Clinical Anatomy of the Anterior Meniscofemoral Ligament of Humphrey

An Original MRI Study, Meta-analysis, and Systematic Review

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Background: The anterior meniscofemoral ligament (aMFL) of Humphrey is an anatomically variable fibrous band of connective tissue that attaches between the lateral aspect of the medial femoral condyle and posterior horn of the lateral meniscus, running posterior to the anterior cruciate ligament and anterior to the posterior cruciate ligament (PCL). The presence of an intact aMFL may contribute to stabilization of the lateral compartment of the knee joint.

Purpose: The original magnetic resonance imaging (MRI) arm of this study aimed to assess the aMFL incidence among Polish patients. The goal of the systematic review and meta-analysis was to review the literature discussing the clinical anatomy of the aMFL and provide data on its prevalence. It was hypothesized that significant heterogeneity exists within the published literature.

Study Design: Cross-sectional study and systematic review; Level of evidence, 3.

Methods: A retrospective investigation was performed on the MRI scans of 100 knees (52 right, 48 left) of Polish patients. Scans were randomly selected from a database of MRI examinations performed in 2019. For the meta-analysis, major online databases were queried for data on the aMFL, and 2 authors independently assessed and extracted data from all included studies. A quality assessment of the included articles was performed using the Anatomical Quality Assessment tool.

Results: In the MRI arm of this study, the aMFL was found in 62 of the 100 lower limbs. The meta-analysis included 41 studies with a total of 4220 limbs. The aMFL was present in 55.5% (95% CI, 45.5%-65.3%) of cases. Arthroscopic studies yielded the highest prevalence (82.3% [95% CI, 36.6%-100.0%]); of MRI studies, the highest prevalence was at 3.0-T strength (51.0% [95% CI, 13.3%-88.2%]).

Conclusion: Significant variability in the prevalence of the aMFL was found in the literature. More emphasis should be placed on the clinical relevance of injuries to the aMFL because of its significant role in the function of the knee. It is important to be aware that, because of the anatomy of the aMFL, the ligament can also function to support a torn PCL.

Keywords: anterior meniscofemoral ligament; ligament of Humphrey; clinical anatomy; evidence-based anatomy; MRI; aMFL

The anterior meniscofemoral ligament (aMFL) of Humphrey (Figures 1 and 2) is an anatomically variable fibrous band of connective tissue that attaches to the lateral aspect of the medial femoral condyle and posterior horn of the lateral meniscus, running posterior to the anterior cruciate ligament (ACL) and anterior to the posterior cruciate ligament (PCL).[2,3,15,45,49,55,59] Since its initial description in 1858, the aMFL has often been considered an anatomic variant for which no primary function or consequence was well-characterized.[26]

There has recently been an increased interest in the biomechanical properties and clinical role of the aMFL. Together with the posterior meniscofemoral ligament (pMFL) of Wrisberg, the meniscotibial ligament, and the popliteomeniscal fascicles, these structures are responsible for the proper mobility and stabilization of the posterolateral part of the lateral meniscus.[4] However, abnormal posttraumatic hypermobility of the lateral meniscus, often associated with ACL and lateral meniscus posterior root tears that may be related to posterolateral tibial plateau fractures, is often poorly diagnosed, leading to lateral meniscal subluxation and the potential early onset of osteoarthritis.[4-6,16,56,57] The presence of an intact aMFL contributes to the proper biomechanical function (optimal contact area and pressure) of the lateral

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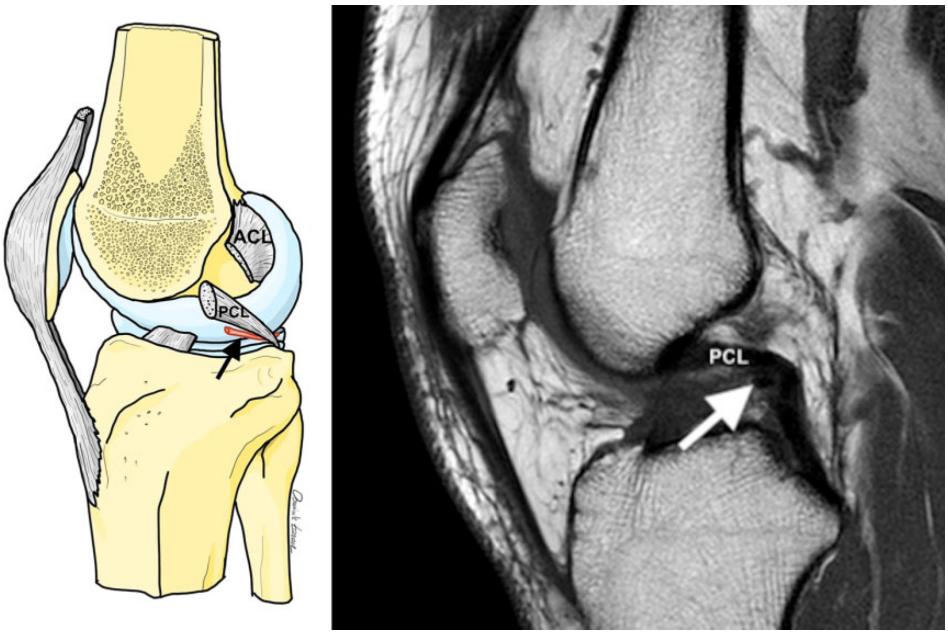

Figure 1. The anterior meniscofemoral ligament of Humphrey in a right knee. (A) Sagittal cross-section of the knee joint (aMFL highlighted with red and marked with black arrow). (B) Sagittal magnetic resonance imaging scan of the knee joint (aMFL marked with white arrow). ACL, anterior cruciate ligament; aMFL, anterior meniscofemoral ligament; PCL, posterior cruciate ligament.

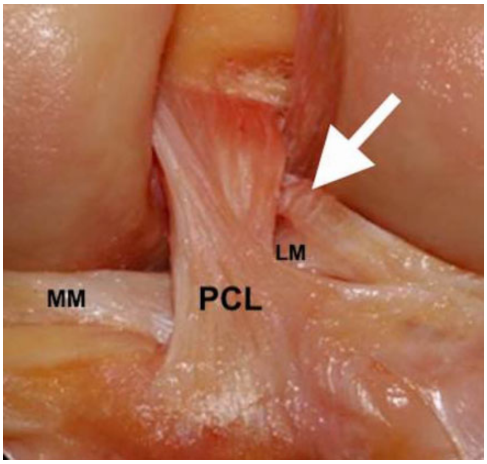

Figure 2. Posterior view of a cadaveric right knee joint with the anterior meniscofemoral ligament of Humphrey (arrow) attached to the lateral meniscus (LM). MM, medial meniscus; PCL, posterior cruciate ligament.

compartment of the knee joint and helps to maintain the correct position of the tibia in relation to the femur.[13,43] Therefore, it is important to raise awareness of the structures anchoring the posterolateral portion of the lateral meniscus, including the aMFL. The use of more powerful magnetic resonance imaging (MRI), along with improved arthroscopic techniques (Figure 3) and an increased knowledge base owing to recent biomechanical studies, has allowed for an improved description of the function of the aMFL.

To the best of our knowledge, there is no study on the prevalence of the aMFL in Polish patients. Therefore, it was decided to perform an MRI evaluation addressing this issue. Moreover, there is no recent comprehensive meta-analysis of the aMFL in the literature. Thus, the purpose of this study was also to provide an up-to-date systematic review and meta-analysis on the clinical anatomy of the aMFL using evidence-based methods. It was hypothesized that the aMFL prevalence varies significantly in published up-to-date studies and that the structure has an important biomechanical function in the knee joint.

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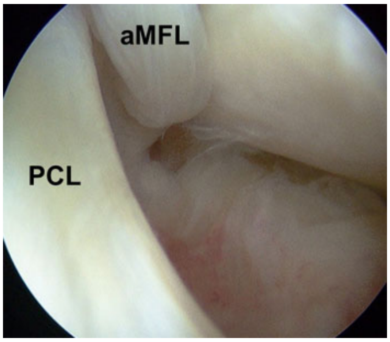

Figure 3. Left knee viewed from an anterolateral arthroscopic portal (anterior cruciate ligament resected) with the anterior meniscofemoral ligament (aMFL) of Humphrey running anterior to the posterior cruciate ligament (PCL).

METHODS

MRI Study

Two of the researchers (P.A.P. and K.A.T.), with experience in musculoskeletal MRI, completed a retrospective MRI analysis of 100 Polish patients in 2019.[48] Scans of nonpaired knees performed in 2019 were randomly selected from a database to assess the prevalence of the aMFL. MRI was originally performed to evaluate "knees with chronic pain." A total of 52 right knees and 48 left knees were analyzed in the study population, which consisted of 44 female and 56 male patients with a mean age of 41.5 ± 13.8 years. The following exclusion criteria were utilized: (1) acute knee injuries, (2) past knee surgery, (3) age younger than 18 years, and (4) deformities of the knee joint. Any disagreements were resolved via a consensus. Scans were generated with 3.0-T scanners using a dedicated 16-channel knee coil in the routine (extended) position and evaluated in the sagittal and coronal planes; the MRI parameters are shown in Appendix Table A1. This study was approved by the ethics committee of our institution.

Chi-square tests were conducted to evaluate significant ($P < .05$) differences in the aMFL prevalence among subgroups. Calculations were performed using SPSS Version 25 (IBM).

TABLE 1
MRI-Based Prevalence of the Anterior Meniscofemoral Ligament[a]

	Total No. of Limbs Examined	Prevalence, n (%)
Overall	100	62 (62.0)
Male	56	33 (58.9)
Female	44	29 (65.9)
Left	48	27 (56.3)
Right	52	35 (67.3)

[a]No significant differences were observed among the analyzed subgroups ($P > .05$ for all). MRI, magnetic resonance imaging.

Systematic Review and Meta-analysis

Search Strategy

The protocol of this study was registered in the PROSPERO database (CRD42020185088). The major relevant online databases (PubMed, ScienceDirect, Google Scholar, Web of Science, and Embase) were queried to aggregate all reports on the aMFL published up to April 2020. To access all relevant literature, the following search terms were used: "anterior meniscofemoral ligament OR humphrey ligament OR ligamentum meniscofemoral antérieur OR ligamentum humphrey OR amfl." There were no other restrictions imposed with regard to language or date. Furthermore, the references of each obtained publication were also included for subsequent analysis. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines[34] were carefully followed while conducting the review.

Eligibility Assessment of Publications

There were 2 authors (P.A.P. and M.A.R.) who independently assessed the eligibility of the articles. Only those studies that satisfied the following criteria were included: (1) complete, unequivocal data on the aMFL prevalence and/or morphometry; (2) MRI, cadaveric, or arthroscopic investigations; and (3) studies performed on at least 5 knees. The following articles were excluded: (1) conference abstracts, case reports, review articles, or letters to the editor; studies on (2) fetuses or (3) animals; and (4) those with overlapping, ambiguous, or missing data. Articles were not excluded on the basis of language. Morphometric analyses were conducted on studies performed on adult knees. Non-English reports were translated by medical professionals fluent in both English and the language of the publication.

Data Extraction

Data extraction was completed independently by 2 authors (P.A.P. and D.P.Ł.); when any disparities were identified, an agreement was reached in the form of a consensus among all reviewers, possibly with the involvement of the original studies' corresponding authors. The compiled statistics included the year, methodology of study (eg, arthroscopic, cadaveric, and/or radiological), country, sample size, and all relevant reported measurements of the aMFL.

Bias Assessment

The studies included in the meta-analysis were assessed for their quality, potential for bias, and reliability via the Anatomical Quality Assessment (AQUA) tool.[33] A total of 5 domains, rated as having a low, high, or unclear risk for bias, were assessed for each study: (1) participant characteristics and objectives, (2) study design, (3) characterization of methods, (4) descriptive anatomy, and (5) reporting of results.

Statistical Analysis

A pooled prevalence statistical analysis (random-effects model) was conducted for the available aMFL measurements using MetaXL 5.3 (EpiGear).[34] Morphometric computations were performed utilizing Comprehensive Meta-Analysis 3.0 (Biostat). Study heterogeneity was determined using the chi-square test and I^2 statistic; $P < .10$ indicated significant heterogeneity. The I^2 statistic was interpreted via the following criteria: 0%-40%, may not be important; 30%-60%, may indicate moderate heterogeneity; 50%-90%, may indicate substantial heterogeneity; and 75%-100%, may represent considerable heterogeneity.[35] To investigate sources of heterogeneity, extensive subgroup analyses were performed based on modality, geographic origin, sex, and side. To fully compare the distribution of the aMFL among male and female patients, additional analyses excluding 1 outlier study (Han et al[29] indicated a prevalence of 1 per 100 knees) were performed. Moreover, a sensitivity analysis of studies performed on ≥100 lower limbs was conducted. Confidence intervals were used to assess statistically significant differences; an overlap or the inclusion of a zero value between intervals indicated a failure to demonstrate significance.

RESULTS

MRI Study

Of the 100 healthy lower limbs examined on MRI, 62 had an identifiable aMFL. None of the observed differences among the subgroups were statistically significant (Table 1).

Meta-analysis

Characteristics of the Included Studies

Overall, 38 articles (40 studies, with 2 articles containing data from 2 different modalities) and the MRI arm of the current study were included in this analysis, for a total of 4220 lower limbs (Appendix Table A2 and Figure 4). There were 15 studies from Europe, 11 from Asia, 12 from North America, and 3 from South America. Moreover, 3 studies were arthroscopic, 28 were cadaveric, and 10 were radio-

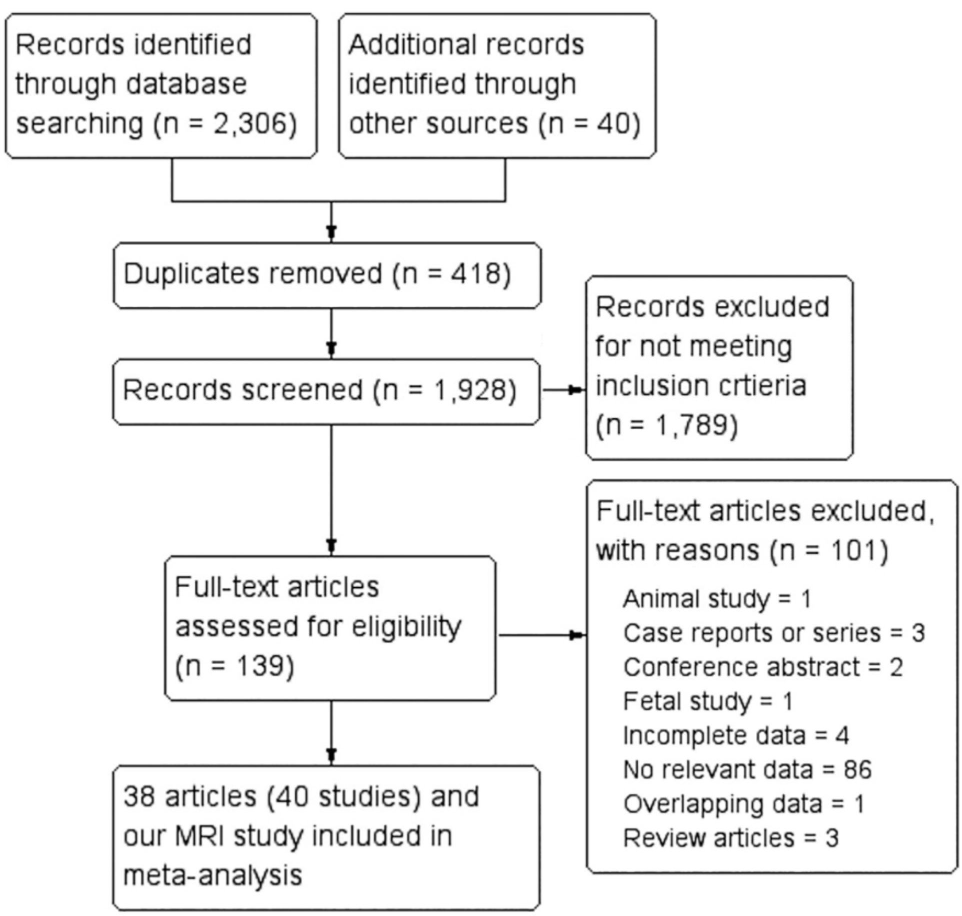

Figure 4. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of study identification, evaluation, and inclusion into the meta-analysis for the anterior meniscofemoral ligament of Humphrey. MRI, magnetic resonance imaging.

TABLE 2
Prevalence of the Anterior Meniscofemoral Ligament by Study Type, MRI Strength, and Geographic Region[a]

	No. of Studies (Limbs)	Pooled Prevalence (95% CI), %	I^2 (95% CI), %	*P* Value (Cochran *Q*)
Overall	41 (4220)	55.5 (45.5-65.3)	97.5 (97.0-97.8)	<.001
Arthroscopic	3 (246)	82.3 (36.6-100.0)	97.9 (96.1-98.9)	<.001
Cadaveric	28 (1263)	60.0 (46.4-72.9)	95.5 (94.4-96.4)	<.001
Radiological (MRI)	10 (2711)	35.8 (23.4-49.2)	97.9 (97.2-98.4)	<.001
3.0-T MRI	3 (890)	51.0 (13.3-88.2)	99.1 (98.5-99.4)	<.001
≤1.5-T MRI	7 (1821)	29.7 (18.5-42.3)	96.5 (94.6-97.7)	<.001
Sensitivity	16 (3398)	44.6 (29.8-59.9)	98.7 (98.4-98.9)	<.001
Asia	11 (672)	21.0 (9.5-35.2)	93.7 (90.6-95.8)	<.001
Europe	15 (2063)	68.0 (52.9-81.4)	97.6 (97.0-98.2)	<.001
North America	12 (1275)	59.6 (48.4-70.3)	90.6 (85.5-93.9)	<.001
South America	3 (210)	90.2 (51.9-100.0)	97.0 (94.0-98.5)	<.001

[a]MRI, magnetic resonance imaging.

logical (MRI). To reduce bias, all studies reporting ambiguous data that could not be interpreted unequivocally were excluded from prevalence calculations.

Bias Assessment

Results of the bias assessment are shown in Appendix Table A3 and Appendix Figure A1. The greatest potential contributors to bias were identified in the methodology characterization of the included articles. However, in the domains of participant characteristics and objective(s), study design, descriptive anatomy, and reporting of results, the risk of bias was low, with the exception of a few studies.

Prevalence of the aMFL

Of the 4220 lower limbs assessed, an aMFL was present in 55.5% (95% CI, 45.5%-65.3%) of the cases (Table 2 and Figure 5). Arthroscopic studies yielded the highest prevalence (82.3% [95% CI, 36.6%-100.0%]); of MRI studies, 3.0-T strength obtained the highest prevalence (51.0% [95% CI, 13.3%-88.2%]). The aMFL was most frequently identified in South American populations (90.2% [95% CI, 51.9%-100.0%]) and was least common in Asia (21.0% [95% CI, 9.5%-35.2%]) (Table 2).

The aMFL was more frequently found in male patients than in female patients (32.4% vs 28.6%, respectively) (Table 3) and in right limbs than in left limbs (88.4% vs 83.1%, respectively) (Table 4). However, these differences were not statistically significant. Only 7.6% (95% CI, 0.0%-20.6%) of the ligaments had accessory bands (Table 5).

Pooling of aMFL Morphometric Data

The mean aMFL was 25.0 mm long (95% CI, 21.8-28.3 mm), with a width ranging from 4.7 mm (95% CI, 4.3-5.2 mm) to 7.9 mm (95% CI, 5.2-10.6 mm) across the variations, and 1.5 mm thick (95% CI, 1.2-1.8 mm) (Table 6). The aMFL:PCL cross-sectional area ratio was 8.4% (95% CI, 1.7%-15.2%), and the mean cross-sectional area of the aMFL across 2 cadaveric studies was 5.0 mm^2 (95% CI, 0.4-10.4 mm^2) (Table 7).

DISCUSSION

In the current review, arthroscopic studies reported the highest aMFL prevalence of 82.3%, followed by cadaveric and MRI studies, with a prevalence of 60.0% and 35.8%, respectively. The overall pooled prevalence of the aMFL was 55.5%. The pooled quantitative anatomic data reported an overall length of 25.0 mm, with a width and thickness of 4.7 and 1.5 mm, respectively.

Noteworthy was the fact that MRI studies performed on a 3.0-T scanner reported a higher aMFL prevalence (51.0%) compared with studies performed on scanners with ≤1.5-T magnetic strength (29.7%). Such results suggest that MRI scanners with stronger magnetic fields are better for visualization of the aMFL. This notion is supported by the results of our MRI study using a 3.0-T scanner, which reported an aMFL prevalence of 62.0%. However, further studies, especially comparing MRI scanners utilizing different field strengths, are required to prove this hypothesis definitively.[17] Röhrich et al[53] contended that the prevalence of the aMFL in MRI studies might be underestimated because of smaller ligaments being overlooked as a result of gap sizes or partial volume effects. Therefore, it is suggested that MRI should not be used to confirm the absence of the aMFL. Anatomic dissections should be considered the gold standard in the identification of the aMFL in basic science research, whereas arthroscopic examinations are optimal for visualizing the aMFL in patients. However, it must be emphasized that the aMFL is partially covered by the synovial tissue located anteriorly to the PCL and is thus not well visualized during standard knee arthroscopic surgery.[17,28,37,38]

The results of our meta-analysis showed a significantly lower aMFL prevalence in the 11 included Asian studies (21.0%) compared with those from other continents (South America: 90.2%; Europe: 68.0%; North America: 59.6%) and the overall pooled prevalence (55.5%). Further studies, especially genetic ones, are required to fully describe this interesting phenomenon, which may influence the future specific approach to injuries of the posterior root of the lateral meniscus in these populations.

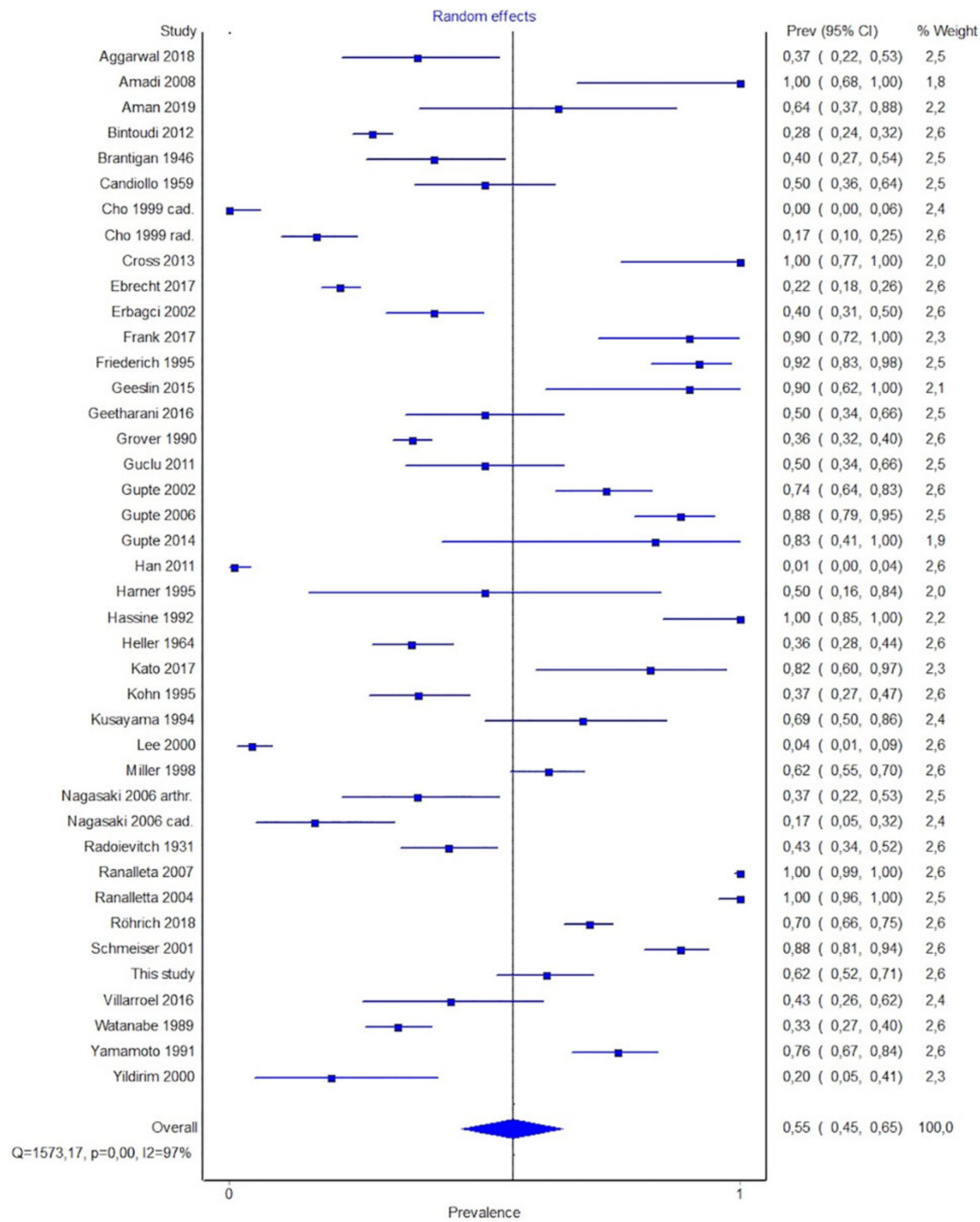

Figure 5. Forest plot for the overall pooled prevalence of the anterior meniscofemoral ligament of Humphrey.

It has been reported that the lateral meniscal attachment of a healthy aMFL on MRI can mimic a tear of the posterior horn of the lateral meniscus ("pseudo-tear") or a small loose body, leading to unnecessary arthroscopic procedures in healthy patients.[46] Before performing arthroscopic surgery, it is critical to perform a detailed physical examination of the patient to account for lateral meniscal tear symptoms to rule out the presence of possible anatomic variants such as the aMFL.[46] On the other hand, one should be careful to not interpret a tear of the lateral meniscus as an aMFL, especially in patients with an ACL tear.[10,47]

The biomechanical function of the aMFL has been noted to occur primarily during knee flexion, when the aMFL pulls the posterior horn of the lateral meniscus anteromedially, increasing stabilization of the lateral meniscocondylar compartment of the knee. Such a protective action, along with the higher mobility of the lateral meniscus, may offer a potential biomechanical explanation for the lower prevalence of lateral

TABLE 3
Prevalence of the Anterior Meniscofemoral Ligament in Relation to Sex

	No. of Studies (Limbs)	Pooled Prevalence (95% CI), %	I^2 (95% CI), %	*P* Value (Cochran *Q*)
Male	6 (420)	32.4 (14.8-52.8)	92.6 (86.6-95.9)	<.001
Female	5 (380)	28.6 (6.7-56.5)	95.2 (91.5-97.3)	<.001
Male[a]	5 (366)	41.4 (25.1-58.6)	86.5 (70.7-93.8)	<.001
Female[a]	4 (334)	41.6 (17.5-67.9)	93.1 (85.4-96.7)	<.001

[a]Analysis performed with the exclusion of the study by Han et al.[29]

TABLE 4
Prevalence of the Anterior Meniscofemoral Ligament With Respect to Side

	No. of Studies (Limbs)	Pooled Prevalence (95% CI), %	I^2 (95% CI), %	*P* Value (Cochran *Q*)
Left	4 (210)	83.1 (46.5-100.0)	96.9 (94.4-98.3)	<.001
Right	4 (210)	88.4 (63.0-100.0)	95.3 (90.8-97.6)	<.001

TABLE 5
Prevalence of Accessory Bands in Lower Limbs With an Anterior Meniscofemoral Ligament

	No. of Studies (Limbs)	Pooled Prevalence (95% CI), %	I^2 (95% CI), %	*P* Value (Cochran *Q*)
Overall	2 (76)	7.6 (0.0-20.6)	55.8 (0.0-89.3)	<.001

meniscal tears compared with those of the medial meniscus, where such a mechanism is absent.[15,20] The aMFL supports the PCL's (mostly during knee flexion) anterolateral bundle and, with a distal insertion on the femur, follows an obliquity similar to the posteromedial bundle of the PCL but at a much greater angle than the PCL fibers when evaluated from the frontal plane. This pathway suggests a unique but complementary biomechanical supporting role to the PCL in joint movement and stability.[14] In contrast, the pMFL assists the posteromedial band of the PCL and remains loaded during knee extension.[3,43]

The MFLs and the posterior root of the lateral meniscus act together to stabilize the knee joint against anterior tibial translation (lower flexion angles) and internal rotation (higher flexion angles) in ACL-deficient knees.[19] Noteworthy is the fact that, in the cases of lateral meniscus root tears, when the MFLs are absent or torn, the contact area in the lateral compartment of the knee is significantly decreased. In such cases, repair of the posterior root of the lateral meniscus, especially in ACL-deficient knees, should be performed to decrease the risk of early osteoarthritis.[21] Moreover, Brody et al[10] found that, in cases of lateral meniscus posterior root

TABLE 6
Morphometric Analysis of the Anterior Meniscofemoral Ligament

	Dimension	No. of Cadaveric Studies (Ligaments)	Pooled Mean Value (95% CI), mm	I^2, %
Overall	Length	5 (185)	25.0 (21.8-28.3)	98.6
Midportion	Width	6 (148)	4.7 (4.3-5.2)	72.7
Meniscal	Width	3 (41)	5.7 (5.3-6.1)	0.0
Femoral	Width	3 (41)	7.9 (5.2-10.6)	93.6
Midportion	Thickness	3 (103)	1.5 (1.2-1.8)	84.2

TABLE 7
Analysis of the Cross-sectional Areas of the aMFL[a]

	Dimension	No. of Cadaveric Studies (Ligaments)	Pooled Mean Value (95% CI)	I^2, %
Midportion	Cross-sectional area, mm^2	2 (23)	5.0 (0.4-10.4)	95.0
Midportion	aMFL:PCL cross-sectional area ratio, %	2 (23)	8.4 (1.7-15.2)	93.4

[a]aMFL, anterior meniscofemoral ligament; PCL, posterior cruciate ligament.

tears, the absence of the MFLs is associated with a higher rate of meniscal extrusion compared with lower limbs with intact MFLs. Such observations support the protective role of the MFLs in preventing degenerative changes. Unfortunately, to the best of our knowledge, there is no recognized method to repair the MFLs.

Structural and material analyses of both aMFL and pMFL fibers reveal biomechanical characteristics similar to the PCL in terms of elasticity and strength.[26] Moreover, proprioceptive nerve endings located on both the MFLs and the cruciate ligaments have been reported to likely function together in response to knee motion to increase stability and assist during rehabilitation.[7,27] However, further studies are needed to fully describe the role of nervous structures in knee joint congruence.

This review was limited by the heterogeneity of the included studies, which may have caused a skewing of data trends. Such sources of heterogeneity included (1) study modalities, (2) ethnic diversity of participants within national groupings, (3) sex differences of participants, (4) lower limb side (left vs right), (5) inconsistencies in experimental methods by study authors, and (6) small sample sizes within individual studies. To minimize data heterogeneity, strict adherence to PRISMA guidelines was followed when searching for available data, and all data were extracted according to AQUA guidelines. The categorization of studies into subgroups for statistical analysis further minimized heterogeneity and improved the interpretation of the results. Our MRI study was limited by its retroactive design and inclusion of patients with chronic knee pain.

CONCLUSION

Significant variability in the prevalence of the aMFL was found in the literature. More emphasis should be placed on the clinical relevance of injuries to the aMFL because of its significant role in the function of the knee. It is important to be aware that, because of the anatomy of the aMFL, it also can function to support a torn PCL. Well-designed future studies are required to investigate the exact function of the aMFL and to develop possible methods of treatment, which are not currently available.

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APPENDIX

TABLE A1
MRI Parameters[a]

Parameter	Proton Density–Weighted TSE (SPAIR)	Sagittal T1-Weighted TSE	Coronal T2-Weighted TSE	Sagittal T2-Weighted FFE
Repetition time, ms	Sagittal: 2569 Coronal: 1980 Axial: 2697	655	3	580
Echo time, ms	Sagittal: 42 Coronal: 45 Axial: 42	8	85	12
Matrix, pixels	Sagittal: 348 × 322 Coronal: 452 × 389 Axial: 424 × 407	348 × 336	360 × 338	244 × 244
Field of view, cm	Sagittal: 17 Coronal: 18 Axial: 16	17	18	17
Slice thickness/gap, mm	3/0.6	3/0.6	3/0.6	3/0.3

[a]FFE, fast field echo; MRI, magnetic resonance imaging; SPAIR, spectral attenuated inversion recovery; TSE, turbo spin echo.

TABLE A2
Characteristics of Included Studies Regarding the aMFL[a]

Author (Year)	Country	Study Type	Total No. of Limbs	aMFL Prevalence, n (%)
Aggarwal[1] (2018)	India	Cadaveric	38	14 (36.8)
Amadi[3] (2008)	UK	Cadaveric	5	5 (100.0)
Aman[4] (2019)	USA	Cadaveric	14	9 (64.3)
Bintoudi[8] (2012)	Greece	Radiological	500	140 (28.0)
Brantigan[9] (1946)	USA	Cadaveric	50	20 (40.0)
Candiollo[11] (1959)	Italy	Cadaveric	50	25 (50.0)
Cho[12] (1999)	Republic of Korea	Cadaveric	28	0 (0.0)
Cho[12] (1999)	Republic of Korea	Radiological	100	17 (17.0)
Cross[14] (2013)	USA	Cadaveric	7	7 (100.0)
Ebrecht[17] (2017)	Germany	Radiological	448	97 (21.7)
Erbagci[18] (2002)	Turkey	Radiological	100	40 (40.0)
Frank[19] (2017)	USA	Cadaveric	20	18 (90.0)
Friederich[20] (1995)	Germany	Cadaveric	50	46 (92.0)
Geeslin[21] (2016)	USA	Cadaveric	10	9 (90.0)
Geetharani[22] (2016)	India	Cadaveric	40	20 (50.0)
Grover[23] (1990)	USA	Radiological	610	218 (35.7)
Güçlü Sözmen[24] (2011)	Turkey	Cadaveric	40	20 (50.0)
Gupte[28] (2002)	UK	Cadaveric	84	62 (73.8)
Gupte[25] (2006)	UK	Arthroscopic	68	60 (88.2)
Gupte[27] (2014)	UK	Cadaveric	6	5 (83.3)
Han[29] (2012)	Republic of Korea	Cadaveric	100	1 (1.0)
Harner[30] (1995)	USA	Cadaveric	8	4 (50.0)
Hassine[31] (1992)	France	Cadaveric	11	11 (100.0)
Heller[32] (1964)	Canada	Cadaveric	140	50 (35.7)
Kato[36] (2018)	USA	Cadaveric	17	14 (82.4)
Kohn[39] (1995)	Germany	Cadaveric	92	34 (37.0)
Kusayama[40] (1994)	USA	Cadaveric	26	18 (69.2)
Lee[41] (2000)	Republic of Korea	Radiological	138	6 (4.3)
Miller[42] (1998)	USA	Radiological	173	108 (62.4)
Nagasaki[44] (2006)	Japan	Arthroscopic	38	14 (36.8)
Nagasaki[44] (2006)	Japan	Cadaveric	30	5 (16.7)
Current study	**Poland**	**Radiological**	**100**	**62 (62.0)**
Radoievitch[50] (1931)	France	Cadaveric	105	45 (42.9)
Ranalletta[52] (2007)	Argentina	Arthroscopic	140	140 (100.0)
Ranalletta[51] (2004)	Argentina	Cadaveric	40	40 (100.0)
Röhrich[53] (2018)	Austria	Radiological	342	241 (70.5)
Schmeiser[54] (2001)	Germany	Cadaveric	102	90 (88.2)
Villarroel[58] (2016)	Chile	Cadaveric	30	13 (43.3)
Watanabe[60] (1989)	USA	Radiological	200	66 (33.0)
Yamamoto[61] (1991)	Germany	Cadaveric	100	76 (76.0)
Yildirim[62] (2000)	Turkey	Cadaveric	20	4 (20.0)

[a]aMFL, anterior meniscofemoral ligament.

TABLE A3
Risk of Bias of the Included Studies According to the AQUA Checklist[a]

Author (Year)	Objective(s) and Study Characteristics	Study Design	Methodology Characterization	Descriptive Anatomy	Reporting of Results
Aggarwal[1] (2018)	Low	Low	High	Low	Low
Amadi[3] (2008)	Low	Low	Low	Low	Low
Aman[4] (2019)	Low	Low	Low	Low	Low
Bintoudi[8] (2012)	Low	Low	Low	Low	Low
Brantigan[9] (1946)	Unclear	Low	High	Low	Low
Candiollo[11] (1959)	Low	Low	High	Low	Low
Cho[12] (1999) (cadaveric)	Low	Low	High	Low	Low
Cho[12] (1999) (radiological)	Low	Low	Low	Low	Low
Cross[14] (2013)	Low	Low	Low	Low	Low
Ebrecht[17] (2017)	Low	Low	Low	Low	Unclear
Erbagci[18] (2002)	Low	Low	High	Low	Low
Frank[19] (2017)	Low	Low	Unclear	Low	Low
Friederich[20] (1995)	Low	Low	High	Low	Unclear
Geeslin[21] (2016)	Low	Low	Unclear	Low	Low
Geetharani[22] (2016)	Low	Low	High	Low	Unclear
Grover[23] (1990)	Low	Low	High	Unclear	Low
Güçlü Sözmen[24] (2011)	Low	Low	High	Low	Low
Gupte[28] (2002)	Low	Low	Low	Low	Low
Gupte[25] (2006)	Low	Low	Low	Low	Low
Gupte[27] (2014)	Low	Low	High	Low	Low
Han[29] (2012)	Low	Low	Low	Low	Low
Harner[30] (1995)	Low	Low	High	Low	Low
Hassine[31] (1992)	Unclear	Low	Unclear	Low	Low
Heller[32] (1964)	Low	Low	High	Low	Low
Kato[36] (2018)	Low	Low	Unclear	Low	Low
Kohn[39] (1995)	Low	Low	High	Low	Low
Kusayama[40] (1994)	Low	Low	High	Low	Unclear
Lee[41] (2000)	Low	Low	Low	Low	Low
Miller[42] (1998)	Low	Low	Low	Low	Low
Nagasaki[44] (2006) (arthroscopic)	Low	Low	High	Low	Unclear
Nagasaki[44] (2006) (cadaveric)	Low	Low	Low	Low	Low

(continued)

TABLE A3 (continued)

Current study	**Low**	**Low**	**Low**	**Low**	**Low**
Radoievitch[50] (1931)	Low	Low	High	Low	High
Ranalletta[52] (2007)	Low	Low	High	Low	Low
Ranalletta[51] (2004)	Low	Low	High	Low	Low
Röhrich[53] (2018)	Low	Low	Low	Low	Low
Schmeiser[54] (2001)	Low	Low	Low	Low	Low
Villarroel[58] (2016)	Low	Low	Low	Low	Low
Watanabe[60] (1989)	Low	Low	High	Unclear	Unclear
Yamamoto[61] (1991)	Low	Low	High	Low	Unclear
Yildirim[62] (2000)	Low	Low	Unclear	Low	Unclear

[a]AQUA, Anatomical Quality Assessment.

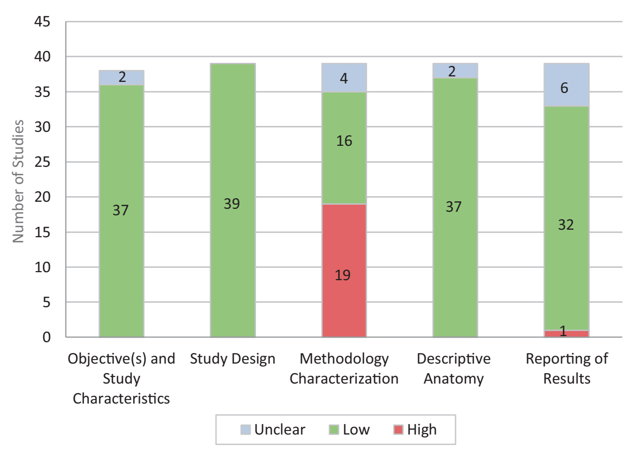

Figure A1. Summary of results from the Anatomical Quality Assessment checklist.