Meniscofemoral ligaments revisited

ANATOMICAL STUDY, AGE CORRELATION AND CLINICAL IMPLICATIONS

C. M. Gupte, A. Smith, I. D. McDermott, A. M. J. Bull, R. D. Thomas, A. A. Amis

From Imperial College, University of London, England

The meniscofemoral ligaments were studied in 84 fresh-frozen knees from 49 cadavers. Combined anterior and posterior approaches were used to identify the ligaments. In total, 78 specimens (93%) contained at least one meniscofemoral ligament. The anterior meniscofemoral ligament (aMFL) was present in 62 specimens (74%), and the posterior meniscofemoral ligament (pMFL) in 58 (69%). The 42 specimens (50%) in which both ligaments were present were from a significantly younger population than that with one MFL or none (p < 0.05). Several anatomical variations were identified, including oblique fibres of the posterior cruciate ligament (PCL), which were seen in 16 specimens (19%). These were termed the ‘false pMFL’.

The high incidence of MFLs and their anatomical variations should be borne in mind during arthroscopic and radiological examination of the PCL. It is important to recognise the oblique fibres of the PCL on MRI in order to avoid wrongly identifying them as either a pMFL or a tear of the lateral meniscus. The increased incidence of MFLs in younger donors suggests that they degenerate with age.

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The meniscofemoral ligaments (MFLs) connect the fibro-cartilaginous menisci of the knee to the intercondylar area of the femur. The term ‘ligament’ is a misnomer since these structures connect meniscus to bone, not bone to bone.

Most commonly, the posterior horn of the lateral meniscus is connected to the lateral (inner) aspect of the medial femoral condyle by two MFLs. One passes anterior to the posterior cruciate ligament (PCL) and is known as the anterior meniscofemoral ligament (aMFL) of Humphry,1 while the other passes posterior to the PCL and is known as the posterior meniscofemoral ligament (pMFL) of Wrisberg. Ligaments from the medial meniscus and the anterior horn of the lateral meniscus have also been described, but are less common.2-4

Several anatomical studies of MFLs were undertaken in the last century3,5-13 (Table I). While Heller and Langman3 found that at least one MFL was present in 71% of their specimens, others have reported the incidence to be 100%.1,2,8,6 These discrepancies are reflected in anatomical texts, some of which describe one or both MFLs, whereas others make no mention of their existence.14,15

There has recently been renewed interest in the MFLs. Biomechanical studies have shown that they have properties comparable to those of the posterior fibre bundle of the PCL, and that they may have a mechanical function in the knee.8,9,16,17 MRI studies have shown that they may be wrongly interpreted as a tear of the lateral meniscus.18-20 The variable position of these ligaments hampers accurate interpretation of MR scans.12

Our aim was to describe anatomical variations of the MFLs which may lead to their misidentification on MRI or arthroscopy. We also investigated the relationship between age and the presence of MFLs.

Materials and Methods

Ethical approval was obtained at a local district general hospital. Fresh-frozen knees from 56 human cadavers with a mean age of 67 years (18 to 96) were thawed at room temperature over 24 hours. The age and mode of death were recorded. We excluded specimens with arthritis or damage to ligaments. This left 84 specimens (49 cadavers) suitable for anatomical study, of which 70 were paired.

Anterior approach. The joint capsule was opened anteriorly by a medial parapatellar incision, reflecting the patella and patellar tendon laterally. The knee was flexed to 90° and the anterior aspect of the joint cavity inspected for pathology such as osteoarthritis. The anterior cruciate liga-
ment (ACL) was divided near its tibial attachment to expose the anterior/distal surface of the PCL. This surface was carefully inspected for a structure attaching to the posterior horn of the lateral meniscus, the aMFL (Fig. 1). The pMFL is not visible through an anterior approach because of its position, which is posterior to the PCL in the flexed knee.

**Posterior approach.** After completion of the anterior approach, the posterior aspect of the knee was studied. The knee was extended and a midline posterior capsulotomy carried out. This allowed close inspection of the PCL and

Table I. The occurrence of MFLs found in previous studies. In some studies the reported individual occurrence did not summate to the total number of specimens examined. These small discrepancies are reflected in the total specimens of the table shown

<table>
<thead>
<tr>
<th>Study</th>
<th>Total one MFL</th>
<th>Total aMFL</th>
<th>aMFL only</th>
<th>Total pMFL</th>
<th>pMFL only</th>
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<td>40</td>
<td>25</td>
<td>10</td>
<td>30</td>
<td>15</td>
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<tr>
<td>Heller and Langman</td>
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<td>99</td>
<td>50</td>
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<td>41</td>
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<td>Yamamoto and Hirohata</td>
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<td>27</td>
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<td>24</td>
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<td>Kusayama et al</td>
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<td>6</td>
<td>20</td>
<td>12</td>
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<td>Harner et al</td>
<td>8</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Wan and Felle</td>
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<td>20</td>
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<td>42</td>
<td>42</td>
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<td>8</td>
<td>38</td>
<td>11</td>
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<td>Cho et al</td>
<td>28</td>
<td>25</td>
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<td>25</td>
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<td>Neiss et al</td>
<td>122</td>
<td>117</td>
<td>71</td>
<td>17</td>
<td>102</td>
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<tr>
<td>Total</td>
<td>781</td>
<td>716</td>
<td>370</td>
<td>167</td>
<td>552</td>
<td>305</td>
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<tr>
<td>Percentage of total specimens</td>
<td>100</td>
<td>92</td>
<td>47</td>
<td>21</td>
<td>71</td>
<td>39</td>
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Photograph showing an aMFL in a cadaver left knee. This clear view is provided by an anterior approach after removing the ACL and collateral ligaments. The aMFL gains attachment to the posterior horn of the lateral meniscus (LM) by passing anterior/distal to the PCL (LM, lateral meniscus).

Fig. 2

Photograph of a pMFL in a cadaver right knee, as viewed after a posterior approach with the joint capsule removed. Unlike Figure 4, the ‘true’ pMFL gains attachment to the posterior horn of the lateral meniscus (LM).

Fig. 3

Photograph of the pMFL connecting the lateral meniscus (LM) to the inner aspect of the medial condyle of the femur (F). The LM has been detached from its tibial attachments.
its immediate posterior vicinity for the presence of a pMFL attaching to the posterior horn of the lateral meniscus (Fig. 2). Any ‘aberrant’ fibres of the PCL which could be mistaken as the MFL were noted.

**Disarticulation of the femur and tibia.** After completion of the anterior and posterior approaches, the medial and lateral collateral ligaments and the remaining capsule were divided, leaving the knee articulating only by the PCL and MFLs. The lengths of MFLs were measured by callipers, positioning the knee so that they were taut. The PCL was then divided and the lateral meniscus detached from the tibia. The knee was thus disarticulated with the MFLs attached to the femur and lateral meniscus (Fig. 3).

**Statistical analysis.** We used an unpaired, one-tailed Student t-test to examine the hypothesis that the knees in which both MFLs were present were from a younger population than those with only one or no MFLs.

**Results**

**Presence of MFLs.** A total of 84 knees was examined of which 78 (93%) had at least one MFL (Table II). An aMFL was present in 62 (74%), a pMFL in 58 (69%) and both in 42 (50%). In the 35 cadavers in whom paired knees were examined, 20 (57%) had the same incidence of MFL in both knees, while in 15 (43%) it was different.

**Variation with age.** The mean age of the donors with both MFLs (54.1±20.8 years) was significantly different (p < 0.05) from those with only one or no MFL (66.2±18.8 years).

**Oblique fibres of the PCL, the ‘false’ pMFL.** In 16 knees, the PCL had oblique fibres, which attached to the tibia at a site proximal to the remainder of the insertion of the PCL (Fig. 4). These could be easily confused with the pMFL. Close scrutiny was required to distinguish whether these fibres were attached to the tibia (PCL) or to the lateral meniscus (LM).

**Variations in the aMFL.** In two knees the aMFL consisted of two separate bundles, one attaching more superiorly to the lateral meniscus than the other. Proximally, they became indistinguishable, having the same attachment to the femur (Fig. 5).

**Variation in sizes of the MFLs** The mean length of the aMFL was 20.7±3.9 mm while that of the pMFL was 23±4.2 mm. Although the lengths of the MFLs were relatively constant, their thickness varied considerably (Fig. 6). In specimens in which the two MFLs coexisted, one was usually much larger than the other.

**Attachments of the MFLs.** Although there was a considerable variation in the size of the MFLs, their attachments were relatively consistent. The aMFL attached proximally to the inner aspect of the medial condyle of the femur, between the distal margin of the femoral attachment of the PCL and the edge of the condylar articular cartilage. The pMFL attached more posteriorly, at the proximal margin of the attachment of the PCL.

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**Table II.** The presence of MFLs in the 84 knees studied

<table>
<thead>
<tr>
<th>Total knees</th>
<th>At least one MFL</th>
<th>Total aMFL</th>
<th>aMFL only</th>
<th>Total pMFL</th>
<th>pMFL only</th>
<th>Both pMFL and aMFL</th>
<th>No MFL</th>
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</thead>
<tbody>
<tr>
<td>Number present</td>
<td>84</td>
<td>78</td>
<td>62</td>
<td>20</td>
<td>58</td>
<td>16</td>
<td>42</td>
</tr>
<tr>
<td>Percentage</td>
<td>100</td>
<td>93</td>
<td>74</td>
<td>24</td>
<td>69</td>
<td>19</td>
<td>50</td>
</tr>
</tbody>
</table>

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**Fig. 4**

Photograph of the ‘false’ pMFL in this specimen of a right knee. The oblique fibres (O) of the PCL arose from a site proximal to the principal attachment of the PCL on the tibia (P). These fibres may be confused with the pMFL, but do not directly attach to the posterior horn of the lateral meniscus (LM).

**Fig. 5**

Photograph of an unusual aMFL with two bundles, attaching adjacent to each other on the posterior horn of the lateral meniscus (LM), but fusing to form one bundle proximally, which attaches to the medial femoral condyle (F).
The meniscal attachments of the MFLs followed their orientation in the sagittal plane, with the aMFL attaching more anteriorly than the pMFL.

Discussion

Presence of MFLs. Previous studies have reported a wide variation of the incidence of MFLs. We have investigated these variations. The incidence of at least one MFL in the specimens examined was 94%. Several authors have reported an incidence of 100%. Heller and Langman used an anterior approach and found one or both ligaments in 71%. This approach may have led to under-reporting of the pMFL, since it lies on the posterior surface of the PCL. They noted that both MFLs were only present in eight of 140 specimens. We suggest, however, that several pMFLs may not have been identified. One cause for over-reporting of the pMFL in other studies was the misidentification of the oblique fibres of the PCL (see below). Our findings are similar to those of Yamamoto and Hirohata, Poynton et al, and Neiss et al, who found that both MFLs were present in approximately half of all specimens.

Variations may also reflect ethnic differences. Cho et al found that there were no aMFLs in 28 specimens of Korean origin, whereas the pMFL was present in 25. This differs greatly from our finding that the aMFL is present in 53% of knees and from previous Western studies, which have reported an aMFL in up to 83% of knees. The reasons for these differences are not clear.

The lengths of the MFLs in our study are similar to those of previous studies, as is the observation that one ligament is much larger when the two coexist.

Age difference between populations. Our study has shown that both ligaments are more likely to be present in younger specimens. It can be speculated that both ligaments may normally be present at birth and disappear after injury and degeneration. It would be interesting to examine whether degeneration of the MFL is associated with abnormalities, such as osteoarthritis or meniscal tears.

Significance of the ‘false pMFL’. Oblique fibres of the PCL were identified in 16 knees (Fig. 4). The pMFL may be mistaken for these fibres. We suggest that this may have occurred in the study of the posteromedial aspect of the knee by Ritchie et al. In their anatomical diagram, the ligament of Wrisberg corresponds to the ‘false pMFL’ described in our study.

These considerations should be borne in mind when interpreting MR scans and during arthroscopy. Previous authors have commented on some variations of the MFLs seen on MRI. There has been no reference to the oblique

![Photograph showing variations in the sizes of the pMFL (single-headed arrows). The width of the mid-substance of the PCL is indicated by double-headed arrows.](image-url)
fibres of the PCL described here. Since this variation was present in almost 20% of specimens, its appearance on MRI requires clarification. The accurate identification of MFLs during arthroscopy relies on tracing their attachment to the posterior horn of the lateral meniscus. In dissection of the cadaver knee, combined anterior and posterior approaches are required in order to identify the MFLs adequately. **Origins of the MFLs.** Kaplan proposed that the aMFL originates from the pMFL as its anterior branch. Our study has shown that the two MFLs are separate structures, coexisting in 50% of knees, with separate attachments to the posterior horn of the lateral meniscus and to the femur. The two are therefore discrete entities. Lablaidi and Vaclavek proposed an embryological explanation for the anatomical variations observed, suggesting that the site of the PCL during organogenesis determines the presence and position of the MFLs, which may arise from the lateral meniscus as a single structure. The meniscal attachments of the two MFLs, however, appeared to be distinct in our study.

From an evolutionary perspective, Le-Minor noted that while the pMFL is always present in animals such as the sheep, the horse and the dog, it is sometimes absent in man, as we have confirmed. There are, however, no reported descriptions of the aMFL in animals, although its incidence was the same as that of the pMFL in the present study. Because of these interspecies differences, Le-Minor proposed that in man the pMFL is a regressive structure, whereas the aMFL is progressive. This is not supported by our observations that neither ligament predominates in incidence or size. **Theories on the function of the MFL.** The function of the MFLs is not known. Several authors have proposed that they control the movement of the posterior horn of the lateral meniscus during flexion of the knee, becoming tense during extension to pull the posterior horn anteriorly and medially. We observed this but it requires more objective evaluation. The MFLs antagonise the posterior/distal pull of the popliteus muscle. Last suggested that the fine control exerted by the MFLs and popliteus protects the lateral meniscus from tears. The medial meniscus lacks this control, and thus suffers more tears. Kimura et al. in their follow-up of patients with arthroscopically repaired lateral meniscal tears, found an increased incidence of recurrent symptoms in those knees in which the MFLs had not been repaired. This would lend some support to Last’s hypothesis. By contrast, Lee et al. examined the MR scans of 100 patients with arthroscopically-proven meniscal tears, and found no association between the presence or absence of MFLs and lateral meniscal tears. The sensitivity and specificity of detecting MFLs on MR scanning have not been determined.

Other authors have postulated a mechanical role for the MFLs. Some have suggested that they act as a secondary restraint, supplementing the PCL. Such a role would necessitate their assessment during arthroscopy and MRI since their presence or absence may affect the function of the knee or the prognosis of injuries such as those to the PCL. Clancy et al. in their follow-up of patients with rupture of the PCL, noted that PCL-deficient knees in which the MFLs are intact have a reduced posterior drawer and may have a better prognosis than for those in which the MFLs are not seen at arthroscopy.

The presence of mechanoreceptors, as shown in the dog by O’Connor, suggests a proprioceptive role for MFLs. This requires assessment in human studies.

Our study confirms the large number of knees with at least one MFL and has highlighted the presence of both MFLs in younger donors. This may indicate that these structures are injured and degenerate during life. Several variations in the anatomy of the MFLs and the PCL have also been identified, which should be borne in mind when interpreting MR scans and at arthroscopy. Knowledge of these variations provides a basis for further studies to examine the function of the MFLs.

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References