of the ligament was 19 mm, proximal width 12 mm, distal width 7.5 mm. There are different ways to visualise the MFiL in MR examination. MRI radial planes were described by Quinn et al. [11]. These planes, when evaluated in correlation with regular planes (especially sagittal) may further improve accurate interpretation of the MFiL integrity.

To the best of our knowledge, there are no other studies describing arthroscopic visualisation and treatment of the MFiL. The protocol proposed herein is minimally invasive and does not require an excessive surgical approach. Based upon the frequency of injury and association with anterior cruciate ligament injuries, it is advisable to routinely evaluate the MFiL, especially in cases of lateral meniscus injury or chronic pain in the postero-lateral knee corner.

CONCLUSIONS

The MFiL is a rarely discussed anatomic structure that is important for stabilisation of the lateral meniscus. Further anatomical and biomechanical studies are needed to fully evaluate its clinical importance. In cases of chronic postero-lateral pain syndrome it may be helpful to evaluate postero-lateral corner structures, as well as the MFiL as a possible cause of pain and instability. The reconstruction of this ligament during lateral meniscus allograft implantation may also be considered.

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Conflict of interest: None declared

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