

# Trends in Meniscus-Related Publications in PubMed Since 1928

## A Bibliometric Study

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**Background:** As information on the meniscus accumulates in PubMed, it is possible to evaluate the trends in research on the topic over time.

**Purpose:** To evaluate the major trends in meniscus-related publications in PubMed from the earliest publication to the present day.

**Study Design:** Cross-sectional study.

**Methods:** PubMed was searched on January 3, 2023, using the search strategy “menisc<sup>\*</sup>”[All Fields] AND (“knee”[MeSH Terms] OR “knee”[All Fields] OR “knee joint”[MeSH Terms] OR (“knee”[All Fields] AND “joint”[All Fields]) OR “knee joint”[All Fields]) AND 1900/01/01:2022/12/31[Date - Publication]. This retrieved 15,569 human and animal studies. We determined the top 10 meniscus-related publications in terms of overall citations and citations per year, as well as the top 10 authors, journals, countries, and institutions of cited publications on the meniscus. In addition, we performed word-cloud analyses based on meniscus-related terms from different periods (before 1981, before 2000, after 2005, and in the past 5 years [2018-2022]), including the year of first appearance and the number of publications featured.

**Results:** Since the first recorded publication on the meniscus in 1928, there was a steady growth in the number of articles until 2005, when there was an upsurge in publications from 254 in 2005 to 955 in 2022. Noyes was the author with the most citations ( $n = 3314$ ), and a 2006 study by Caplan and Dennis had the most citations per year ( $n = 125$ ). *Arthroscopy* published the most articles on the meniscus with 1118, whereas the *Journal of Cellular Biochemistry* had the most citations per article with 125.69. The most published countries and institutes were the United States and the Hospital for Special Surgery, respectively. Word-cloud analysis of article titles showed that “meniscectomy” had become less prominent, and “root,” “ramp,” “transplantation,” and “slope” had become more prominent.

**Conclusion:** There has been an upsurge in publications on the meniscus since 2005, with word-cloud analysis indicating shifting interests in meniscus-related research.

**Keywords:** bibliometric study; meniscus; meniscal; knee; sports medicine; meniscectomy; RAMP; arthroscopy; repair; transplantation; bucket handle

The method for treating meniscus-related issues was fundamentally altered 60 years ago when it was discovered that removing the meniscus from the knee joint—at the

time, thought to be the only method for treating sports-related injuries—caused articular cartilage to deteriorate and the sluggish onset of arthritis.<sup>13</sup> Partial meniscectomy was proposed as a substitute for total meniscectomy in 1982,<sup>14</sup> and the first documented case of a meniscus transplant was reported in 1989.<sup>23</sup> These studies, which served as a turning point in our knowledge of the anatomy and purpose of the knee meniscus, sparked a plethora of

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subsequent studies looking at various therapeutic modalities. Keeping the tissue intact wherever possible is the current standard of care for meniscus-related lesions.<sup>12,24,26,36</sup> In cases of severe or complete traumatic lesions, however, the inability of surgeons to reconstruct the tissue—both morphologically and functionally—continues to pose difficulties.<sup>17</sup> The inability to stop osteoarthritis (OA) from progressing at the same time provides a similar incentive to look for novel therapeutic approaches.<sup>32,34</sup> PubMed is an important source of literature searches among orthopaedic surgeons. It has been more than 20 years since it was rolled out for public use, and it has gained popularity ever since. The meniscus is one of the oldest structures in the knee to be studied and treated surgically.<sup>16</sup> As information on this structure accumulates and is cited in PubMed, trends in interest in a particular topic may vary from time to time.<sup>18</sup>

This study aimed to look at the major trends involving publications on the meniscus on PubMed from the earliest publication to the present day.

## METHODS

PubMed was searched on January 3, 2023, using the following search strategy: “menisc\*”[All Fields] AND (“knee”[MeSH Terms] OR “knee”[All Fields] OR “knee joint”[MeSH Terms] OR (“knee”[All Fields] AND “joint”[All Fields]) OR “knee joint”[All Fields]) AND 1900/01/01:2022/12/31[Date - Publication]. This search retrieved 15,569 human and animal studies.

We recorded trends in the publication of meniscus studies and analyzed the top 10 studies in terms of overall citations and citations per year (calculated as the number of citations divided by the number of years since publication). The online PubMed by Year tool<sup>33</sup> was used to compare the yearly number of publications on the meniscus per 100,000 PubMed publications. Publications were also analyzed in terms of study type (eg, systematic review, randomized controlled trial [RCT], or case report), which was obtained by using filters in the PubMed search output. We also evaluated the top 10 authors, journals, countries, and institutions of cited publications on the meniscus.

Most of the analysis was performed using the output from PubMed (overall citations, citations per year, top authors, top journals). However, we used the Scopus

database for information on the top 10 countries and institutions publishing on the meniscus, as this information is not provided in PubMed. We are aware that the 2 databases are not the same since Scopus includes more journals than PubMed, but the trends appear to be similar in both databases.

In addition, word-cloud analyses was performed based on author names and on terms related to the meniscus from different periods (before 1981, before 2000, after 2005, and during the past 5 years [2018-2022]), the year of first appearance, and the number of publications. Data mining was performed using Orange software (Mac version 3.32.0; <https://orangedatamining.com>) from the titles of all articles.

## RESULTS

### Trends in Publications on the Meniscus

The first recorded publication on the meniscus in PubMed was by Pandalai in the *Indian Medical Gazette* in 1928.<sup>28</sup> It was about a cyst of the meniscus in the knee. The next study was published by Charnley in 1945.<sup>8</sup> The number of publications crossed 100 in 1982 and 200 in 1993. However, it took only 16 years to increase from 300 to over 900 publications per year. There was a steady growth in the number of publications until 2005, when there was an upsurge in publications from 254 in 2005 to 955 in 2022; this was almost a fourfold increase. A graph of publications per year is shown in Figure 1. A 2-order polynomial trend line was added to the chart to indicate the increasing trend in the number of publications.

Information on number of meniscus-related citations was only available from 1980, as represented in Figure 2 along with the number of publications. A threefold increase in the number of citations was seen from 1990 to 2006, from 5264 to more than 16,000. The number of citations in the most recent 5 to 7 years was lower, as expected, as it takes time for citations to accumulate for any article.

Figure 3 shows the yearly trend in number of meniscus-related publications compared with all PubMed publications (estimated as a proportion of 100,000 publications in PubMed) since 1945. There was a steady increase in the proportion of attention garnered by meniscus articles, from a low of 8 per 100,000 in 1951 to 65 per 100,000 in 2015.

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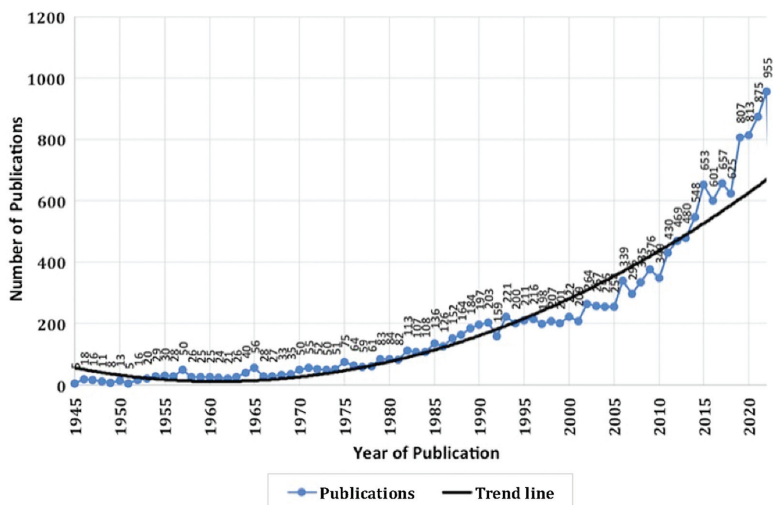
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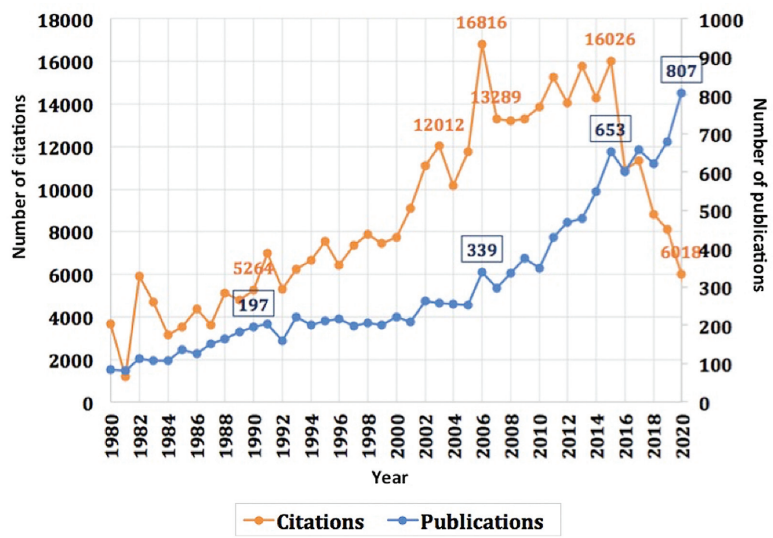
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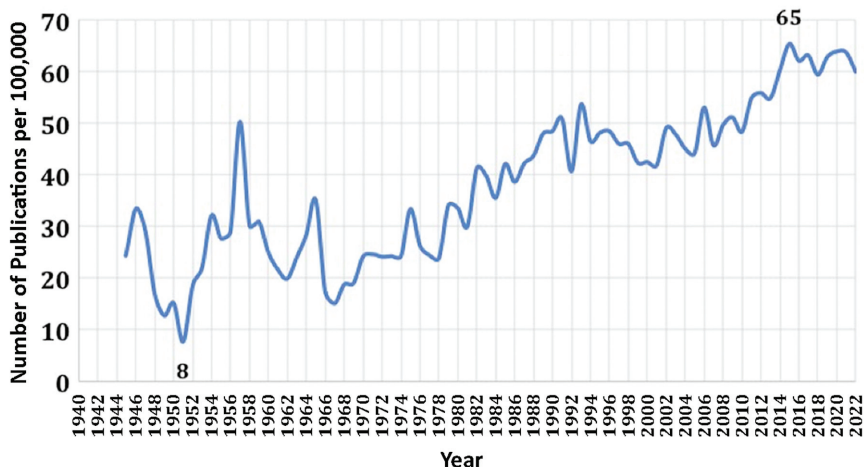
Ethical approval for this study was waived by IRCCS Ospedale Galeazzi–Sant’Ambrogio.



**Figure 1.** Numbers of publications per year (blue line) with trend line (black curve). An upsurge in publications beginning in 2005 can be seen. The blue dots indicate the number of publications each year.



**Figure 2.** Numbers of citations and publications on the meniscus per year.



**Figure 3.** Number of meniscus-related publications per year compared with all PubMed publications since 1945 (shown as number of publications per 100,000).

TABLE 1  
Top 10 Most-Cited Publications on the Meniscus on PubMed

Year	Authors	Title	Total Citations
2006	Caplan and Dennis <sup>7</sup>	Mesenchymal stem cells as trophic mediators	2011
1982	Lysholm and Gillquist <sup>23</sup>	Evaluation of knee ligament surgery results with special emphasis on the use of a scoring scale	1836
2007	Lohmander, Englund, Dahl, et al <sup>22</sup>	The long-term consequence of anterior cruciate ligament and meniscus injuries: osteoarthritis	1392
2004	Peterfy, Guermazi, Zaim, et al <sup>29</sup>	Whole-Organ Magnetic Resonance Imaging Score (WORMS) of the knee in osteoarthritis	999
2002	Taunton, Ryan, Clement, et al <sup>35</sup>	A retrospective case-control analysis of 2002 running injuries	885
1994	Daniel, Stone, Dobson, et al <sup>11</sup>	Fate of the ACL-injured patient. A prospective outcome study	871
1997	Curl, Krome, Gordon, et al <sup>10</sup>	Cartilage injuries: a review of 31,516 knee arthroscopies	838
2007	Glasson, Blanchet, and Morris <sup>15</sup>	The surgical destabilization of the medial meniscus (DMM) model of osteoarthritis in the 129/SvEv mouse	821
2003	Steadman, Briggs, Rodrigo, et al <sup>34</sup>	Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up	758
2003	Murphy, Fink, Hunziker, et al <sup>25</sup>	Stem cell therapy in a caprine model of osteoarthritis	698

### Top 10 Cited Publications

Table 1 lists the top 10 cited studies on the meniscus. The most-cited article, a 2006 study by Caplan and Dennis,<sup>7</sup> collected 2011 citations, and the 10th most-cited article collected 698 citations. Most articles in this list were not specific to the meniscus. Since meniscus pathologies are frequently involved with other structures such as the anterior cruciate ligament (ACL) and articular cartilage, these were also pulled in the search for meniscus studies.

### Top 10 Authors and Journals Publishing on the Meniscus

Overall, there were 390 first authors and 1294 journals that published articles on the meniscus. The top 10 authors by citations per year are shown in Figure 4A. Caplan and Dennis,<sup>7</sup> with their 2006 article in the *Journal of Cellular Biochemistry*, topped the list with 125.69 citations per year. *Arthroscopy* topped the journals list in terms of the number of meniscus studies published overall, with 1118 studies (Figure 4B) followed by *Knee Surgery, Sports Traumatology, Arthroscopy (KSSTA)*; n = 1044) and *American Journal of Sports Medicine (AJSM)*; n = 955). When arranged by overall number of citations, *AJSM* topped the list (n = 55,898), followed by *Arthroscopy* and *KSSTA* (Figure 4C). The top 3 journals accounted for 31% of all citations on this topic, with *AJSM* alone accounting for 15%. Although the number of citations was high for *AJSM* relative to the number of studies published (n = 947), the number of meniscus studies published was higher for *Arthroscopy* (n = 1118) and *KSSTA* (n = 1044). When sorted according to the number of citations per year, the *Journal of Cellular Biochemistry* was the leader (n = 125.69) followed by *AJSM* and *Nature Reviews Rheumatology* (Figure 4D).

We list the top 10 first authors by overall number of citations and publications in Figure 5. According to overall number of citations, the top 3 authors were Noyes,

Englund, and Lohmander. These 3 authors accounted for 2.6% of all citations.

### Types of Studies on the Meniscus

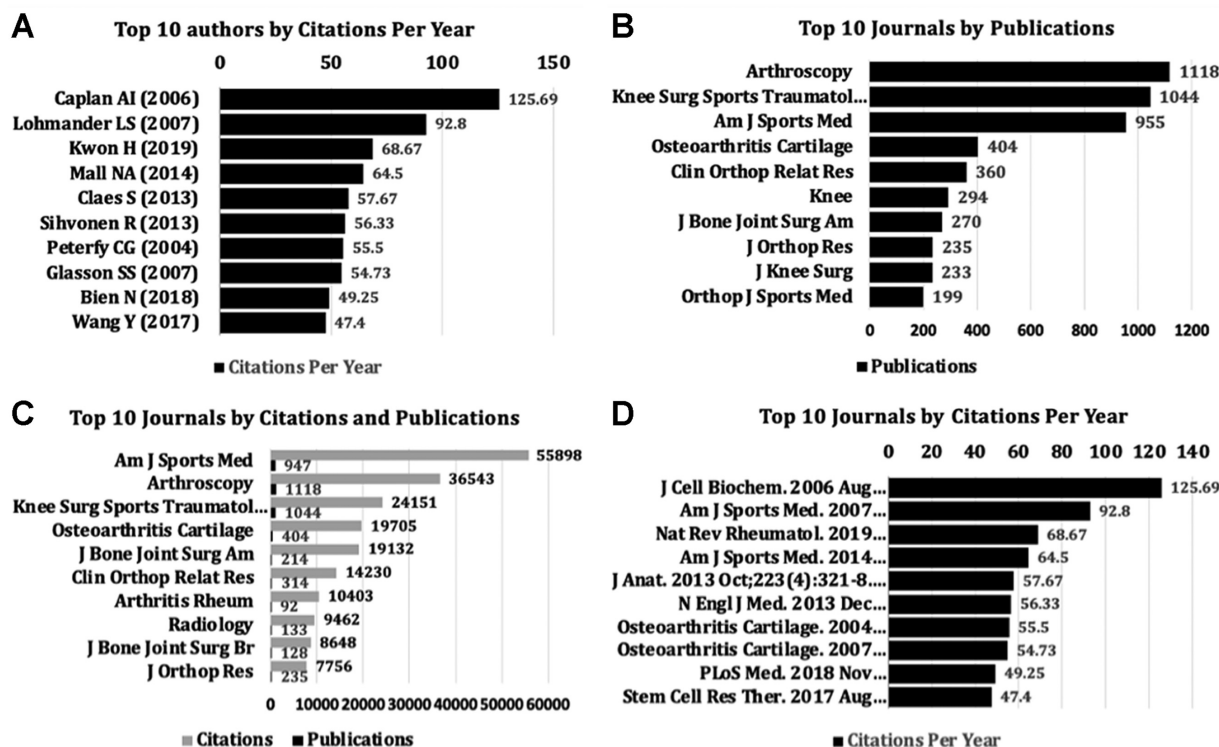
We looked at the number of different study types as shown in PubMed and analyzed their yearly numbers (Figure 6). This classification was given by PubMed to only 4582 studies out of 15,157 from 1966 to 2022. Overall, the publications consisted of systematic reviews (n = 329), meta-analyses (n = 122), RCTs (n = 331), clinical trials (n = 517), reviews (n = 1580), case reports (n = 1235), and others (n = 468).

Systematic reviews and meta-analyses started in 1997 with single-digit publications until 2010. There has been a steady increase in systematic reviews and meta-analyses since 2011, ending with 62 and 19, respectively, in 2022. RCTs and clinical trials started in 1966 but were irregular with single-digit publications until 1993 for clinical trials and 2004 for RCTs. Their numbers were at a maximum of 20 for RCTs in 2022 and 27 for clinical trials in 2013. Reviews were the maximum number of publications, with the first publication in 1964, having single-digit publication numbers until 1987 to a maximum of 104 in 2022.

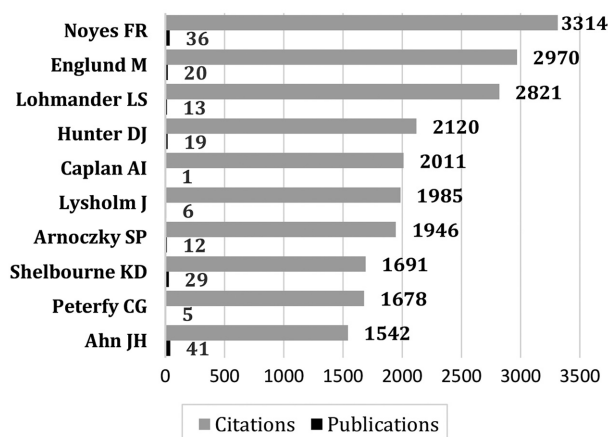
The information on countries and institutions publishing on meniscus is available in Appendix Figure A1. The most published country was the United States (US), followed by Germany and Japan, and the most published institutions on this topic were the Hospital of Special Surgery, followed by Harvard Medical School and the University of California at San Francisco.

### Word-Cloud Analysis

**Author Names.** The top 5 authors (in any position) along with the number of publications included Guermazi (n = 152), LaPrade (n = 151), Englund (n = 116), Okazaki (n = 106), and Furumatsu (n = 105). Figure 7 shows the word cloud that was created with all the names of the authors.



**Figure 4.** (A) Top 10 authors by citations per year. (B) Top 10 journals by number of overall publications. (C) Top 10 journals by overall citations and publications. (D) Top 10 journals by citations per year. *Am J Sports Med* = American Journal of Sports Medicine; *Clin Orthop Relat Res* = Clinical Orthopaedics and Related Research; *J Bone Joint Surg Am* = The Journal of Bone and Joint Surgery; *J Orthop Res* = Journal of Orthopaedic Research; *J Knee Surg* = The Journal of Knee Surgery; *Orthop J Sports Med* = Orthopaedic Journal of Sports Medicine; *Arthritis Rheum* = Arthritis and Rheumatism; *J Bone Joint Surg Br* = The Bone and Joint Journal (previously *The Journal of Bone and Joint Surgery: British Volume*); *J Cell Biochem* = Journal of Cellular Biochemistry; *Nat Rev Rheumatol* = Nature Reviews Rheumatology; *J Anat* = Journal of Anatomy; *N Engl J Med* = The New England Journal of Medicine; *PLoS Med* = PLoS Medicine; *Stem Cell Res Ther* = Stem Cells Research and Therapy.



**Figure 5.** Top 10 first authors by overall citations, with number of publications.

*Keywords in Titles.* We created separate word clouds based on the titles of articles before 1981, before 2005,

and after 2005 (Figure 8) to see if there were differences, as there had been a significant upsurge in the number of publications on the meniscus since 2005. Before 1981, the words “meniscectomy,” “arthrography,” “contrast,” “diagnosis,” and “clinical” were more prominent, and “arthroscopy” was less prominent in titles. After 2005, “tears,” “repair,” “root,” “transplantation,” “systematic,” “medial,” “imaging,” and “MRI” were more prominent than in the word cloud before 2005. Before 2000, “arthroscopy,” “imaging,” “magnetic resonance,” “cruciate,” and “study” were prominent, and “meniscectomy” was still prominent. There was more emphasis on diagnosis before 2000.

However, in the past 5 years, “meniscectomy” has become less prominent. “Root,” “repair,” and “tear” have become more prominent, and “allograft,” “osteoarthritis,” “cruciate,” and “reconstruction” have also become more prominent. “Medial” and “posterior” are more prominent, possibly indicating more work on the medial meniscus and posterior root tears. “Ramp,” “extrusion,” and “transplantation” have also appeared. “Discoid” is less prominent, and “slope” has appeared, indicating recently work on these fronts concerning the meniscus.





**Figure 8.** Word cloud of keywords in titles during different periods: before 1981, before 2000, after 2005, and in the most recent 5 years (2018-2022).

articles. The top 50 most-cited articles were published between 1941 and 2014 and were collectively cited 13,152 times. The median number of total citations per article was 203.5, whereas the median citation rate was 9.6 citations per year.<sup>21</sup> The majority of articles were clinical outcome studies (56%).<sup>21</sup>

**Top Authors, Institutions, Countries, and Journals**

In 2022, Chen et al<sup>9</sup> performed the first comprehensive analysis of the knowledge structure of knee OA and the meniscus across 2 decades and identified emerging research trends from a bibliometric perspective. A total of 3,218 articles were retrieved. Guermazi was identified as the author who had contributed the most to the field and *Osteoarthritis and Cartilage* was identified as the most productive research journal.<sup>9</sup> The US was found to be the global leader in the field and the center for international cooperation, with less international collaboration occurring in Eastern Asia. Boston University was the most prolific institution.<sup>9</sup>

Yang et al<sup>40</sup> investigated the publication conditions of stem cell therapy for meniscal regeneration and visualized the research trends and frontiers. A total of 354 publications were collected and analyzed. The US contributed the largest number of publications (34.104%). Tokyo

Medical Dental University contributed the largest number of publications (n = 34) among all full-time institutions. The journal *Stem Cell Research Therapy* published the largest number of studies on stem cells for meniscal regeneration (n = 17).<sup>40</sup> Sekiya contributed the majority of publications in this field (n = 31), whereas Horie was the most frequently cited author (n = 166). The chief keywords were (n = 1) tissue engineering, (n = 2) articular cartilage, (n = 3) ACL, (n = 4) regenerative medicine, and (n = 5) scaffold.<sup>40</sup> This indicates that the current research hotspot has been transformed from basic surgical research to tissue engineering.<sup>40</sup>

**Bibliometrics**

The bibliometric techniques help quantitative evaluation of publications and are best recognized for their efforts to gauge the significance of scientific research by using several indicators, such as the *impact factor* and the *H-index*.<sup>3</sup> Reviewers and policymakers are increasingly using these indicators to evaluate the research impact because these are more objective than a peer review.<sup>3</sup> There may be confusion over how bibliometric indicators function, which causes assessors to use them incorrectly. The most typical error is probably to gauge the significance of an article published in a journal by its impact factor, which is not

TABLE 2  
Terms Related to the Meniscus and Their First Appearance in Titles

Term	First Appearance	Number of Appearances	Comment
Medial meniscus	1928	784	641 articles published from 2006
Cyst	1928	337	Average of 7.5 publications per year from 2006
Meniscectomy	1946	952	At least 20 publications per year from 2011; 54 published in 2022
Lateral meniscus	1946	585	456 articles published from 2006
Discoid	1946	471	>20 publications per year from 2015
ACL, anterior cruciate	1958	2242	>50 publications from 2009 and >100 from 2015; 218 published in 2022
Lateral meniscectomy	1963	36	<10 publications are seen per year throughout
Arthroscopy	1970	570	Between 10 and 30 publications from 2008 with an average of 16.6 per year from 2008
Repair	1974	1406	102, 127, 113, and 144 in years 2019 to 2022, respectively
Transplantation	1974	465	At least 20 publications per year from 2014; 39 published in 2022
Meniscus, bucket handle	1975	49	<10 publications a year
Medial meniscectomy	1978	94	<10 publications are seen per year throughout
Meniscomfemoral	1990	58	<5 publications a year
Extrusion	1991	232	>20 publications every year from 2018
Scaffold	1992	180	At least 10 articles published from 2018
Root	2002	514	At least 20 publications per year from 2014; 85 published in 2022
Stem cell	2003	121	Average of 10.22 articles every year from 2014
Ramp	2011	92	At least 20 publications per year from 2020
PRP	2013	8	1 or 2 every year

truly correct, as only a smaller percentage (10-30%) of the papers published in a journal receive the majority of the citations (“skewed publications”) that a journal receives to establish its impact factor.<sup>30,31</sup>

Comparing the values of typical bibliometric metrics across disciplines, such as the impact factor or an author’s H-index, is another error, as huge disparities in the number of citations exist among various subject fields.<sup>3</sup> A third frequent error made by assessors is failing to account for time. Not only do citations take time to build up but they also keep building up over time. Studies have indicated that for bibliometric indicators to be trustworthy, manuscripts must have accumulated enough citations for at least 2 to 3 years after publication.<sup>1</sup> This implies that at least 2 years should have passed since the publication of the most current studies included in any institutional evaluation using bibliometric markers.<sup>38</sup>

### Recent Trends in Meniscus Surgery

As recently as 2012, the consensus was that “partial meniscectomy is managed for the majority of other types of meniscal tears that are degenerative, significantly traumatized, and/or located in an avascular area of the meniscus” and that “as a result of biologic issues and technical limitations, repair of the meniscus is indicated for unstable, peripheral vertical tears”.<sup>5</sup> However, more forms of meniscus tears can now be repaired because of recent advances in technology and a deeper understanding of tear patterns. Currently, older patients and more complicated tear

patterns have been included in the indications for meniscus repair.<sup>39</sup> This is reflected in the changes seen in our word-cloud findings.

Recent articles have analyzed the surgical technique and clinical outcome of meniscus transplantation. Although a meniscectomy is a successful surgery, some people experience early postmeniscectomy knee pain. This is because the knee is typically susceptible to OA changes over time.<sup>4</sup> When conservative treatments fail, these patients have a variety of surgical choices. One of these options is a meniscal allograft, although there may be some disadvantages, such as complete removal of the remaining healthy meniscal tissue, more difficult surgery, the need for bone tunnels for fixation, factors related to donor compatibility, and potential difficulties in graft procurement.<sup>4</sup> Concerns about disease transmission and immunological reactivity are also raised by the transplantation of live cells into an allograft. However, the outcomes are encouraging.

Recent trends in the meniscus appear to be on topics such as ramp lesions, meniscus root repair, and meniscus allograft transplantation. The keywords related to these terms were not prominent when the word clouds from the 2000s and before 1981 were compared, and “osteoarthritis” has also appeared more prominently in the word cloud in the past 5 years, indicating that research on OA is closely linked to the meniscus.

Meniscus repair has undergone significant advancements over the past 2 decades. If the repairs are biologically enhanced, success rates may be higher. Although trials using fibrin clots, platelet-rich plasma, and stem



cells have shown encouraging results, further research is required to establish superiority.<sup>39</sup> In Europe and many other parts of the world, partial meniscus replacements are becoming popular. Synthetic complete meniscus replacements are the next stage in this progression.<sup>39</sup> The middle-aged patient with moderate arthritis who has postmeniscectomy pain in a knee but is too advanced for a meniscus transplant but too early for a partial knee arthroplasty may benefit from this to target 1 particularly problematic group.<sup>4</sup> A medial meniscus implant intended to replace a missing meniscus is soon to be used in the US.<sup>27</sup> The implant's objective is to restore load distribution across the knee joint, which should help prevent additional articular cartilage deterioration. An animal model has proven chondroprotective characteristics.<sup>27</sup>

### Limitations

There are several limitations to this study. The analysis was performed using terms from the titles only. This has the limitation that if a particular term is not included in the title, it will not be picked up in the analysis. Standardization of the titles of manuscripts, such as systematic reviews and RCTs, has been a recent stipulation and has not been uniformly followed by authors and publishers; hence, some data may be omitted. In addition, the articles analyzed also included articles from veterinary journals. We did not make any effort to separate veterinary publications since most of the basic sciences work on the meniscus was done on animals, and some of these articles may have been published in veterinary journals.

The classification of articles has been a recent development. The early articles published on this topic may not have been classified according to the current standards and, hence, may not have been included in the early articles. In addition, systematic reviews and meta-analyses were not performed in the early days and were recent developments.

We included most of the data for this bibliometric study from PubMed, and only limited data about the top 10 universities, countries, and types of publications were taken from Scopus. However, there is no single definitively superior database, and we chose 1 of the most widely used databases. Citations are a dynamic entity, and as such, our search and article reflect the picture of the day, and a search on a later date may produce a different set of articles or the citation number may vary. Finally, another limitation concerns the level of evidence and quality of articles; even though 1 paper is cited frequently, it could be a level 5 paper.

### CONCLUSION

The results of this bibliometric analysis indicated that there has been a steady growth in the number of meniscus-related publications since the first study in 1928, with an upsurge of publications seen after 2005. According to overall number of citations, the top 3 first

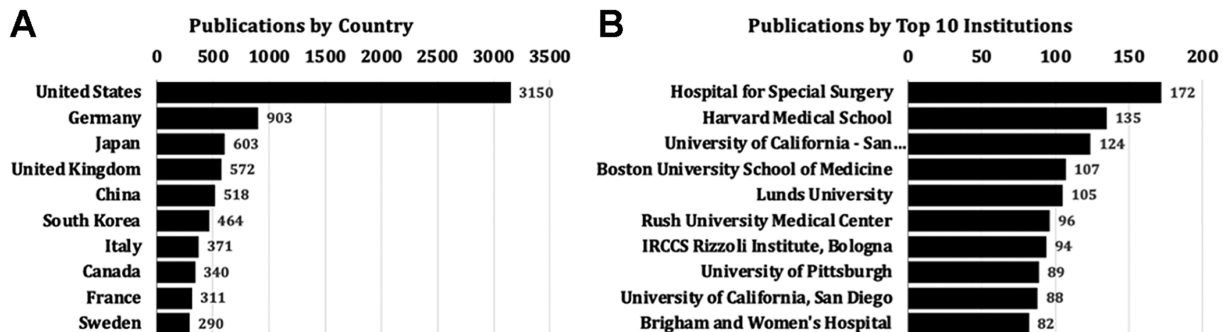
authors were Noyes, Englund, and Lohmander, and the top 3 journals were *AJSM*, *Arthroscopy*, and *KSSTA*.

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## APPENDIX



Appendix Figure A1. Top 10 meniscus-related publications according to (A) country and (B) institution.