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The Top 50 Most Cited Articles on the Medial Patellofemoral Ligament (MPFL): A Bibliometric Analysis

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Abstract:

Objectives: To determine which original articles on the topic of the medial patellofemoral ligament (MPFL) have been cited the most in the literature utilizing a bibliometric approach. Secondarily, to determine temporal trends between article types.

Methods: Articles on the topic of the MPFL were identified by utilizing the Web of Science Database. The search yielded 1,596 results and the top 50 cited original articles were collected for further analysis. The following information was gathered for all included articles: title, first author's name, journal name, year of publication, impact factor of the journal in 2021, total number of citations of the article, average citations per year (ACY), geographic origin, institutions, research theme, and keywords. Articles were then grouped into one of three categories: cadaveric/anatomic, clinical, and radiologic.

Results: The total number of citations was 10,393. Publication dates ranged from 1992 to 2015 and majority of articles originated in the United States (38%). Most were published between the years 2000-2009 (66%) and in the journal, *American Journal of Sports Medicine* (34%). The mean ACY was 11.73 ± SD 5.86 and the Kawasaki Municipal Hospital was the institution with the most articles included in the top 50 (n=6, 12%). The top-cited articles focused on 3 themes: cadaveric/anatomic (n=18, 36%), clinical (n=25, 50%), and radiologic (n=7, 14%). Cadaveric/anatomic articles had the highest average number of citations at 271.4 ± 153.9, followed by radiologic (173.3 ± 53.0) and clinical articles (171.8 ± 102.4). The two most common keywords were “medial patellofemoral ligament” (53%) and “patella” (23%). Over

time, clinical articles were more likely to be included in the top 50 list, compared to cadaveric/anatomic/radiologic articles.

Conclusion: The current study showcased that the MPFL is a growing area of research. The most impactful articles relate to cadaveric/anatomic articles; however, over time, clinical articles became more prevalent.

Keywords: MPFL, bibliometric, epidemiology, medial patellofemoral ligament, top cited

Introduction:

The medial patellofemoral ligament (MPFL) is a commonly injured ligament in the knee [1]. With injury, there is a potential for lateral patellar dislocations, especially in children [2]. Multiple treatment modalities have been offered to treat MPFL injuries depending on severity, ranging from conservative measure like physical therapy to more invasive measures, such as surgery [3]. Over the decades, new techniques have been developed to continually improve on the procedure [4]. In the general population, the incidence of lateral patellar dislocations ranges from 5.8-7 cases per 100,000 person-years to 29 cases per 100,000 person-years in children aged 10-17 [2], indicating the importance of innovation. Generally, 60% of first-time patellar dislocations occur during physical activity or sports either through direct contact or through a non-contact mechanism involving external rotation of the leg with a planted foot [2], placing athletes at an increased risk.

Collecting and analyzing the most impactful research studies throughout the years can help clinicians better understand the progression of MPFL literature. Specifically, with a bibliometric analysis, synthesizing multiple studies can be a helpful tool in mapping studies [5]. This is in contrast to narrative reviews, as they have the potential of introducing bias from the

researchers performing the study [5]. There have been multiple bibliometric studies done in the past, including on the anterior cruciate ligament (ACL) [5,6], posterior cruciate ligament (PCL) [7], and meniscus [8]. In performing a bibliometric analysis, there exists an opportunity for insight into the trending topics in any particular field by quantitatively analyzing studies. It can be seen which topics are trending by quantitatively analyzing studies in any particular field, potentially guiding direction of future research [9].

The purpose of this study is to determine which original articles on the topic of the MPFL have been cited the most in the literature utilizing a bibliometric approach. Secondarily, to determine temporal trends between article types.

Methods:

Collection and Allocation of Articles

All relevant articles on MPFL were searched by using the Web of Science database, which includes the Web of Science Core Collection, Biological Abstracts, BIOSIS Citation Index, Current Contents Connect, Data Citation Index, Derwent Innovations Index, KCI-Korean Journal Database, MEDLINE, SciELO Citation Index, and Zoological Record. Two researchers independently identified articles for inclusion to enhance the search sensitivity. The search terms were “MPFL” OR “Medial Patellofemoral Ligament.”

The search was performed on August 4th, 2022, and yielded 1,596 results in total. Filtering the search results via “article” resulted in 1,463 articles. Original articles and registry data were included, whereas meta-analyses, systematic reviews, guidelines, and other review articles were excluded. All articles and registry data were ranked by the number of citations; articles with <70 citations were excluded to reduce the workload. This resulted in 127 publications included for analysis. After review, the title and abstract of each article were

categorized by 2 independent investigators based on the inclusion criteria. The three categories included: cadaveric/anatomic, clinical, and radiologic. Duplicates were removed, and any disagreements were discussed with the senior author until a consensus was reached. After the review of all included articles, 94 articles remained. These articles were arranged according to number of citations and the top 50 most cited articles were included in the final analysis (**Figure I**).

Data Extraction

The following information was listed for all articles: title, first author's name, journal name, year of publication, impact factor of the journal in 2021, total number of citations of the article, average citations per year (ACY), geographic origin, institutions, research theme, and keywords.

Results:

The 50 most cited articles arranged by citation rank are shown in **Appendix Table I**. The total number of citations was 10,393 (mean [SD] = 207.86 [126.57]), including 2,403 citations (343.29 [193.15]) before the 2000s, 6,622 citations (200.67 [108.76]) in the 2000s, and 1,368 citations (136.8 [15.11]) in the 2010s. Of note, 3 articles were cited >500 times. Overall, the mean ACY for all 50 articles was 11.73 ± (SD) 5.86.

Characteristics of the Top 10 Most Cited Articles Per Year

The top 10 most cited articles by average citations per year (ACY) are listed in **Table I**. The number of ACY ranged from 14.06 to 33.53. Most of these articles (n=7) were published before 2010. The mean number of total citations was 371.80, and the mean citation rank was 12.60.

Table I. Top 10 Articles with the Largest Number of Average Citations Per Year

Rank	Article	Citations	Citation Rank	ACY
1	Fithian et al, *Am J Sports Med* (2004)[10]	637	1	33.53
2	LaPrade et al, *J. Bone Jt. Surg Am* (2007)[11]	478	4	29.88
3	Desio et al, *Am J Sports Med* (1998)[12]	615	2	24.60
4	Schöttle et al, *Am J Sports Med* (2007)[13]	376	6	23.50
5	Steensen et al, *Am J Sports Med* (2015)[14]	149	28	18.63
6	Conlan et al, *J. Bone Jt. Surg Am* (1993)[15]	555	3	18.50
7	Hautamaa et al, *Clin. Orthop. Relat. Res*. (1998)[16]	384	5	15.36
8	Wagner et al, *Knee Surg. Sports Traumatol. Arthrosc*. (2013)[17]	144	32	14.40
9	Parikh et al, *Am J Sports Med* (2013)[18]	141	35	14.10
10	Elias et al, Am J Sports Med (2006)[19]	239	10	14.06

Characteristics of the Top 10 Most Cited

The article with most overall citations (n=637) involved the epidemiology of acute patellar dislocation and was published in the *American Journal of Sports Medicine* in 2004 by Fithian et al. [10] This study demonstrated that patient who present with a prior history of instability are more likely to be female, older, and have a greater risk of continued patellar instability than those with a first-time dislocation. The second most cited article was by Desio et al. [12] and was published in the *American Journal of Sports Medicine* in 1998. It was an anatomical study showing that the medial patellofemoral ligament was the primary restraint to

lateral patellar translation at 20 degrees of flexion. The third most cited article was published in the *Journal of Bone and Joint Surgery- American Volume* by Conlan et. al. in 1993 [15]. This anatomical study characterized medial patellofemoral ligament insertions. The smallest number of citations in the top 50 articles was 120. The research topics and conclusions of the top 10 most cited articles are presented in **Table II**.

Table II. Topics and Conclusions of the Top 10 Overall Cited Articles.

Rank	Article	First Author	Topics and Conclusions
1	Epidemiology and Natural History of Acute Patellar Dislocation	Fithian [10]	Study demonstrating that patellar dislocators who present with a prior history of instability were more likely to be female, older, and have a greater risk of subsequent patellar instability episodes than first-time dislocators.

2	Soft Tissue Restraints to Lateral Patellar Translation in the Human Knee	Desio [12]	Study showing that the medial patellofemoral ligament was the primary restraint to lateral patellar translation at 20 degrees of flexion, contributing 60% of the total restraining force.
3	Evaluation of the Medial Soft-Tissue Restraints of the Extensor Mechanism of the Knee	Conlan [15]	Study characterizing medial patellofemoral ligament insertions and demonstrating that this ligament is the major medial soft-tissue restraint preventing lateral displacement of the distal knee-extensor mechanism.
4	The Anatomy of the Medial Part of the Knee	LaPrade [11]	Study characterizing the average relative location of medial patellofemoral ligament attachments (on the femur 1.9mm anterior and 3.8mm distal to the adductor tubercle).
5	Medial Soft Tissue Restraints in Lateral Patellar Instability and Repair	Hautamaa [16]	Study demonstrating that the medial patellofemoral ligament was the major medial ligamentous stabilizer of the patella.
6	Radiographic Landmarks for Femoral Tunnel Placement in Medial Patellofemoral Ligament Reconstruction	Schöttle [13]	Study characterizing the radiographic landmarks for medial patellofemoral ligament insertion.
7	Acute Dislocation of the Patella - A Correlative Pathoanatomic Study	Sallay [20]	Study characterizing the pathoanatomy associated with patellar dislocation and reporting the preliminary results of early surgical repair.
8	Acute Lateral Patellar Dislocation at MR Imaging: Injury Patterns of Medial Patellar Soft-Tissue Restraints and Osteochondral Injuries of the Inferomedial Patella	Elias [21]	Study assessing magnetic resonance imaging findings after acute lateral patellar restraints with emphasis on medial patella restraints and describing a medial patellar impaction deformity.
9	Clinical and Radiological Outcome of Medial patellofemoral Ligament Reconstruction with a	Schöttle [22]	Study assessing clinical and radiological outcome after linear MPFL reconstruction

	Semitendinosus Autograft for Patella Instability		using an ipsilateral Semitendinosus tendon autograft after a 4-year follow-up.
10	Technical Errors During Medial Patellofemoral Ligament Reconstruction Could Overload Medial Patellofemoral Cartilage - A Computational Analysis	Elias [19]	Study analyzing how errors in graft length and position in medial patellofemoral ligament reconstruction affect the force and pressure applied to the ligament cartilage.

MPFL, medial patellofemoral ligament; MR, magnetic resonance

Time Distribution of Publications

The year of publication ranged from 1992 to 2015, and the majority of the articles were published in the 2000s (66%). Articles published before 2000 and those published after 2010 accounted for 14% and 20%, respectively (**Figure II**).

The years with the greatest number of articles were 2005 (n=5) and 2006 (n=5), followed by 2000 (n=4). The citation density revealed a slight trend toward increasing frequency of citations for the more recent articles (**Figure III**).

Country of Origin

The top 50 most cited articles originated from 12 countries. The country with the greatest number of published articles was the United States (n=19), followed by Japan (n=10), Germany (n=5), Brazil and England (n=4 each). Denmark contributed 3 articles, whereas Canada, Australia, Finland, Greece, and Switzerland each contributed 1 article. In the United States, Ohio was the state that published the most articles (n=4), followed by Utah (n=3) and California (n=2). New York, Minnesota, Michigan, Louisiana, Indiana, Colorado, Alabama, Texas, Oregon, and Massachusetts all had 1 article in the list.

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124 *Distribution of Journals*

125 All of the top-cited articles were published in 14 journals, led by *American Journal of*
126 *Sports Medicine* (n=17), followed by *Arthroscopy* (n=9), *Knee Surgery, Sports Traumatology,*
127 *Arthroscopy* (n=6), and *The Knee* (n=4). The remainder are described in **Table III**.

128

129 **Table III.** Journals in Which the Top 50 Most Cited Articles Were Published

Journal	Country	Impact Factor (2021)	No. of Articles	No. of Citations
American Journal of Sports Medicine	USA	7.01	17	4,010
Arthroscopy - The Journal of Arthroscopic and Related Surgery	USA	5.97	9	1,387
Knee Surgery, Sports Traumatology, Arthroscopy	Germany	4.11	6	1,094
The Knee	UK	2.42	4	707
Journal of Bone and Joint Surgery - American Volume	USA	6.56	3	1,154
Journal of Bone and Joint Surgery - British Volume	UK	3.31	3	497
Acta Orthopaedica Belgica	Belgium	0.35	1	121
Clinical Orthopaedics and Related Research	USA	4.76	1	384
International Orthopaedics	Germany	3.48	1	200
Journal of Computer Assisted Tomography	USA	2.08	1	135
Medicine and Science in Sports and Exercise	USA	6.29	1	148

Radiographics	USA	6.31	1	166
Radiology	USA	29.15	1	258
The American Journal of Knee Surgery	USA	2.50	1	132

130 *Distribution of Institutions*

131 The most cited research institution was the Kawasaki Municipal Hospital (n=6), followed
132 by Mount Carmel Health System and the University of Utah (n=3 each). The Imperial College of
133 London, Hiroshima University, Aarhus University, University of Toronto, and the Federal
134 University of Rio Grande do Sul each contributed 2 articles. The remaining institutions,
135 according to the number of the most cited articles, are listed in **Figure IV.**

136 *High-Impact Authors*

137 A total of 6 first authors have published ≥2 publications within the top 50 most cited
138 articles **(Table IV)**. The most prolific first author was E. Nomura (n=7) from Kawasaki
139 Municipal Hospital and later from the University of Fukui School of Medicine.

140 **Table IV.** Authors with 2 or more cited articles.

Author	No. of Articles	Institution	Rank of Articles	Total No. of Citations
E. Nomura	7	Kawasaki Municipal Hospital, Kawasaki, Kanagawa, Japan	16, 17, 18, 34, 39, 43, 44	1,116
R. Steensen	3	Mount Carmel Health System	15, 28, 46	480
P. Schöttle	2	Free & Humboldt University, Berlin, Germany	6, 9	616

S. Christiansen	2	Aarhus University Hospital, Aarhus, Denmark	19, 22	351
M. Deie	2	Hiroshima University, Hiroshima, Japan	21, 26	325
J. Gomes	2	Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil	27, 29	299

Distribution of Themes

The top-cited articles focused on 3 themes: cadaveric/anatomic (n=18), clinical (n=25), and radiologic (n=7). Cadaveric/anatomic articles had the highest average number of citations at 271.4 ± 153.9, followed by radiologic (173.3 ± 53.0) and clinical articles (171.8 ± 102.4). The total number of citations for each theme is showcased in **Figure V**.

Article Trends

When plotting the trends of the three articles themes: anatomical/epidemiologic, clinical, and radiologic, a trend arose that showcased clinically focused articles were more likely to be included in the top 50 list in recent years compared to the other two. (**Figure VI**).

Distribution of Keywords

Keywords of each article (n=47) were analyzed to determine the top 10 most common keywords. The most common keyword was “medial patellofemoral ligament” (53% of papers), followed by “patella” (23%), “patellar dislocation” (17%), “knee” (17%), “dislocation” (17%), “reconstruction” (15%), “dislocation” (13%), “recurrent dislocation” (13%), “MPFL Reconstruction” (11%), and “joint” (9%).

Discussion:

In the present study, we utilized bibliometric indicators to provide insight into the reach of publications surrounding the medial patellofemoral ligament. Importantly, these results revealed the most cited articles that have influenced the evolution of MPFL literature and treatments. By identifying and distinguishing important aspects of these articles, we hoped to uncover the historical pathway that led to current articles and guidelines today.

The top 50 articles in the field of MPFL were cited a mean of 208 times, comparable to the mean in other fields such as ACL reconstruction [5], spine deformity [23], or cervical spine surgery [24]. Many of the articles were published in the 2000s (66%) and 2010s (20%) with only 14% percent published from 1990-1999. This draws on the speculation that articles gain value 20 years after the date of publication [25]. An important confounding effect is that older articles are cited more frequently, whereas new articles may not influence writers as dramatically. Many article writers use references from other papers to guide their review of the literature, therefore recently published articles have a disadvantage due to inadequate time to accumulate citations [5]. When articles are ranked by ACY, there is a shift in this trend, revealing more frequent citing of recent articles. The majority of top 10 articles by ACY are published before 2010 with a mean number of citations of 372. It has been discussed previously that ACY may be more reflective of the impact of an article's future citation success [5]. This is supported by the idea that an article with a high number of citations, but a low ACY has accumulated citations overtime, but is no longer a strong influence in the literature [5].

Many of the journals (57%) and articles (38%) in this paper are associated with the United States (US). The explanation for this phenomenon is three-fold. The US is a leader in publishing, US authors usually publish in US journals and cite US articles, and US associated reviews preferentially accept US-based articles.[26] The most popular journal in the 50 most

cited articles was *AJSM*, with 17 articles published in the journal for a total of 4,010 citations. *AJSM* is a well-known and respected journal which may explain the extent of its influence. Its impact factor was most recently reported as 7.01 (2021). Additionally, this search revealed the most popular research themes. The most common research theme found in our study was clinical (n=25).

Cadaveric/anatomic articles had the highest average number of citations when compared to clinical or radiologic articles. These articles are important in discussing the basic science, osseous landmarks, and relationships between structures to guide the diagnosis and treatment in MPFL injury. Then, throughout the years, clinical articles became more prevalent in the top 50 list, showcasing the progression of MPFL literature. Over the past two decades, the field of patellofemoral instability has changed vastly [27]. There has been a shift from anatomic studies to biomechanical ones, evaluating surgical techniques. For example, in 2007, Schöttle et al. established Schöttle's point, which is a radiographic landmark for intraoperative femoral MPFL insertion [13]. As anatomic characteristics became well understood, a shift into more clinical outcome-based articles was seen [27]. In 2013, Fulkerson and Edgar described the medial quadriceps tendon-femoral ligament (MQTFL), which is a prominent anatomic structure extending from the deep quadriceps tendon to the adductor tubercle region. Reconstruction of this structure has shown to stabilize the patellofemoral joint without drilling into the patella, resulting in a reduced risk of patellar fracture compared to MPFL reconstruction [28]. Later in 2017, Tanaka published a review on the Medial Patellofemoral Complex (MPFC). This was defined as the static medial stabilizer of the patella located in layer II of the medial knee, deep to the vastus medialis obliquus (VMO), 0.44 ± 0.19 mm at its midpoint [29]. It consists of both the MPFL and MQTFL. As athletes are at an increased risk for patellar dislocations [1], the return-

to-play (RTP) has been reported to be 85% following MPFC surgery. However, only 68% return to the same level of play at an average of 7 months [30].

Overall, the present study can aid future researchers in constructing ideas that build upon these topics to continuously improve the MPFL literature. With social determinants of health (SDOH) becoming a hot-button topic in recent years, future research can be performed to not only determine anatomic risk factors for failure following reconstruction, but patient demographics as well.

This study was not without limitations. Self-citation was not accounted for and excluded. Also, since only original articles were included, there were systematic reviews and guidelines that had more citations than some of the included articles that did not get analyzed. Next, a "snowball" effect has been demonstrated in previous literature, which states that authors prefer to cite articles that already have a large number of citations [5,31]. Finally, since majority of articles were research themes were not clinical, level of evidence was not collected and analyzed.

Conclusion:

The current study showcased that the MPFL is a growing area of research. The most impactful articles relate to cadaveric/anatomic articles; however, over time, clinical articles became more prevalent.

Conflicts of Interest: None

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Figure I. Flowchart Illustrating the Procedure of Allocation of Articles

Figure II. Time Distribution of the Top 50 Cited Articles

Figure III. Time Dependent Citation Density Trend

Figure IV. Institutional Distribution of All Articles (Number of Articles at Bottom of Bar)

Figure V. Theme and Citation Distribution of Articles

Figure VI. Trend of Articles Throughout the Years

312 **Appendix:**

313 **Table I.** Rank, title, country of Origin, ACY, and citations for each of the top 50 most cited
314 MPFL articles.

315

Rank	Paper	Country	ACY	No. of Citations
1	Epidemiology and Natural History of Acute Patellar Dislocation	USA (CA)	33.53	637
2	Soft Tissue Restraints to Lateral Patellar Translation in the Human Knee	USA (UT)	24.60	615
3	Evaluation of the Medial Soft-Tissue Restraints of the Extensor Mechanism of the Knee	USA (AL)	18.50	555
4	The Anatomy of the Medial Part of the Knee	USA (MN)	29.87	478
5	Medial Soft Tissue Restraints in Lateral Patellar Instability and Repair	USA (CA)	15.36	384
6	Radiographic Landmarks for Femoral Tunnel Placement in Medial Patellofemoral Ligament Reconstruction	Germany	23.50	376

7	Acute Dislocation of the Patella - A Correlative Pathoanatomic Study	USA (IN)	13.63	368
8	Acute Lateral Patellar Dislocation at MR Imaging: Injury Patterns of Medial Patellar Soft-Tissue Restraints and Osteochondral Injuries of the Inferomedial Patella	Canada	12.29	258
9	Clinical and Radiological Outcome of Medial patellofemoral Ligament Reconstruction with a Semitendinosus Autograft for Patella Instability	Switzerland	13.33	240
10	Technical Errors During Medial Patellofemoral Ligament Reconstruction Could Overload Medial Patellofemoral Cartilage - A Computational Analysis	USA (CO)	14.06	239
11	The Anatomy and Reconstruction of the Medial Patellofemoral Ligament	Australia	11.95	239
12	Medial Patellofemoral Ligament Reconstruction in Patients with Lateral Patellar Instability and Trochlear Dysplasia	USA (MI)	13.35	227

13	Tensile Strength of the Medial Patellofemoral Ligament Before and After Repair or Reconstruction	England	12.28	221
14	Results of Medial Patellofemoral Ligament Reconstruction in the Treatment of Patellar Dislocation	USA (LA)	9.64	212
15	The Anatomy and Isometry of the Medial Patellofemoral Ligament - Implications for Reconstruction	USA (OH)	11.00	209
16	Anatomical Analysis of the Medial Patellofemoral Ligament of the Knee, Especially the Femoral Attachment	Japan	11.17	201
17	Classification of Lesions of the Medial Patello-Femoral Ligament in Patellar Dislocation	Japan	8.33	200
18	Medial Patellofemoral Ligament Restraint in Lateral Patellar Translation and Reconstruction	Japan	8.52	196
19	Reconstruction of the Medial Patellofemoral Ligament with Gracilis Tendon Autograft in Transverse Patellar Drill Holes	Denmark	12.27	184

20	Cadaveric Study on Static Medial Patellar Stabilizers: The Dynamizing Role of the Vastus Medialis Obliquus on Medial Patellofemoral Ligament	Greece	10.76	183
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