The 100 Top-Cited Articles on Medial Patellofemoral Ligament

A Bibliometric Analysis and Review

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Background: The medial patellofemoral ligament (MPFL) has been investigated widely in the past 30 years, resulting in many research achievements in this field.

Purpose: To perform a comprehensive bibliometric analysis to evaluate the 100 top-cited articles on the MPFL.

Study Design: Cross-sectional study.

Methods: We searched the Scopus database in December 2022 using the terms ''medial patellofemoral ligament'' OR ''MPFL.'' The search was confined to English-language articles, including technical notes, systematic reviews on clinical outcomes and/or complications, clinical studies, studies regarding complications, and basic science articles (either cadaveric or biomechanical); we excluded letters, case reports, personal opinions, guidelines, editorials, and narrative or other types of reviews. Analysis of the 100 top-cited articles was performed according to total number of citations, average citations per year (ACY), study type, country of origin, journal of publication, affiliated institution, and most published authors.

Results: The total number of citations was 16,358 (range of citations per article, 72-692). The majority of articles were published as clinical studies (54%), with cadaveric studies being the second most common (21%). Most studies originated in the United States (32%), with Japan (15%) and Germany (13%) following. The *American Journal of Sports Medicine* published the majority of the 100 top-cited articles (37/100; 6304 citations) as well as the 10 top-cited articles according to ACY (7/10; mean, 285.14 citations). The most prolific authors were Nomura (8 articles); Burks (6 articles); and Inoue, Sillanpää, and Dreyhaupt (5 articles each).

Conclusion: By analyzing the characteristics of the 100 top-cited articles, this study demonstrated that the MPFL is a growing and popular area of research, with the focus varying through timeline trends. Questions regarding MPFL anatomy, isometry, and biomechanics might have been answered adequately, but research regarding optimal fixation technique under various circumstances is still ongoing.

Keywords: bibliometric analysis; knee; medial patellofemoral ligament; most cited articles; MPFL; patella; reconstruction

Patellar dislocation/instability is a common knee problem, affecting about 5.8 persons per 100,000 of the general population and 29 per 100,000 in the 10- to 17-year-old age- group.[22,25] It accounts for 2% to 3% of all acute knee injuries.[62] The causes lie in osseous abnormalities, patellar alta, trochlea dysplasia, tibial tubercle-trochlea groove distance >20 mm, valgus malalignment, patellar tilt, and soft tissue laxity, usually due to medial patellofemoral ligament (MPFL) rupture or vastus medialis oblique (VMO) weakness.[11,23] Numerous studies have proposed that MPFL reconstruction is superior to conservative management in terms of functional outcomes and recurrent episodes among patients with recurrent patellar instability.[10,31,32,60] Although nonoperative treatment is primarily recommended for first-time dislocation, 44% to 70% of patients progress to recurrent dislocation and subsequent surgical management.[32] Newer studies, analyzing risk stratification models for recurrency after the first-time

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episode, have suggested surgical treatment for the high-risk groups only,[10,31,71] while others have proposed MPFL reconstruction for all first-time dislocation.[10,23] Palpable defects on VMO, adductor mechanism, or gross patellar dislocation constitute prognostic factors for recurrent episodes after first-time patellar dislocation.[26] Anterior knee pain with effusion on exertion, a persistent sensation of instability, a positive J-sign, and a positive patellar tilt test are also considered important clinical signs of MPFL insufficiency.[27]

The first published article on the MPFL dates back to 1992 and is by Ellera Gomes et al,[19] reporting the first case series on MPFL reconstruction using a synthetic graft. Since then, numerous articles have been published regarding the anatomy, biomechanical properties, radiological landmarks, clinical results, and complications of MPFL reconstruction. Bibliometric analyses have been used to highlight consensus areas, controversial aspects, research frontiers, and centers as well as current trends on various topics to provide a comprehensive updated reference for the readers. Reviewing previous bibliometric articles on Scopus and PubMed, we found articles on anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) reconstruction and patellar instability,[29,65,71] but no bibliometric articles were found on the MPFL.

As MPFL reconstruction has been an increasingly accepted procedure, we decided to identify the 100 most cited articles on the MPFL from 1992 onward and to describe the characteristics of these articles, providing a reference for better comprehension of research in this area and also highlighting potential directions for future research.

METHODS

Data Collection and Allocation

We undertook a search of Scopus—one of the largest databases of qualified scientific articles that provides citation data—for our literature review. The terms used were "medial patellofemoral ligament" OR "MPFL" in all fields. The search was confined to English-language articles, without any timeframe restriction. We included technical notes, systematic reviews on clinical outcomes and/or complications, clinical studies, studies regarding complications, and basic science articles (either cadaveric or biomechanical), whereas letters, case reports, personal opinions, guidelines, editorials, and narrative or other types of review were excluded. Two authors (V.G. and A.P.) independently identified articles for inclusion to enhance sensitivity. The search was performed during December 2022 and yielded 2556 results, which included all articles published since 1992.

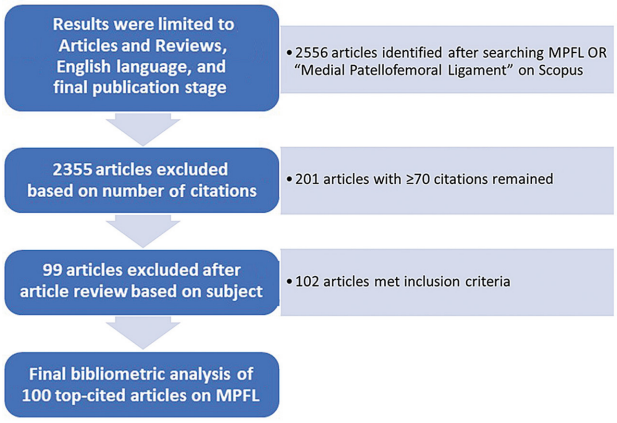

Figure 1. Flowchart illustrating the article selection procedure for the top 100 most cited articles on the MPFL. MPFL, medial patellofemoral ligament.

All articles were then ranked by the number of citations; after removing those with fewer than 70 citations, a total of 201 articles remained for analysis. After review of the title and abstract, each article was categorized based on study type into 7 categories: (1) cadaveric (anatomic and/or biomechanical), (2) clinical, (3) computational, (4) radiological, (5) technical, (6) complications, and (7) systematic reviews. After excluding nonrelevant articles and reaching a mutual decision on the controversial articles, a total of 102 articles remained. Then, after arranging them according to the number of citations, the top 100 most cited articles were ultimately included in the analysis (Figure 1).

Data Extraction

We used Bibliometrix R-package software (https://www.bibliometrix.org) for the data analysis. An Excel (2021; Microsoft Corp) file containing the article titles and citation number was extracted from Scopus on December 31, 2022, so as to establish data congruity during the study. The full text of all the selected articles was reviewed, and the following information extracted: title, author names, journal, publication year, total number of citations, average citations per year (ACY), geographic origin, primary institution involved, study type, level of evidence, and keywords. Statistical analysis and data visualization were

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Ethical approval was not sought for the present study.

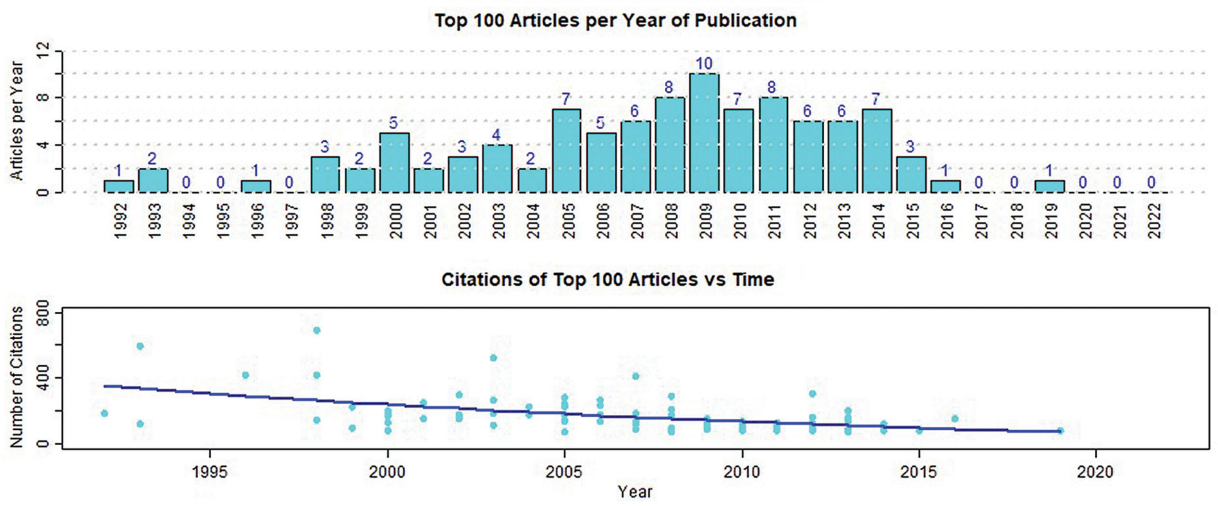

Figure 2. Top 100 most cited articles on the MPFL per year of publication and the distribution of overall citations over time. MPFL, medial patellofemoral ligament.

held in R and RStudio, both well-known open-source statistical software products.

RESULTS

Nature of Published Articles

The 100 most cited articles on the MPFL are listed in Appendix Table A1. Research on the MPFL is relatively new ground, as confirmed by the late publication date of the first article (1992, Ellera Gomes[19]) and the small total number of articles during our extensive search (2556 results). For comparison, the term "ACL" in PubMed revealed more than 34,000 results. Most articles (73 of 100) appeared during the decade 2005 to 2015, as shown in Figure 2. The reduction in the number of top-cited articles from the most recent years is reflective of the type of analysis of top-cited articles and not of research trends. The total number of citations was 16,358 (range of citations per article, 72-692). Analysis per decade indicated that 9 of the articles were published between 1990 and 1999, 52 articles were published between 2000 and 2009, and 39 articles were published between 2010 and 2019, showing the growing research interest in the field.

Figure 3A shows the top 100 articles after being categorized by study type (clinical, cadaveric, radiological, complications, technical notes, reviews, and computational studies). Cadaveric studies were subcategorized as anatomic (33.3%), biomechanical (47.6%), and both (19%) (Figure 3B), whereas clinical studies were subcategorized as prospective (79.6%) and retrospective (Figure 3C). The majority of the articles were clinical studies (54%), with cadaveric being the second most popular (21%).

Source Analysis

An analysis of articles per country was performed. The United States was the most common country of publication (32%), with Japan (15%) and Germany (13%) also showing good contribution rates (Figure 4).

Regarding the affiliated institutions, Kawasaki Municipal Hospital in Japan had the largest number of top-cited articles (7 articles) and the most related citations (1224 total citations). Tampere University Hospital, Aarhus University Hospital and Imperial College were also in the top 10 institutions in both respects (Figure 5). Articles and citations per journal were also analyzed, with the top 5 journals being the same in both categories: *American Journal of Sports Medicine* (37 articles and 6304 citations), *Knee Surgery, Sports Traumatology, Arthroscopy* (20 articles), *Arthroscopy* (11 articles), *Knee (7 articles)* and *Clinical Orthopedics and Related Research* (4 articles) (Figure 6). The top 25 authors were extracted, with Nomura having the most articles in the top 100 with 8 articles. Burks (6 articles) and Inoue, Sillanpää, and Dreyhaupt (5 articles each) completed the top 5 authors (Figure 7).

Characteristics of the Top 10 Most Cited Articles

The top 10 most cited articles by ACY are listed in Table 1. The number of ACY ranged from 30.30 to 17.77. Most of these articles (n = 7) were published in the *American Journal of Sports Medicine*, and the mean number of total citations was 340.3. Five articles were published in or before 2008 and 5 in or after 2012. The top 3 articles with most overall citations (>500) were all anatomic/biomechanical studies. Desio et al,[15] with 692 citations (ACY, 28.8), found that the MPFL is the primary restraint to lateral patellar translation at 20° of flexion, contributing 60% of the total restraining force. Conlan et al,[12] with 595 citations (ACY, 20.51), also confirmed that MPFL is a major medial soft tissue restraint, contributing an average of 53% of the total force, with an average of 22% rendered to the patellomeniscal ligament. Amis et al,[2] with 522 citations (ACY, 27.47), described the anatomy of the MPFL in detail, highlighted

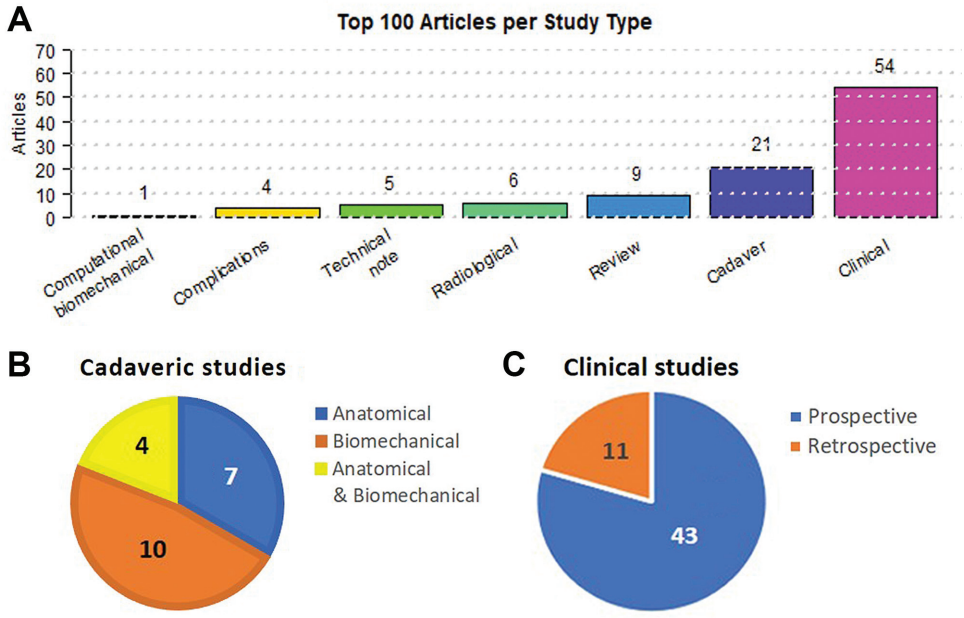

Figure 3. (A) Categorization of the top 100 most cited articles on the MPFL by study type. Subcategorization of (B) cadaveric studies and (C) clinical studies. MPFL, medial patellofemoral ligament.

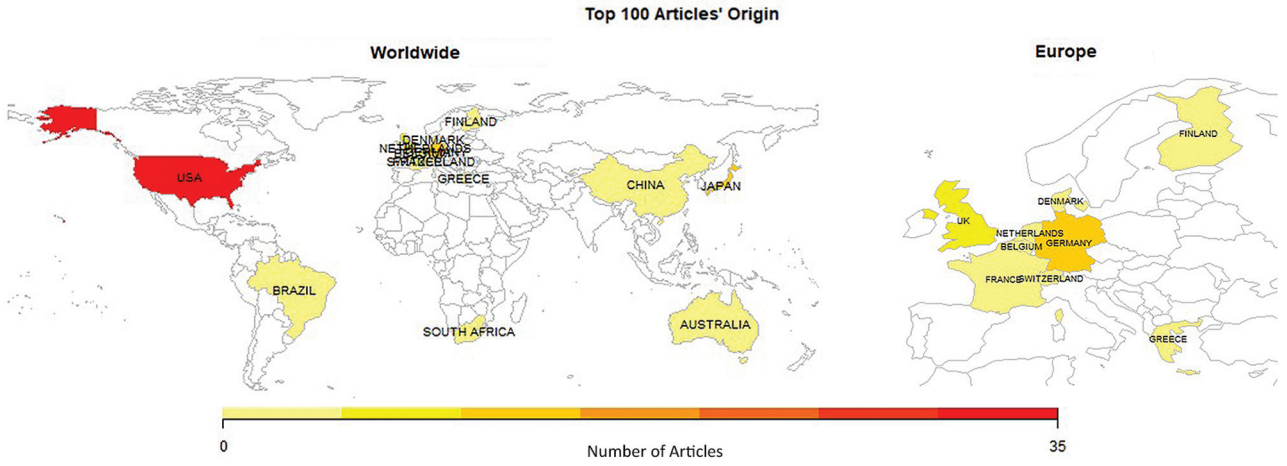

Figure 4. Country of origin of the 100 most cited articles on the MPFL. MPFL, medial patellofemoral ligament.

the length change pattern of the MPFL as the knee flexes, and noted that, if the MPFL is to be reconstructed, the femoral medial epicondyle is an adequate landmark.

The article with the best ACY (30.30) and 303 overall citations was a systematic review published in 2012 by Shah et al,[58] who reported a complication rate of 26.1% after MPFL reconstruction. In fourth place of the 10 most cited articles was the cadaveric/radiological study of Schöttle et al,[56] with 412 citations (ACY, 27.46), which was the first study to indicate a reproducible anatomic and radiographic point for proper intra- and postoperative control for the insertion of the reconstructed MPFL (1 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior origin of the medial femoral condyle, and proximal to the level of the posterior point of the Blumensaat line on a lateral radiograph with both posterior condyles projected in the same plane). The 5 remaining ACY top 10 articles discussed patellar instability factors in isolated MPFL reconstruction,[67] clinical outcomes after isolated MPFL reconstruction,[54] predictors of recurrent instability after acute dislocation in pediatric and adolescent patients,[30] management of acute patellar dislocation in children and adolescents,[40] and, finally, complications of MPFL reconstruction in young patients.[44]

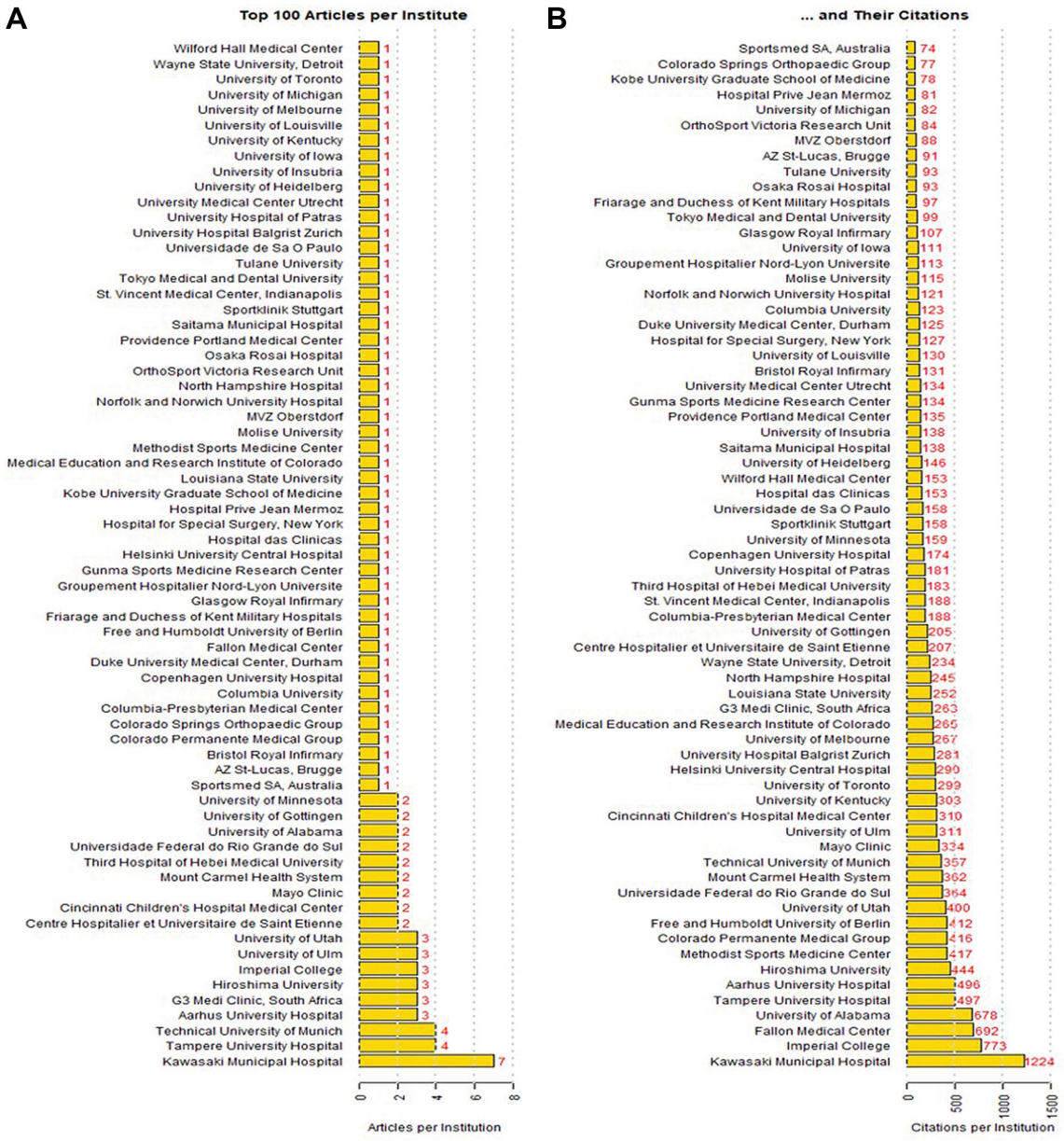

Figure 5. (A) Top 100 most cited articles on the MPFL according to affiliated institution. (B) Ranking of institutions in (A) according to number of related citations. MPFL, medial patellofemoral ligament.

DISCUSSION

The research potential on the MPFL should be considered high if we take into account recent advancements in its research (1992 and onward), as the top 100 MPFL citations (16,358) were more than those of the 50 top-cited PCL (7908; 1975 and onward)[29] and nearly half of the 100 most cited ACL articles (29,629; 1975 and onward).[65] The *American Journal of Sports Medicine* was again the journal with the most cited articles, as noted in the ACL and PCL bibliometric studies.[29,65] The United States plays a leading role in MPFL research, with Germany and Japan also holding an important role. After reviewing the latest articles, we were able to ascertain that the main controversies on MPFL anatomy, attachments, function, insertion point, and isometry have been answered to a large extent, and research nowadays focuses on the best reconstruction techniques, clinical outcomes, complications, and concomitant procedures in cases of dysplasia and other skeletal abnormalities. Our world cloud analysis contained keywords such as adolescent, child, recurrence, treatment, outcome, and biomechanics, with bold font showing where research is concentrated today. A comprehensive summary of the most important issues on the MPFL is provided below.

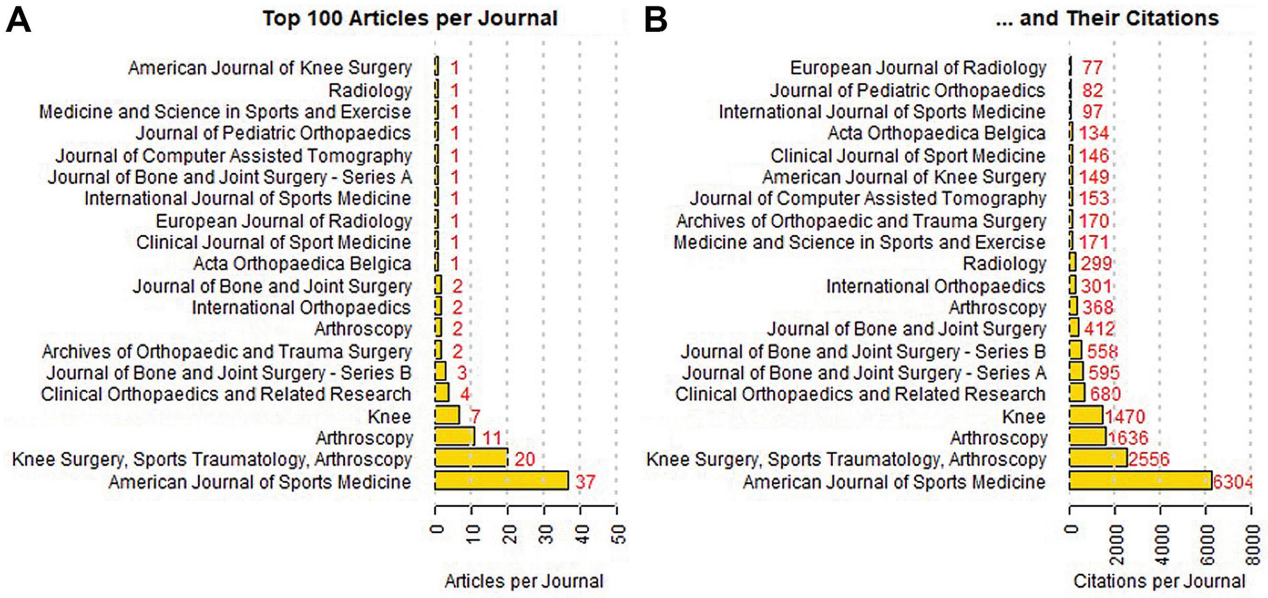

Figure 6. (A) Top 100 most cited articles on the MPFL according to journal of publication. (B) Ranking of journals in (A) according to number of related citations. MPFL, medial patellofemoral ligament.

Anatomy and Biomechanics

In our bibliometric review of the 100 most cited papers, 21 papers studied MPFL anatomy and biomechanical properties. A wide agreement regarding MPFL femoral and patellar attachments was identified. In 2003, Smirk and Morris[59] concluded that the MPFL attaches to the superomedial patella and on the femur 10 mm distal and 5 mm posterior to the adductor tubercle. In 2005, Nomura et al[39] found also a superior patellar insertion and a femoral attachment just distal to the adductor tubercle, whereas they reported a wispy MPFL in 3 of 20 knees dissected. In 2009, Baldwin[3] identified 2 femoral origins for the MPFL, a transverse 10.6-mm attachment on the bony groove between the medial epicondyle and adductor tubercle and an oblique decussation originating from the proximal 30 mm of the leading edge of the superficial MCL. This conclusion had also been reached by Feller et al[21] in 1993, who identified the MPFL and VMO blending as well as the positioning of the MPFL in layer 2. In 2009, Philippot et al[46] measured the MPFL to VMO junction at 25.7 ± 6 mm and identified an anatomic femoral attachment of the MPFL at 10 mm posterior to the medial epicondyle and 10 mm distal to the adductor tubercle. In 2002, Tuxøe et al[68] suggested following the VMO fibers, adductor longus tendon, and superior edge of the MPFL to successfully identify the MPFL in layer 2, as the inferior edge of the MPFL can be challenging to identify. In 2014, Stephen et al[64] also identified the anatomic femoral attachment as equidistant along the line connecting the medial epicondyle to the adductor tubercle. They used a radiological rule of 40% from the posterior, 50% from the distal and 60% from the anterior outline, provided that anteroposterior size is 100%. Finally, in 2010, Kang et al[28] identified 2 MPFL bundles: an inferior straight bundle being the main static soft tissue restraint to lateral patella displacement and a superior oblique bundle providing dynamic stability in conjunction with VMO. We see a consensus regarding femoral attachment of the MPFL just distal to the adductor tubercle and superomedial patellar attachment.

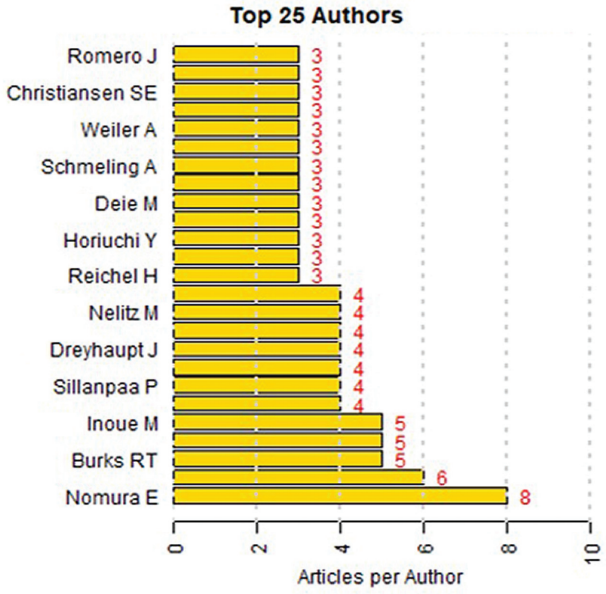

Figure 7. Top 25 authors among the top 100 most cited articles on the MPFL according to number of articles per author. MPFL, medial patellofemoral ligament.

Contribution to Lateral Patellar Displacement

A number of articles studied the contribution of the MPFL, medial retinaculum (MR), medial patellomeniscal ligament

TABLE 1
Top 10 Articles According to ACY[a]

No.	Lead Author	Year	Title	Journal[b]	Total Citations	ACY
1	Shah[58]	2012	A systematic review of complications and failures associated with medial patellofemoral ligament reconstruction for recurrent patellar dislocation	*Am J Sports Med*	303	30.30
2	Desio[15]	1998	Soft tissue restraints to lateral patellar translation in the human knee	*Am J Sports Med*	692	28.80
3	Amis[2]	2003	Anatomy and biomechanics of the medial patellofemoral ligament	*Knee*	522	27.47
4	Schöttle[56]	2007	Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction	*Am J Sports Med*	412	27.46
5	Tompkins[67]	2015	Patellar instability factors in isolated medial patellofemoral ligament reconstructions - what does the literature tell us? A systematic review	*Am J Sports Med*	77	25.66
6	Schneider[54]	2016	Outcomes after isolated medial patellofemoral ligament reconstruction for the treatment of recurrent lateral patellar dislocations: a systematic review and meta-analysis	*Am J Sports Med*	150	25.00
7	Lewallen[30]	2013	Predictors of recurrent instability after acute patellofemoral dislocation in pediatric and adolescent patients	*Am J Sports Med*	202	22.44
8	Palmu[40]	2008	Acute patellar dislocation in children and adolescents: a randomized clinical trial	*J Bone Joint Surg Am*	290	20.71
9	Conlan[12]	1993	Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee	*J Bone Joint Surg Am*	595	20.51
10	Parikh[44]	2013	Complications of medial patellofemoral ligament reconstruction in young patients	*Am J Sports Med*	160	17.77

[a]Average citations per year.
[b]Journal titles abbreviated according to the format in PubMed.

(MPML), and medial patellotibial ligament (MPTL) to lateral patellar displacement (LPD). In 1998, Desio et al,[15] cited by 692 articles (the most cited article on the MPFL), tested medial and lateral restraint to LPD at 20° of flexion, suggesting 60% contribution for the MPFL, 13% for the MPML, and 10% for the lateral retinaculum (LR) and a not measurable contribution for the MPTL and MR. Hautamaa et al,[24] Nomura et al,[38] and Sandmeier et al[52] reached a similar conclusion, ie, that the MPFL is the major stabilizer of LPD and can restore normal kinematics after its reconstruction, especially at 20° to 90° of flexion. Panagiotopoulos et al[41] suggested 50% MPFL contribution to medial stability, 24% MPML, and 13% each for MPTL and MR, whereas VMO and MPFL meshing increases the MPFL percentage to more than 50%. Finally, in 2012, Philippot et al[45] also measured MPFL contribution to LPD and lateral tilt reduction at 50% to 60% and suggested that MPFL reconstruction is performed at 20° to 30° of flexion.

Isometry

Stephen et al[64] tested 3 superomedial patellar attachments and 5 femoral attachments, suggesting that the anatomic femoral position (at the midpoint between the medial epicondyle and the adductor tubercle) was the most isometric with a mean length increase of 2.1 mm, whereas attachment 5 mm proximal and 5 mm distal increased MPFL length by 6.4 mm and 9.1 mm, respectively. Steensen et al[61] agreed with a previous finding that the correct femoral attachment is the most important parameter for MPFL isometry. Victor et al[69] found the MPFL to be nonisometric, suggesting that, although the middle part of the MPFL is isometric, the cranial part is most taut at full extension and the caudal part at 30°, interpreting the 2-bundle theory of Kang et al[28] differently. A computational study by Elias and Cosgarea[18] revealed an increase in medial pressure at 30° of flexion either by proximal femoral graft malposition or by reduced graft resting length, whereas both scenarios increased medial pressure significantly at 30° to 90° of flexion. Beck et al[4] examined the graft tensioning force and found that 2 N restored normal translation but that higher forces increased medial pressure and restricted motion. A more recent study by Stephen et al[64] also concluded that 2 N restores joint contact pressures, proposing an anatomic femoral fixation with 2 N at 30° or 60° of flexion. Finally, Mountney et al[33] examined the force to failure of native MPFL, suture-only repair, bone anchors plus suture, blind-tunnel tendon graft and through-tunnel tendon graft, measuring 208, 37, 142, 126, and 195 N, respectively, and found no statistical difference between native MPFL and blind tunnel graft.

Clinical Results

Ellera Gomes[19], with 186 citations, was the first to describe a technique of MPFL reconstruction, presenting a series of

30 patients with 83% showing significant improvement after an average follow-up of 39 months. Sallay et al[50], with 417 citations to date, performed a pathoanatomic correlation study and presented a case series of 11 MPFL repairs, with 58% of the patients showing excellent-to-good results according to Lysholm score and return-to-play data. Nomura[36], with 229 citations, classified MPFL injuries intraoperatively, with most knees presenting with scar tissue along the MPFL course. Schöttle et al[55], being in the top 10 most cited articles with 281 citations, presented in 2005 a technique of MPFL reconstruction utilizing a semitendinosus autograft fixed with 2 sutures anchors at the superomedial border of the patella and tendon to bone tunnel fixation by an interference screw at the adductor tubercle.

Since then, numerous top-cited articles presented very good to excellent results after MPFL reconstruction with various techniques for recurrent patellar dislocation in adults.[1,5,7,8,13,16,20,37,63] Limited results, however, were reported among subjects with high tibial tubercle-trochlear groove distance, severe trochlear dysplasia, failure to repair VMO, and children and adolescents presenting with first-time patellar dislocation.[9,14,30,40,70] The majority of the rest of the clinical studies in the top 100 most cited MPFL articles showed good clinical results and low rates of redislocation after MPFL reconstruction.

Worth noting is the dynamic MPFL reconstruction technique proposed by Panagopoulos et al,[42] where the semitendinosus tendon, being attached to its insertion, is rerouted though the adductor magnus pulley and fixed to the superomedial patella at 60° of flexion. Remarkable also are the clinical results of the divergent patellar transverse 2-tunnel technique with autologous semitendinosus graft reported by Panni et al,[43] demonstrating 80% patient satisfaction and a low rate of redislocation. A biomechanical study by Mountney et al[33] has also shown the superiority of the through tunnel technique; however, the incidence of patellar fracture, as noted by Panni et al,[43] is a subject still studied today.[47,48] An article by Thaunat and Erasmus[66] suggested that every patella fits its own trochlea and therefore MPFL reconstruction can be an isolated procedure, aiming at a favorable anisometry, with isometry gained at full extension. For children and adolescents with open femoral physes, primary MPFL repair, anatomic reconstruction with respect to the femoral physes, and dynamic reconstruction with the medial collateral ligament acting as a pulley have shown good results in the current pool of studies.[13,14,35,40] To conclude, MPFL reconstruction was found to be an effective procedure for recurrent patellar dislocation, in terms of postoperative dislocation and functional scores, in isolation or combined with additional procedures when so indicated.

Radiological Results

The top-cited radiological study in our review, with 412 citations, was that of Schöttle et al[56] in 2007 defining the radiological femoral attachment of the MPFL as previous mentioned. In 2010, Redfern et al[49] proposed another reproducible radiographic landmark for femoral MPFL insertion as 0.5 mm anterior to the distal posterior cortex and just 3 mm proximal to the apex where it meets the Blumensaat line. Elias et al[17] and Sanders et al[51] showed that lateral patellar dislocation is accompanied by medial retinaculum, MPFL, and VMO injury, accurately identified by magnetic resonance imaging (MRI). Seeley et al[57] studied the MRI injury patterns after acute patellar dislocation among children, recognizing MPFL, VMO, and chondral injuries, and Nelitz et al[34] suggested that the femoral insertion of the MPFL in children is distal to the physis, so as to avoid tightening of the MPFL in knee flexion.

Complications

Two articles describing complications after MPFL reconstruction are among the top 10 articles with the best ACY. Shah et al[58] (ACY, 30.30) performed a systematic review in 2012 regarding complication rates after MPFL reconstruction; 25 articles were identified and reviewed, with the authors reporting a total of 164 complications occurring in 629 knees (26.1%). These adverse events included patellar fracture, failures, clinical instability, loss of knee flexion, wound complications, and pain. A trend of more overall complications was observed utilizing the tunnel techniques (29.8%) compared with suture techniques (21.6%). However, the suture techniques demonstrated a higher rate of recurrent dislocation/subluxation (4.8%) and apprehension/hypermobility (24.0%) than the tunnel technique (3.3% and 8.6%, respectively). Parikh et al[44] (ACY, 17.77) performed a retrospective clinical study in 2013, evaluating 179 knees that underwent MPFL reconstruction and found an incidence of complications (34 major and 4 minor) of 16.2%. Major complications included recurrent lateral patellar instability (23.5% of patients), knee motion stiffness with flexion deficits (23.5%), patellar fractures (17.6%), and patellofemoral arthrosis/pain (14.7%). Female sex and bilateral MPFL reconstructions were significant risk factors, whereas 47% of the complications were secondary to technical factors and were considered preventable. Bollier et al[6] highlighted the importance of femoral tunnel mispositioning in MPFL reconstruction, presenting a series of 5 patients who underwent revision surgery, and, in a series of 211 patients, Sapey-Marinier et al[53] reported 10 failures (4.7%) requiring surgical revision and also identified that patella alta and positive J-sign are the 2 major preoperative risk factors for failure.

Limitations

Only articles published in English were included in our research; thus, high-quality articles in other languages might have been omitted. In addition, only the Scopus database was utilized for data collection, as it is considered highly accurate and extensive and we were able to export citation data; other databases such as PubMed or Cochrane library were not included. Finally, the last limitation is inherent to the bibliometric research type, as the included articles might not reflect the current standard of

care and evidence. However, this bibliometric study of the 100 top-cited papers on the MPFL provides a good base from which to identify research trends on the MPFL and hotspot research centers and provide some reading material for new residents and researchers to study the most influential papers on the MPFL and build on them with the current bibliography.

CONCLUSION

By analyzing the characteristics of the 100 top-cited articles, this study demonstrated that the MPFL is a growing and popular area of research, with the focus varying through timeline trends. Questions regarding native MPFL anatomy, isometry, and biomechanics might have been answered adequately, but research regarding optimal fixation technique under various circumstances is still ongoing.

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63. Steiner TM, Torga-Spak R, Teitge RA. Medial patellofemoral ligament reconstruction in patients with lateral patellar instability and trochlear dysplasia. *Am J Sports Med*. 2006;34(8):1254-1261.
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APPENDIX

TABLE A1
List of 100 Top-Cited Articles on the MPFL[a]

No.	Authors	Year	Title	Journal[b]	No. of Citations
1	Desio SM, Burks RT, Bachus KN	1998	Soft tissue restraints to lateral patellar translation in the human knee	*Am J Sports Med*	692
2	Conlan T, Garth WP Jr, Lemons JE	1993	Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee	*J Bone Joint Surg Am*	595
3	Amis AA, Firer P, Mountney J, Senavongse W, Thomas NP	2003	Anatomy and biomechanics of the medial patellofemoral ligament	*Knee*	522
4	Sallay PI, Poggi J, Speer KP, Garrett WE	1996	Acute dislocation of the patella: a correlative pathoanatomic study	*Am J Sports Med*	417
5	Hautamaa PV, Fithian DC, Kaufman KR, Daniel DM, Pohlmeyer AM	1998	Medial soft tissue restraints in lateral patellar instability and repair	*Clin Orthop Relat Res*	416
6	Schöttle PB, Schmeling A, Rosenstiel N, Weiler A	2007	Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction	*Am J Sports Med*	412
7	Shah JN, Howard JS, Flanigan DC, Brophy RH, Carey JL, Lattermann C	2012	A systematic review of complications and failures associated with medial patellofemoral ligament reconstruction for recurrent patellar dislocation	*Am J Sports Med*	303
8	Elias DA, White LM, Fithian DC	2002	Acute lateral patellar dislocation at MR imaging: injury patterns of medial patellar soft-tissue restraints and osteochondral injuries of the inferomedial patella	*Radiology*	299
9	Palmu S, Kallio PE, Donell ST, Helenius I, Nietosvaara Y	2008	Acute patellar dislocation in children and adolescents: a randomized clinical trial	*J Bone Joint Surg Am*	290
10	Schöttle PB, Fucentese SF, Romero J	2005	Clinical and radiological outcome of medial patellofemoral ligament reconstruction with a semitendinosus autograft for patella instability	*Knee Surg Sports Traumatol Arthrosc*	281
11	Smirk C, Morris H	2003	The anatomy and reconstruction of the medial patellofemoral ligament	*Knee*	267
12	Elias JJ, Cosgarea AJ	2006	Technical errors during medial patellofemoral ligament reconstruction could overload medial patellofemoral cartilage: a computational analysis	*Am J Sports Med*	265
13	Drez D Jr, Edwards TB, Williams CS	2001	Results of medial patellofemoral ligament reconstruction in the treatment of patellar dislocation	*Arthroscopy*	252
14	Mountney J, Senavongse W, Amis AA, Thomas NP	2005	Tensile strength of the medial patellofemoral ligament before and after repair or reconstruction	*J Bone Joint Surg Br*	245
15	Steiner TM, Torga-Spak R, Teitge RA	2006	Medial patellofemoral ligament reconstruction in patients with lateral patellar instability and trochlear dysplasia	*Am J Sports Med*	234
16	Nomura E	1999	Classification of lesions of the medial patello-femoral ligament in patellar dislocation	*Int Orthop*	229
17	Steensen RN, Dopirak RM, McDonald WG III	2004	The anatomy and isometry of the medial patellofemoral ligament: implications for reconstruction	*Am J Sports Med*	225
18	Nomura E, Inoue M, Osada N	2005	Anatomical analysis of the medial patellofemoral ligament of the knee, especially the femoral attachment	*Knee Surg Sports Traumatol Arthrosc*	224
19	Christiansen SE, Jacobsen BW, Lund B, Lind M	2008	Reconstruction of the medial patellofemoral ligament with gracilis tendon autograft in transverse patellar drill holes	*Arthroscopy*	208

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No.	Authors	Year	Title	Journal[b]	No. of Citations
20	Lewallen LW, McIntosh AL, Dahm DL	2013	Predictors of recurrent instability after acute patellofemoral dislocation in pediatric and adolescent patients	*Am J Sports Med*	202
21	Nomura E, Horiuchi Y, Kihara M	2000	Medial patellofemoral ligament restraint in lateral patellar translation and reconstruction	*Knee*	201
22	Bicos J, Fulkerson JP, Amis A	2007	Current concepts review: the medial patellofemoral ligament	*Am J Sports Med*	188
23	Ahmad CS, Stein BES, Matuz D, Henry JH	2000	Immediate surgical repair of the medial patellar stabilizers for acute patellar dislocation: a review of eight cases	*Am J Sports Med*	188
24	Ellera Gomes JL	1992	Medial patellofemoral ligament reconstruction for recurrent dislocation of the patella: a preliminary report	*Arthroscopy*	186
25	Deie M, Ochi M, Sumen Y, Yasumoto M, Kobayashi K, Kimura H	2003	Reconstruction of the medial patellofemoral ligament for the treatment of habitual or recurrent dislocation of the patella in children	*J Bone Joint Surg Br*	182
26	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*	181
27	Christiansen SE, Jakobsen BW, Lund B, Lind M	2008	Isolated repair of the medial patellofemoral ligament in primary dislocation of the patella: a prospective randomized study	*Arthroscopy*	178
28	Ellera Gomes JL, Stigler Marczyk LR, De César PC, Jungblut CF	2004	Medial patellofemoral ligament reconstruction with semitendinosus autograft for chronic patellar instability: a follow-up study	*Arthroscopy*	178
29	Deie M, Ochi M, Sumen Y, Adachi N, Kobayashi K, Yasumoto M	2005	A long-term follow-up study after medial patellofemoral ligament reconstruction using the transferred semitendinosus tendon for patellar dislocation	*Knee Surg Sports Traumatol Arthrosc*	177
30	Tuxøe JI, Teir M, Winge S, Nielsen PL	2002	The medial patellofemoral ligament: a dissection study	*Knee Surg Sports Traumatol Arthrosc*	174
31	Sillanpää P, Mattila VM, Iivonen T, Visuri T, Pihlajamäki H	2008	Incidence and risk factors of acute traumatic primary patellar dislocation	*Med Sci Sports Exerc*	171
32	Nomura E, Horiuchi Y, Kihara M	2000	A mid-term follow-up of medial patellofemoral ligament reconstruction using an artificial ligament for recurrent patellar dislocation	*Knee*	170
33	Parikh SN, Nathan ST, Wall EJ, Eismann EA	2013	Complications of medial patellofemoral ligament reconstruction in young patients	*Am J Sports Med*	160
34	Wagner D, Pfalzer F, Hingelbaum S, Huth J, Mauch F, Bauer G	2013	The influence of risk factors on clinical outcomes following anatomical medial patellofemoral ligament (MPFL) reconstruction using the gracilis tendon	*Knee Surg Sports Traumatol Arthrosc*	158
35	Bitar AC, Demange MK, D'Elia CO, Camanho GL	2012	Traumatic patellar dislocation: nonoperative treatment compared with MPFL reconstruction using patellar tendon	*Am J Sports Med*	158
36	Camanho GL, Viegas Ade C, Bitar AC, Demange MK, Hernandez AJ	2009	Conservative versus surgical treatment for repair of the medial patellofemoral ligament in acute dislocations of the patella	*Arthroscopy*	153
37	Sanders TG, Morrison WB, Singleton BA, Miller MD, Cornum KG	2001	Medial patellofemoral ligament injury following acute transient dislocation of the patella: MR findings with surgical correlation in 14 patients	*J Comput Assist Tomogr*	153

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No.	Authors	Year	Title	Journal[b]	No. of Citations
38	Schneider DK, Grawe B, Magnussen RA, Ceasar A, Parikh SN, Wall EJ, Colosimo AJ, Kaeding CC, Myer GD	2016	Outcomes after isolated medial patellofemoral ligament reconstruction for the treatment of recurrent lateral patellar dislocations: a systematic review and meta-analysis	*Am J Sports Med*	150
39	Nomura E, Horiuchi Y, Inoue M	2002	Correlation of MR imaging findings and open exploration of medial patellofemoral ligament injuries in acute patellar dislocations	*Knee*	150
40	Burks RT, Desio SM, Bachus KN, Tyson L, Springer K	1998	Biomechanical evaluation of lateral patellar dislocations	*Am J Knee Surg*	149
41	Buchner M, Baudendistel B, Sabo D, Schmitt H	2005	Acute traumatic primary patellar dislocation: long-term results comparing conservative and surgical treatment	*Clin J Sport Med*	146
42	Nelitz M, Dreyhaupt J, Reichel H, Woelfle J, Lippacher S	2013	Anatomic reconstruction of the medial patellofemoral ligament in children and adolescents with open growth plates: surgical technique and clinical outcome	*Am J Sports Med*	140
43	Ronga M, Oliva F, Longo UG, Testa V, Capasso G, Maffulli N	2009	Isolated medial patellofemoral ligament reconstruction for recurrent patellar dislocation	*Am J Sports Med*	138
44	Nomura E, Inoue M, Kobayashi S	2007	Long-term follow-up and knee osteoarthritis change after medial patellofemoral ligament reconstruction for recurrent patellar dislocation	*Am J Sports Med*	138
45	Steensen RN, Dopirak RM, Maurus PB	2005	A simple technique for reconstruction of the medial patellofemoral ligament using a quadriceps tendon graft	*Arthroscopy*	137
46	Baldwin JL	2009	The anatomy of the medial patellofemoral ligament	*Am J Sports Med*	135
47	Buckens CFM, Saris DBF	2010	Reconstruction of the medial patellofemoral ligament for treatment of patellofemoral instability: a systematic review	*Am J Sports Med*	134
48	Nomura E, Inoue M	2006	Hybrid medial patellofemoral ligament reconstruction using the semitendinous tendon for recurrent patellar dislocation: minimum 3 years' follow-up	*Arthroscopy*	134
49	Mikashima Y, Kimura M, Kobayashi Y, Miyawaki M, Tomatsu T	2006	Clinical results of isolated reconstruction of the medial patellofemoral ligament for recurrent dislocation and subluxation of the patella	*Acta Orthop Belg*	134
50	Stephen JM, Lumpaopong P, Deehan DJ, Kader D, Amis AA	2012	The medial patellofemoral ligament: location of femoral attachment and length change patterns resulting from anatomic and nonanatomic attachments	*Am J Sports Med*	132
51	Camp CL, Krych AJ, Dahm DL, Levy BA, Stuart MJ	2010	Medial patellofemoral ligament repair for recurrent patellar dislocation	*Am J Sports Med*	132
52	Howells NR, Barnett AJ, Ahearn N, Ansari A, Eldridge JD	2012	Medial patellofemoral ligament reconstruction: a prospective outcome assessment of a large single centre series	*J Bone Joint Surg Br*	131
53	Fisher B, Nyland J, Brand E, Curtin B	2010	Medial patellofemoral ligament reconstruction for recurrent patellar dislocation: a systematic review including rehabilitation and return-to-sports efficacy	*Arthroscopy*	130
54	Sandmeier RH, Burks RT, Bachus KN, Billings A	2000	The effect of reconstruction of the medial patellofemoral ligament on patellar tracking	*Am J Sports Med*	129

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TABLE A1
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No.	Authors	Year	Title	Journal[b]	No. of Citations
55	Balcarek P, Ammon J, Frosch S, Walde TA, Schüttrumpf JP, Ferlemann KG, Lill H, Stürmer KM, Frosch K-H	2010	Magnetic resonance imaging characteristics of the medial patellofemoral ligament lesion in acute lateral patellar dislocations considering trochlear dysplasia, patella alta, and tibial tuberosity-trochlear groove distance	*Arthroscopy*	128
56	Kepler CK, Bogner EA, Hammoud S, Malcolmson G, Potter HG, Green DW	2011	Zone of injury of the medial patellofemoral ligament after acute patellar dislocation in children and adolescents	*Am J Sports Med*	127
57	Feller JA, Feagin JA Jr, Garrett WE Jr	1993	The medial patellofemoral ligament revisited: an anatomical study	*Knee Surg Sports Traumatol Arthrosc*	125
58	Ahmad CS, Brown GD, Stein BS	2009	The docking technique for medial patellofemoral ligament reconstruction: surgical technique and clinical outcome	*Am J Sports Med*	123
59	Sillanpää PJ, Peltola E, Mattila VM, Kiuru M, Visuri T, Pihlajamäki H	2009	Femoral avulsion of the medial patellofemoral ligament after primary traumatic patellar dislocation predicts subsequent instability in men: a mean 7-year nonoperative follow-up study	*Am J Sports Med*	122
60	Sillanpää PJ, Mattila VM, Mäenpää H, Kiuru M, Visuri T, Pihlajamäki H	2009	Treatment with and without initial stabilizing surgery for primary traumatic patellar dislocation: a prospective randomized study	*J Bone Joint Surg Am*	122
61	Beck P, Brown NAT, Greis PE, Burks RT	2007	Patellofemoral contact pressures and lateral patellar translation after medial patellofemoral ligament reconstruction	*Am J Sports Med*	122
62	Smith TO, Walker J, Russell N	2007	Outcomes of medial patellofemoral ligament reconstruction for patellar instability: a systematic review	*Knee Surg Sports Traumatol Arthrosc*	121
63	Stephen JM, Kaider D, Lumpaopong P, Deehan DJ, Amis AA	2014	The effect of femoral tunnel position and graft tension on patellar contact mechanics and kinematics after medial patellofemoral ligament reconstruction	*Am J Sports Med*	119
64	Nomura E, Inoue M	2003	Surgical technique and rationale for medial patellofemoral ligament reconstruction for recurrent patellar dislocation	*Arthroscopy*	116
65	Panni AS, Alam M, Cerciello S, Vasso M, Maffulli N	2011	Medial patellofemoral ligament reconstruction with a divergent patellar transverse 2-tunnel technique	*Am J Sports Med*	115
66	Servien E, Fritsch B, Lustig S, Demey G, Debarge R, Lapra C, Neyret P	2011	In vivo positioning analysis of medial patellofemoral ligament reconstruction	*Am J Sports Med*	113
67	Bollier M, Fulkerson J, Cosgarea A, Tanaka M	2011	Technical failure of medial patellofemoral ligament reconstruction	*Arthroscopy*	111
68	Kang HJ, Wang F, Chen BC, Su YL, Zhang ZC, Yan CB	2010	Functional bundles of the medial patellofemoral ligament	*Knee Surg Sports Traumatol Arthrosc*	111
69	Enderlein D, Nielsen T, Christiansen SE, Faunø P, Lind M	2014	Clinical outcome after reconstruction of the medial patellofemoral ligament in patients with recurrent patella instability	*Knee Surg Sports Traumatol Arthrosc*	110
70	Schöttle PB, Hensler D, Imhoff AB	2010	Anatomical double-bundle MPFL reconstruction with an aperture fixation	*Knee Surg Sports Traumatol Arthrosc*	108
71	Hopper GP, Leach WJ, Rooney BP, Walker CR, Blyth MJ	2014	Does degree of trochlear dysplasia and position of femoral tunnel influence outcome after medial patellofemoral ligament reconstruction?	*Am J Sports Med*	107
72	Philippot R, Chouteau J, Wegrzyn J, Testa R, Fessy MH, Moyen B	2009	Medial patellofemoral ligament anatomy: implications for its surgical reconstruction	*Knee Surg Sports Traumatol Arthrosc*	105
73	Philippot R, Boyer B, Testa R, Farizon F, Moyen B	2012	The role of the medial ligamentous structures on patellar tracking during knee flexion	*Knee Surg Sports Traumatol Arthrosc*	102

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TABLE A1
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No.	Authors	Year	Title	Journal[b]	No. of Citations
74	Muneta T, Sekiya I, Tsuchiya M, Shinomiya K	1999	A technique for reconstruction of the medial patellofemoral ligament	*Clin Orthop Relat Res*	99
75	Schöttle P, Schmeling A, Romero J, Weiler A	2009	Anatomical reconstruction of the medial patellofemoral ligament using a free gracilis autograft	*Arch Orthop Trauma Surg*	97
76	Panagopoulos A, Van Niekerk L, Triantafillopoulos IK	2008	MPFL reconstruction for recurrent patella dislocation: a new surgical technique and review of the literature	*Int J Sports Med*	97
77	Kita K, Tanaka Y, Toritsuka Y, Amano H, Uchida R, Takao R, Horibe S	2015	Factors affecting the outcomes of double-bundle medial patellofemoral ligament reconstruction for recurrent patellar dislocations evaluated by multivariate analysis	*Am J Sports Med*	93
78	Stupay KL, Swart E, Shubin Stein BE	2015	Widespread implementation of medial patellofemoral ligament reconstruction for recurrent patellar instability maintains functional outcomes at midterm to long-term follow-up while decreasing complication rates: a systematic review	*Arthroscopy*	93
79	Lippacher S, Dreyhaupt J, Williams SRM, Reichel H, Nelitz M	2014	Reconstruction of the medial patellofemoral ligament: clinical outcomes and return to sports	*Am J Sports Med*	92
80	Victor J, Wong P, Witvrouw E, Sloten JV, Bellemans J	2009	How isometric are the medial patellofemoral, superficial medial collateral, and lateral collateral ligaments of the knee?	*Am J Sports Med*	91
81	Thaunat M, Erasmus PJ	2009	Management of overtight medial patellofemoral ligament reconstruction	*Knee Surg Sports Traumatol Arthrosc*	89
82	Nelitz M, Dreyhaupt J, Lippacher S	2013	Combined trochleoplasty and medial patellofemoral ligament reconstruction for recurrent patellar dislocations in severe trochlear dysplasia: a minimum 2-year follow-up study	*Am J Sports Med*	88
83	Thaunat M, Erasmus PJ	2008	Recurrent patellar dislocation after medial patellofemoral ligament reconstruction	*Knee Surg Sports Traumatol Arthrosc*	88
84	Thaunat M, Erasmus PJ	2007	The favourable anisometry: an original concept for medial patellofemoral ligament reconstruction	*Knee*	86
85	Deie M, Ochi M, Adachi N, Shibuya H, Nakamae A	2011	Medial patellofemoral ligament reconstruction fixed with a cylindrical bone plug and a grafted semitendinosus tendon at the original femoral site for recurrent patellar dislocation	*Am J Sports Med*	85
86	Feller JA, Richmond AK, Wasiak J	2014	Medial patellofemoral ligament reconstruction as an isolated or combined procedure for recurrent patellar instability	*Knee Surg Sports Traumatol Arthrosc*	84
87	Garth WP Jr, Dichristina DG, Holt G	2000	Delayed proximal repair and distal realignment after patellar dislocation	*Clin Orthop Relat Res*	83
88	Seeley M, Bowman KF, Walsh C, Sabb BJ, Vanderhave KL	2012	Magnetic resonance imaging of acute patellar dislocation in children: patterns of injury and risk factors for recurrence	*J Pediatr Orthop*	82
89	Arendt EA, Moeller A, Agel J	2011	Clinical outcomes of medial patellofemoral ligament repair in recurrent (chronic) lateral patella dislocations	*Knee Surg Sports Traumatol Arthrosc*	82
90	Sillanpää P, Mattila VM, Visuri T, Mäenpää H, Pihlajamäki H	2008	Ligament reconstruction versus distal realignment for patellar dislocation	*Clin Orthop Relat Res*	82
91	Sappey-Marinier E, Sonnery-Cottet B, O'Loughlin P, Ouanezar H, Reina Fernandes L, Kouevidjin B, Thaunat M	2019	Clinical outcomes and predictive factors for failure with isolated MPFL reconstruction for recurrent patellar instability: a series of 211 reconstructions with a minimum follow-up of 3 years	*Am J Sports Med*	81

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TABLE A1
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No.	Authors	Year	Title	Journal[b]	No. of Citations
92	Banke IJ, Kohn LM, Meidinger G, Otto A, Hensler D, Beitzel K, Imhoff AB, Schöttle PB	2014	Combined trochleoplasty and MPFL reconstruction for treatment of chronic patellofemoral instability: a prospective minimum 2-year follow-up study	*Knee Surg Sports Traumatol Arthrosc*	79
93	Nelitz M, Dornacher D, Dreyhaupt J, Reichel H, Lippacher S	2011	The relation of the distal femoral physis and the medial patellofemoral ligament	*Knee Surg Sports Traumatol Arthrosc*	79
94	Matsushita T, Kuroda R, Oka S, Matsumoto T, Takayama K, Kurosaka M	2014	Clinical outcomes of medial patellofemoral ligament reconstruction in patients with an increased tibial tuberosity-trochlear groove distance	*Knee Surg Sports Traumatol Arthrosc*	78
95	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*	77
96	Balcarek P, Walde TA, Frosch S, Schüttrumpf JP, Wachowski MM, Stürmer KM, Frosch K-H	2011	Patellar dislocations in children, adolescents and adults: a comparative MRI study of medial patellofemoral ligament injury patterns and trochlear groove anatomy	*Eur J Radiol*	77
97	Redfern J, Kamath G, Burks R	2010	Anatomical confirmation of the use of radiographic landmarks in medial patellofemoral ligament reconstruction	*Am J Sports Med*	77
98	Cossey AJ, Paterson R	2005	A new technique for reconstructing the medial patellofemoral ligament	*Knee*	74
99	Schottle PB, Romero J, Schmeling A, Weiler A	2008	Technical note: anatomical reconstruction of the medial patellofemoral ligament using a free gracilis autograft	*Arch Orthop Trauma Surg*	73
100	Wang C-H, Ma L-F, Zhou J-W, Ji G, Wang H-Y, Wang F, Wang J	2013	Double-bundle anatomical versus single-bundle isometric medial patellofemoral ligament reconstruction for patellar dislocation	*Int Orthop*	72

[a]MPFL, medial patellofemoral ligament.
[b]Journal titles are abbreviated according to the format in PubMed.