



## Systematic Review

## Unicondylar Knee Arthroplasty: A Bibliometric Analysis of the 50 Most Commonly Cited Studies

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## ABSTRACT

**Background:** Unicondylar knee arthroplasty (UKA) is an accepted treatment option for unicompartamental femorotibial degeneration and is gaining in popularity. The goal of this review is to evaluate the top 50 most cited articles pertaining to UKA to better help surgeons understand the trends, identify influential articles, and navigate this body of literature more effectively.

**Methods:** The Institute for Scientific Information Web of Knowledge database was used to identify all articles related to UKA. The initial screening was based on the number of citations for each article. The list was then refined to include only peer-reviewed original articles, review articles, or editorials. Data were extracted from the articles to rank the articles in the descending order from the most citations to the least.

**Results:** Initial search yielded 1844 articles. Fifty were identified to match the study criteria. The highest ranked article was cited a total of 463 times, whereas the lowest ranked article was cited 101 times. The average total number of citations per publication was 162. The earliest article on the list was published in 1978. The majority of publications assessed long-term outcomes of UKA ( $n = 6$ , 52%). The majority of articles were graded a level of evidence of III ( $n = 21$  42%), whereas only 3 articles were graded a level I. **Conclusions:** This review provides a quantitative analysis of the most-cited literature pertaining to UKA, which has a paucity of level I studies.

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## Introduction

Osteoarthritis (OA) remains a prevalent disease in the United States, with symptomatic knee OA occurring in 10% of men and 13% of women in patients aged 60 years or older [1]. Total knee arthroplasty (TKA) is a well-accepted treatment for end-stage OA in patients who have failed conservative treatment. When treating end-stage unicompartamental femorotibial degeneration, unicondylar knee arthroplasty (UKA) may present an alternative treatment modality, but widespread clinical use of UKA has been curbed by limited indications, technical difficulties, and lack of familiarity with the procedure among orthopaedic surgeons [2].

However, over the past decade, the interest for UKA has increased, and there has been more research activity regarding UKA. This is related to improved implant design, advancement in surgical techniques, the use of navigation and robotic assistance, and the fact that the procedure is less invasive and preserves the uninvolved femorotibial compartment when compared with TKA [3]. In addition, the ability to retain all nearby ligaments results in a more normal physiologic feeling to the patient compared with current TKA designs, furthering current interest [4].

To generate a better understanding of the body of literature surrounding UKA, a bibliometric, also known as scientometric, analysis can be used. Bibliometric analysis is a common study tool used within the medical community that quantifiably ranks the top scientific articles in a specific medical sector. Using such an analysis allows researchers improved access to the most influential articles in a certain field, where one can better understand trends in a certain topic and assess the quality of available literature.

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A review of the literature reveals no prior bibliographic analysis regarding the research surrounding UKA. A recent article ‘Trends in Unicompartamental knee arthroplasty’ attempts to evaluate the trends in the available literature on UKA, but this study is not a bibliometric analysis and does not evaluate the quality of the data available or identify influential articles on the topic [5]. Given the rising interest in UKA, the goal of this review is to conduct a bibliometric analysis of UKA to identify the 50 most prominent studies discussing UKA. The authors have performed a comprehensive bibliometric analysis to identify trends and the most influential articles published about UKA.

## Methods

The Institute for Scientific Information Web of Knowledge database (also known as the Web of Science Core Collection, MEDLINE, BIOSIS Citation Index, Scielo Citation Index, KCI-Korean Journal Database, and Russian Science Citation Index) was used to conduct a search for articles pertaining to UKA. Our query was conducted in February of 2020 with multiple Boolean operative combinations by 2 independent reviewers (R.Y. and D.N.G.). The Boolean operative that yielded the largest search results was [(unicompartamental OR unicondylar) AND (arthroplasty)].

Our initial screen was not restricted to any particular language, data range, journal, or article type. However, because the authors assumed the query would yield 50 articles that were cited at least 100 times, any article that did not reach 100 citations was automatically removed. Search results were then refined to include only peer-reviewed original articles, review articles, or editorials, which were subsequently sorted by the descending number of total citations. Articles were included regardless of their level of evidence (LOE) so long as they matched our initial search criteria. To be included for further analysis, all publications must have pertained to UKA, and articles were thus screened by title and abstract to ensure our data set only pertained to UKA. Articles were excluded if the primary focus was not UKA.

Based on these criteria, 2 independent authors (R.Y. and D.N.G.) conducted a separate search and subsequently screened the articles from their respective searches. Both lists were then compared and discussed, with a final list of included articles compiled by the first author (R.Y.) and verified by the senior author (V.H.H.). Articles that were included in the final list were further reviewed. Data extracted from these articles included the following: the manuscript title, first author, total citation count, year of publication, citation density since publication, current citation rate since 2013, journal, country of origin, and LOE. If 2 articles had the same number of citations, the citation density since publication was used as a tiebreaker. The LOE was determined via the Oxford evidence-based medicine levels of evidence.

After individual review of each article, articles were then placed into a thematic category, which included (1) anatomy and biomechanics, (2) general long-term survivorship of greater than 5 years, (3) imaging, (4) outcomes of specific surgical techniques, (5) outcomes when directly compared with TKA, (6) cost analysis, and (7) epidemiology and demographics. We opted to categorize how each article assessed outcomes based on the research question the authors attempted to address.

## Statistics

To test the distribution of individual variables for normality, the Shapiro-Wilk test was used. Normally distributed data are presented with the mean and standard deviation. One-way analysis of variance was used to test for differences with normally distributed data, whereas the Kruskal-Wallis test was used for skewed data.

The Spearman rank was used to test for correlations among any variables. Statistical significance was set at  $P < .05$ . Microsoft Excel, version 16.33, was used for statistical analysis.

## Results

The initial search yielded 1844 articles, but only 54 publications had more than 100 citations (Fig. 1). Within this cohort, 50 publications were eventually identified pertaining to our search criteria. The publication date range for these 50 publications was from 1978 to 2014. The highest ranked article was cited 463 times, whereas the 50th ranked article was cited 101 times (Table 1). When taking into account all 50 publications, the average total number of citations per publication was 162, whereas the average citation density since the year of publication was 9.3. The average citation rate since 2013 for our cohort was 5.4.

The earliest article on our list was published in 1978 by Laskin et al, which is not much younger than the oldest article in our initial query published in 1975. Most articles were published in the early 2000s (48%), followed by the 1990s (26%) (Fig. 2). The 2 most prolific single years of publication were 1998 and 2005, respectively, yielding 4 articles each. The 22nd ranked article had the highest citation density since the year of publication (2014), whereas the top-cited article was published in 1998. Unsurprisingly, the 47th ranked article had the lowest citation density since the year of publication (1979).

A positive correlation  $R = 0.63$  ( $P < .001$ ) was seen between the year published and citation density, while a regression analysis found an  $R^2$  value of 0.4 (Fig. 3a). When addressing the citation rate since 2013, a positive correlation was also seen favoring more recent articles ( $R = 0.42$ ,  $R^2 = 0.18$ ,  $P = .002$ ) (Fig. 3b).

The most prolific countries contributing to these publications were the United States and United Kingdom, contributing to 42% and 32% of publications, respectively (Fig. 4). A total of 8 countries contributed to the articles within our final list.

A total of 9 different journals were represented, with the *Journal of Bone and Joint Surgery* accounting for 27 articles or 54%, followed by *Clinical Orthopaedics and Related Research* with 10 articles, or 20% (Fig. 5). When assessing journal impact by their normalized citation impact (the ratio of the number of citing items per publication to

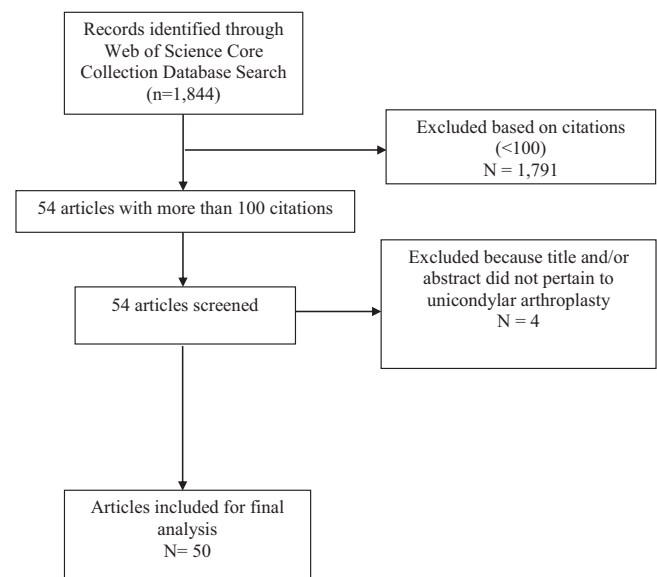


Figure 1. Search methodology.

**Table 1**  
Summary of 50 most cited articles.

Rank	Article	Total citations	Citations/the year of publication until January 2020	Citations since 2013
1	Murray, D.W., J.W. Goodfellow, and J.J. O'Connor, <i>The Oxford medial unicompartmental arthroplasty—A ten-year survival study</i> . Journal of Bone and Joint Surgery-British Volume, 1998. <b>80B</b> (6): p. 983-989.	463	21.05	13
2	Kozinn, S.C. and R. Scott, <i>Current concepts review - unicondylar knee arthroplasty</i> . Journal of Bone and Joint Surgery-American Volume, 1989. <b>71A</b> (1): p. 145-150	323	10.4	10
3	Engh, G.A., K.A. Dwyer, and C.K. Hanes, <i>Polyethylene wear of metal-backed tibial components in total and unicompartmental knee prostheses</i> . Journal of Bone and Joint Surgery-British Volume, 1992. <b>74</b> (1): p. 9-17.	282	10.07	3
4	Berger, R.A., et al., <i>Results of unicompartmental knee arthroplasty at a minimum of ten years of follow-up</i> . Journal of Bone and Joint Surgery-American Volume, 2005. <b>87A</b> (5): p. 999-1006.	268	17.87	12
5	Svard, U.C.G. and A.J. Price, <i>Oxford medial unicompartmental knee arthroplasty - A survival analysis of an independent series</i> . Journal of Bone and Joint Surgery-British Volume, 2001. <b>83B</b> (2): p. 191-194.	266	14	7
6	Price, A.J., et al., <i>Rapid recovery after oxford unicompartmental arthroplasty through a short incision</i> . Journal of Arthroplasty, 2001. <b>16</b> (8): p. 970-976.	239	12.58	12
7	Insall, J. and P. Aglietti, <i>A 5-year to 7-year follow-up of unicondylar arthroplasty</i> . Journal of Bone and Joint Surgery-American Volume, 1980. <b>62</b> (8): p. 1329-1337.	229	5.73	3
8	Newman, J.H., C.E. Ackroyd, and N.A. Shah, <i>Unicompartmental or total knee replacement? Arthritis five-year results of a prospective, randomised trial of 102 osteoarthritic knees with unicompartmental arthritis</i> . Journal of Bone and Joint Surgery-British Volume, 1998. <b>80B</b> (5): p. 862-865.	227	10.32	5
9	Laskin, R.S., <i>Unicompartmental tibiofemoral resurfacing arthroplasty</i> . Journal of Bone and Joint Surgery-American Volume, 1978. <b>60</b> (2): p. 182-185.	225	5.36	3
10	Argenson, J.N.A., Y. Chevrol-Benkeddache, and J.M. Aubaniac, <i>Modern unicompartmental knee arthroplasty with cement - A three to ten-year follow-up study</i> . Journal of Bone and Joint Surgery-American Volume, 2002. <b>84A</b> (12): p. 2235-2239.	195	10.83	3
11	Hernigou, P. and G. Deschamps, <i>Alignment influences wear in the knee after medial unicompartmental arthroplasty</i> . Clinical Orthopaedics and Related Research, 2004(423): p. 161-165.	184	11.5	6
12	Pandit, H., et al., <i>Minimally invasive Oxford phase 3 unicompartmental knee replacement RESULTS OF 1000 CASES</i> . Journal of Bone and Joint Surgery-British Volume, 2011. <b>93B</b> (2): p. 198-204.	182	20.2	6
13	Newman, J., R.V. Pydisetty, and C. Ackroyd, <i>Unicompartmental or total knee replacement the 15-year results of a prospective randomised controlled trial</i> . Journal of Bone and Joint Surgery-British Volume, 2009. <b>91B</b> (1): p. 52-57.	182	16.55	15
14	Cartier, P., J.L. Sanouillier, and R.P. Grelsamer, <i>Unicompartmental knee arthroplasty surgery - 10-year minimum follow-up period</i> . Journal of Arthroplasty, 1996. <b>11</b> (7): p. 782-788.	181	7.54	5
15	Goodfellow, J.W., et al., <i>The Oxford knee for unicompartmental osteo-arthritis - the 1st 103 cases</i> . Journal of Bone and Joint Surgery-British Volume, 1988. <b>70</b> (5): p. 692-701.	174	5.44	2
16	Pandit, H., et al., <i>The Oxford medial unicompartmental knee replacement using a minimally-invasive approach</i> . Journal of Bone and Joint Surgery-British Volume, 2006. <b>88B</b> (1): p. 54-60.	171	12.2	1
17	Laurencin, C.T., et al., <i>Unicompartmental versus total knee arthroplasty in the same patient - a comparative-study</i> . Clinical Orthopaedics and Related Research, 1991(273): p. 151-156.	169	5.83	9
18	Price, A.J. and U. Svard, <i>A second decade lifetable survival analysis of the oxford unicompartmental knee arthroplasty</i> . Clinical Orthopaedics and Related Research, 2011. <b>469</b> (1): p. 174-179.	162	18	11
19	Scott, R.D. and R.F. Santore, <i>Unicondylar unicompartmental replacement for osteo-arthritis of the knee</i> . Journal of Bone and Joint Surgery-American Volume, 1981. <b>63</b> (4): p. 536-544.	161	4.13	3
20	Robertsson, O., et al., <i>The routine of surgical management reduces failure after unicompartmental knee arthroplasty</i> . Journal of Bone and Joint Surgery-British Volume, 2001. <b>83B</b> (1): p. 45-49.	160	8.42	0
21	Price, A.J., J.C. Waite, and U. Svard, <i>Long-term clinical results of the medial Oxford unicompartmental knee arthroplasty</i> . Clinical Orthopaedics and Related Research, 2005(435): p. 171-180.	155	10.33	9
22	Liddle, A.D., et al., <i>Adverse outcomes after total and unicompartmental knee replacement in 101 330 matched patients: a study of data from the National Joint Registry for England and Wales</i> . Lancet, 2014. <b>384</b> (9952): p. 1437-1445	154	25.67	24
23	Barrett, W.P. and R.D. Scott, <i>Revision of failed unicondylar unicompartmental knee arthroplasty</i> . Journal of Bone and Joint Surgery-American Volume, 1987. <b>69A</b> (9): p. 1328-1335.	148	4.48	1
24	Scott, R.D., et al., <i>Unicompartmental knee arthroplasty - 8-year to 12-year follow-up evaluation with survivorship analysis</i> . Clinical Orthopaedics and Related Research, 1991(271): p. 96-100.	146	5.03	3
25	Cobb, J., et al., <i>Hands-on robotic unicompartmental knee replacement - A prospective, randomised controlled study of the Acrobot system</i> . Journal of Bone and Joint Surgery-British Volume, 2006. <b>88B</b> (2): p. 188-197.	145	10.36	22

(continued on next page)

Table 1 (continued)

Rank	Article	Total citations	Citations/the year of publication until January 2020	Citations since 2013
26	Hernigou, P. and G. Deschamps, <i>Posterior slope of the tibial implant and the outcome of unicompartmental knee arthroplasty</i> . Journal of Bone and Joint Surgery-American Volume, 2004. <b>86A</b> (3): p. 506-511.	143	8.94	1
27	Marmor, L. <i>Unicompartmental knee arthroplasty - 10-year to 13-year follow-up-study</i> . Clinical Orthopaedics and Related Research, 1988(226): p. 14-20.	140	4.38	1
28	Psychoyios, V., et al., <i>Wear of congruent meniscal bearings in unicompartmental knee arthroplasty - A retrieval study of 16 specimens</i> . Journal of Bone and Joint Surgery-British Volume, 1998. <b>80B</b> (6): p. 976-982.	133	6.05	1
29	Repicci, J.A. and R.W. Eberle, <i>Minimally invasive surgical technique for unicondylar knee arthroplasty</i> . Journal of the Southern Orthopaedic Association, 1999. <b>8</b> (1): p. 20-27.	129	6.14	1
	Berger, R.A., et al., <i>Unicompartmental knee arthroplasty - Clinical experience at 6-to 10-year followup</i> . Clinical Orthopaedics and Related Research, 1999(367): p. 50-60.	125	5.95	3
30	Pennington, D.W., et al., <i>Unicompartmental knee arthroplasty in patients sixty years of age or younger</i> . Journal of Bone and Joint Surgery-American Volume, 2003. <b>85A</b> (10): p. 1968-1973.	124	7.29	5
31	Emerson, R.H. and L.L. Higgins, <i>Unicompartmental knee arthroplasty with the Oxford prosthesis in patients with medial compartment arthritis</i> . Journal of Bone and Joint Surgery-American Volume, 2008. <b>90A</b> (1): p. 118-122.	122	10.17	6
32	Price, A.J., et al., <i>Oxford medial unicompartmental knee arthroplasty in patients younger and older than 60 years of age</i> . Journal of Bone and Joint Surgery-British Volume, 2005. <b>87B</b> (11): p. 1488-1492.	121	8.07	2
33	Riddle, D.L., W.A. Jiranek, and F.J. McGlynn, <i>Yearly incidence of unicompartmental knee arthroplasty in the United States</i> . Journal of Arthroplasty, 2008. <b>23</b> (3): p. 408-412.	120	10	2
34	Furnes, O., et al., <i>Failure mechanisms after unicompartmental and tricompartmental primary knee replacement with cement</i> . Journal of Bone and Joint Surgery-American Volume, 2007. <b>89A</b> (3): p. 519-525.	116	8.92	5
35	Broughton, N.S., J.H. Newman, and R.A.J. Baily, <i>Unicompartmental replacement and high tibial osteotomy for osteoarthritis of the knee - a comparative-study after 5-10 years follow-up</i> . Journal of Bone and Joint Surgery-British Volume, 1986. <b>68</b> (3): p. 447-452.	116	3.41	1
36	Lombardi, A.V., Jr., et al., <i>Is recovery faster for mobile-bearing unicompartmental than total knee arthroplasty?</i> Clinical Orthopaedics and Related Research, 2009. <b>467</b> (6): p. 1450-1457	115	10.45	5
37	Koskinen, E., et al., <i>Unicondylar knee replacement for primary osteoarthritis - A prospective follow-up study of 1819 patients from the Finnish Arthroplasty Register</i> . Acta Orthopaedica, 2007. <b>78</b> (1): p. 128-135.	115	8.85	4
38	Padgett, D.E., S.H. Stern, and J.N. Insall, <i>Revision total knee arthroplasty for failed unicompartmental replacement</i> . Journal of Bone and Joint Surgery-American Volume, 1991. <b>73A</b> (2): p. 186-190.	115	3.97	1
40	Lyons, M.C., et al., <i>Unicompartmental versus total knee arthroplasty database analysis: is there a winner?</i> Clinical Orthopaedics and Related Research, 2012. <b>470</b> (1): p. 84-90.	114	14.25	17
41	Willis-Owen, C.A., et al., <i>Unicondylar knee arthroplasty in the UK National Health Service: an analysis of candidacy, outcome and cost efficacy</i> . Knee, 2009. <b>16</b> (6): p. 473-478.	113	10.27	7
42	Patil, S., et al., <i>Can normal knee kinematics be restored with unicompartmental knee replacement?</i> Journal of Bone and Joint Surgery-American Volume, 2005. <b>87A</b> (2): p. 332-338.	112	7.47	1
43	Lewold, S., et al., <i>Revision of unicompartmental knee arthroplasty - Outcome in 1135 cases from the Swedish Knee Arthroplasty study</i> . Acta Orthopaedica Scandinavica, 1998. <b>69</b> (5): p. 469-474.	112	5.09	0
44	Romanowski, M.R. and J.A. Repicci, <i>Minimally invasive unicondylar arthroplasty: 8-year follow-up</i> . The journal of knee surgery, 2002. <b>15</b> (1): p. 17-22.	110	6.11	0
45	Koskinen, E., et al., <i>Comparison of survival and cost-effectiveness between unicondylar arthroplasty and total knee arthroplasty in patients with primary osteoarthritis - A follow-up study of 50,493 knee replacements from the Finnish Arthroplasty Register</i> . Acta Orthopaedica, 2008. <b>79</b> (4): p. 499-507.	108	9	3
46	Lewold, S., et al., <i>Oxford meniscal bearing knee versus the Marmor knee in unicompartmental arthroplasty for arthrosis - A Swedish multicenter survival study</i> . Journal of Arthroplasty, 1995. <b>10</b> (6): p. 722-731.	108	4.32	2
47	Marmor, L., <i>Marmor modular knee in unicompartmental disease - minimum 4-year follow-up</i> . Journal of Bone and Joint Surgery-American Volume, 1979. <b>61</b> (3): p. 347-353.	107	2.6	0
48	Squire, M.W., et al., <i>Unicompartmental knee replacement - A minimum 15 year followup study</i> . Clinical Orthopaedics and Related Research, 1999(367): p. 61-72.	105	5	4
49	Naal, F.D., et al., <i>Return to sports and recreational activity after unicompartmental knee arthroplasty</i> . American Journal of Sports Medicine, 2007. <b>35</b> (10): p. 1688-1695.	102	7.85	7
50	Borus, T. and T. Thornhill, <i>Unicompartmental knee arthroplasty</i> . Journal of the American Academy of Orthopaedic Surgeons, 2008. <b>16</b> (1): p. 9-18.	101	8.42	4

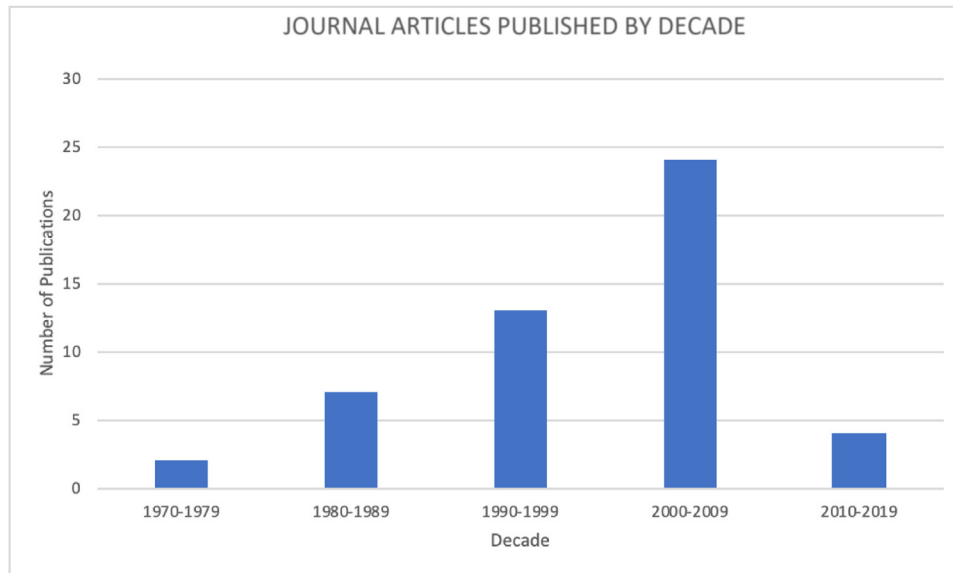


Figure 2. Journal articles published by the decade.

the average citation rate of publications per document type in the same journal and year), articles published within the *Journal of Bone and Joint Surgery* were deemed the most impactful followed by those published in *Clinical orthopaedics and Related Research*, demonstrating that both these journals are responsible for the majority of the most impactful UKA research published (Fig. 6).

The majority of articles were graded with an LOE of III at 21 (42%), whereas only 3 articles achieved level I (Fig. 7a). A total of 3 literature reviews also made our list. When looking at the mean number of citations per LOE, level 1 evidence had the highest total mean, but a one-way analysis of variance showed no significant difference in citations per article among various LOE ( $P = .94$ ) (Fig. 7b).

In terms of topics discussed, the majority of publications assessed long-term unicompartmental outcomes ( $n = 26, 52\%$ ) followed by analysis of specific surgical techniques ( $n = 9, 18\%$ ) and outcomes when directly compared with TKA ( $n = 8, 16\%$ ) (Fig. 8a). If one were to combine all outcome articles regardless of the research question, then the total number of publications is 44 (88%). The remaining publications were classified as follows: cost analysis ( $n = 3$ ), demographics ( $n = 3$ ), and finally anatomy/biomechanics ( $n = 1$ ),

with no articles assessing the imaging technique or strategy. As shown in Figure 8b, long-term outcome articles also garnered the highest number of citations ( $n = 4,259, 52.5\%$ ). The remaining topics based on citation were ordered as follows: surgical technique outcomes ( $n = 1,437, 17.7\%$ ), outcomes directly compared with TKA ( $n = 1,400, 17.2\%$ ), cost analysis ( $n = 544, 6.7\%$ ), demographics ( $n = 365, 4.5\%$ ), and anatomy/biomechanics ( $n = 112, 1.4\%$ ). When looking at key terms, ‘replacement,’ ‘follow-up,’ ‘unicompartmental arthroplasty,’ and ‘arthroplasty’ were the most common and likely to garner the highest number of citations (Fig. 9).

Finally, only one author, Price et al contributed to 4 or more publications and is subsequently the most prolific author on this list. Eight authors had 2 publications (Berger et al, Hernigou et al, Koskinen et al, Lewold et al, Marmor et al, Newman et al, Pandit et al, and Scott et al).

**Discussion**

UKA is a well-accepted and commonly used treatment in patients with isolated unicompartmental OA who have failed conservative treatment [2]. As the interest in UKA grows, it is

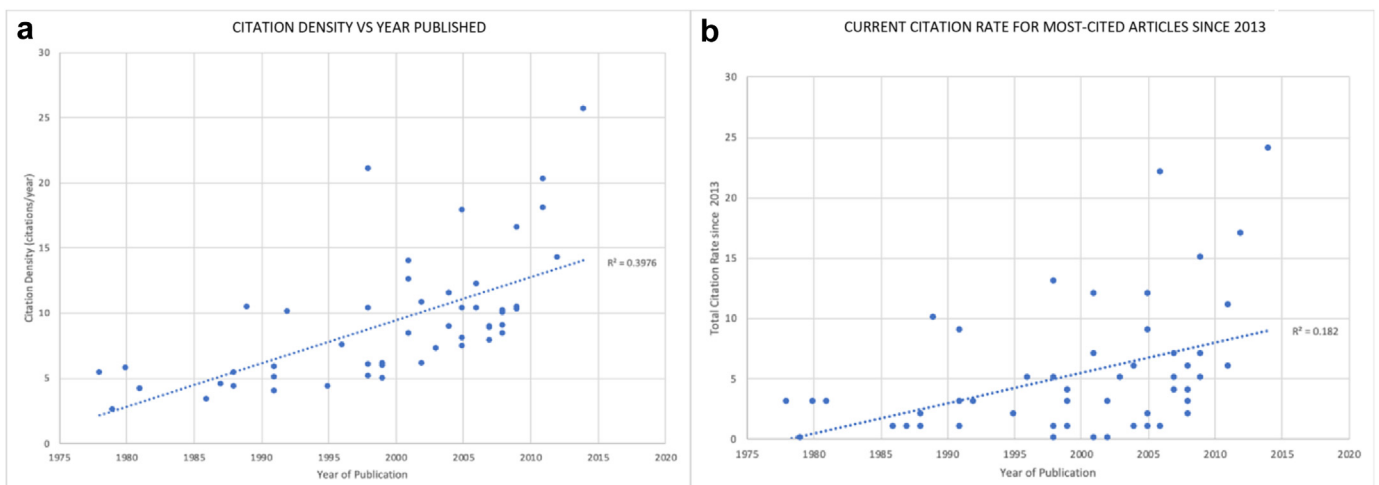


Figure 3. (a) Citation density vs year published. (b) Current citation rate for most-cited articles since 2013.

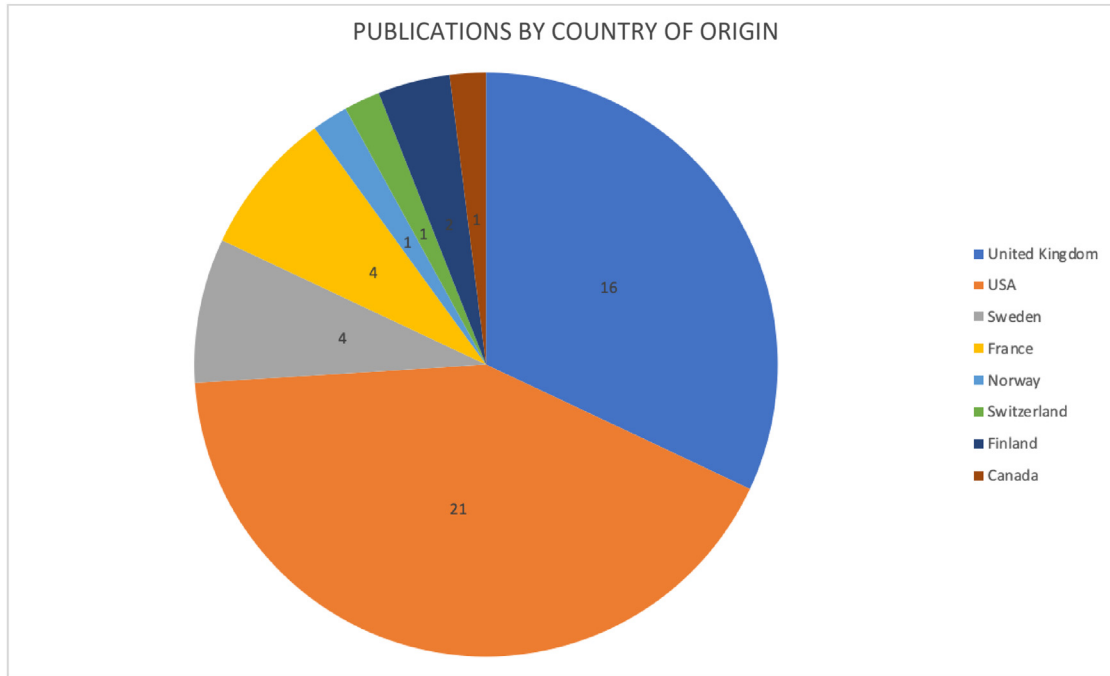


Figure 4. Publications by country of origin.

important to characterize the literature available regarding the field to better identify the 'classic articles' and to identify the milestones in the development of this surgical technique. The literature available in regard to UKA is widely distributed in time with the

earliest article identified in our review published in 1978 and the earliest overall article on the topic published in 1975. This bibliometric analysis allows surgeons, residents, and fellowship programs interested in adding UKA to their tool kit to both quickly

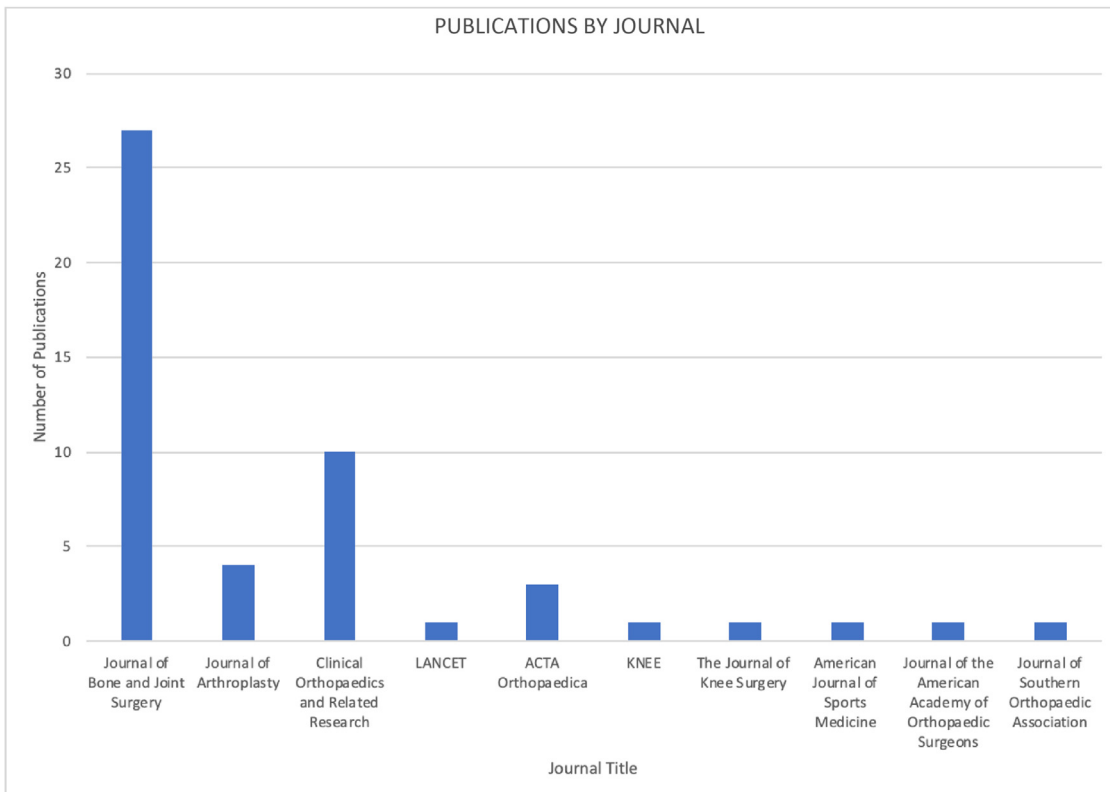


Figure 5. Publications by journal.

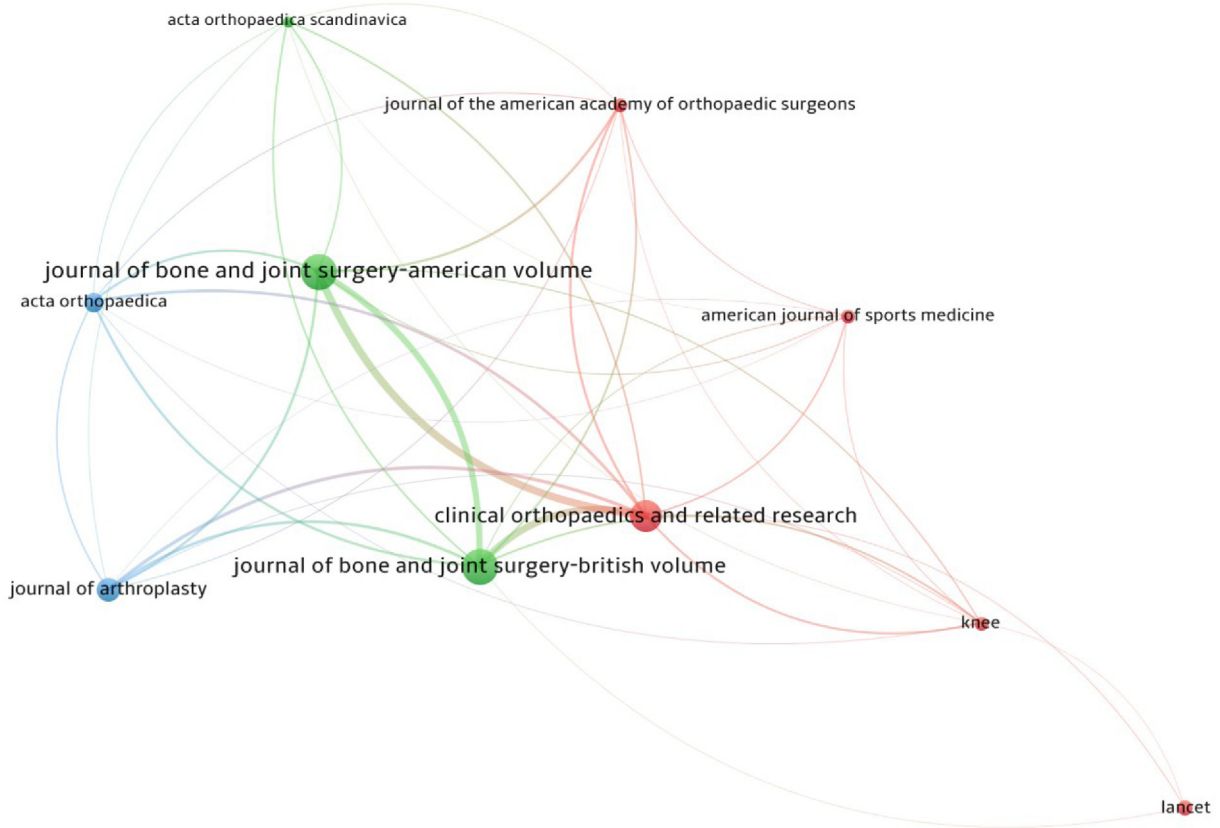


Figure 6. Cosine-normalized map demonstrating journal citation impact.

identify the important articles one should be familiar with while also assisting them in sorting through the vast amount of literature available on the topic. This analysis also helps more experienced surgeons reacquaint themselves with important milestones in the development of UKA.

In our analysis, we found that the most cited articles pertaining to UKA is ‘The Oxford medial unicompartmental arthroplasty—A ten-year survival study’ by Murray et al. This was the first high-quality article to show long-term survival of the oxford mobile-bearing unicompartmental arthroplasty implant [6]. Published in

1998, the authors presented the 10-year survival rate of mobile-bearing unicondylar arthroplasty, concluding that ‘a properly inserted congruous mobile polyethylene bearing can survive for at least 10 years without failure from wear.’ It was also mentioned that the 10-year survival rate was 98%, likely because of stringent selection criteria for surgical candidates. It should be noted that many of these criteria established in 1998 are still being used for UKA presently [6].

Four of the top 5 most cited articles discuss wear properties or long-term survival of the unicondylar arthroplasty implants, calling

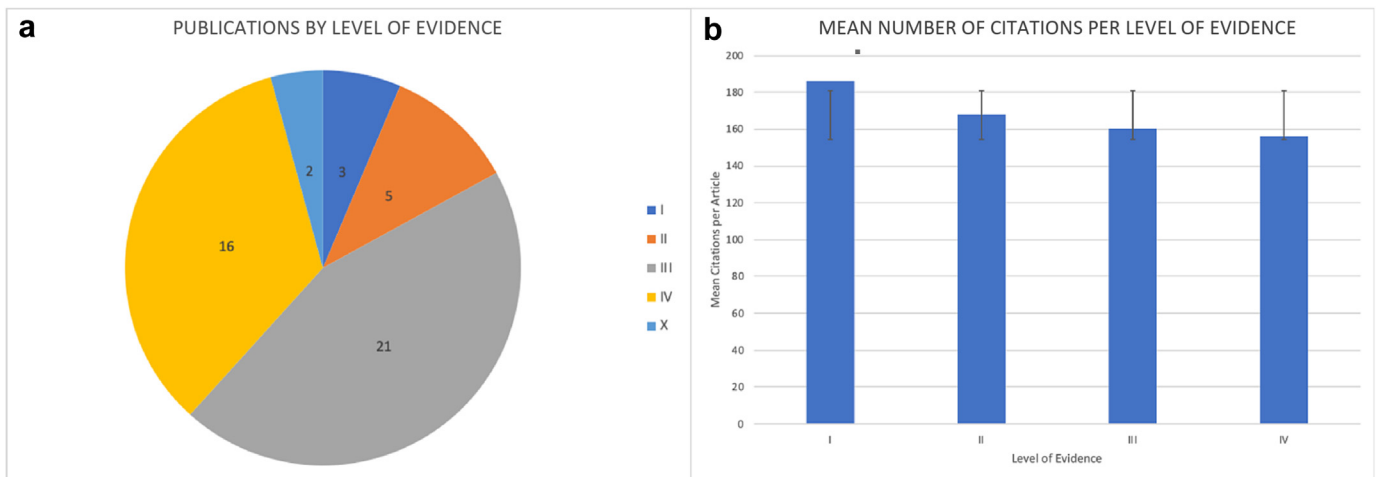
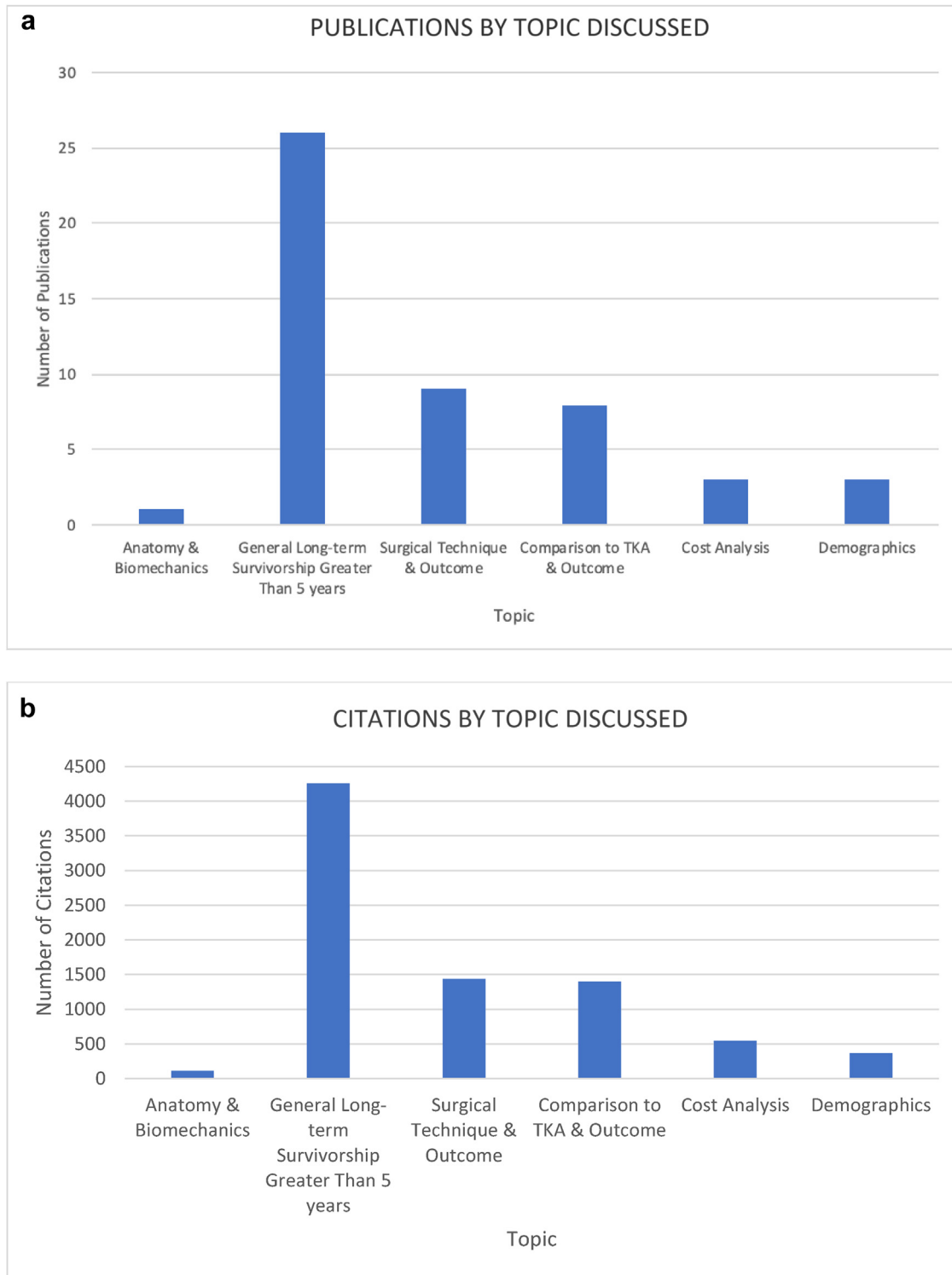


Figure 7. (a) Publications by level of evidence. (b) Mean number of citations per level of evidence.



**Figure 8.** (a) Publications by topic discussed. (b) Citations by topic discussed.

to attention the fact that survival rates and revision rates are a concern for UKA. The most recently published study among the top 5 most-cited studies is 'Results of unicompartmental knee arthroplasty at a minimum of ten years of follow-up.' [7]. This article evaluated 62 patients who underwent UKA using the cemented modular Miller-Galante implants and concluded that the cemented modular unicompartmental knee design was associated with good survival rates at 10 years, both clinically and radiographically. This

article was submitted in 2005, which illustrates the impact it has made in the relative short amount of time it has been in circulation when compared with the other studies in the top 10, a majority of which were published in the 1990s.

Using the total number of citations of an article as a measure of impact can be flawed, as this does not necessarily indicate the publication quality or the level of active clinical use. Although imperfect, this metric does highlight the readership and overall



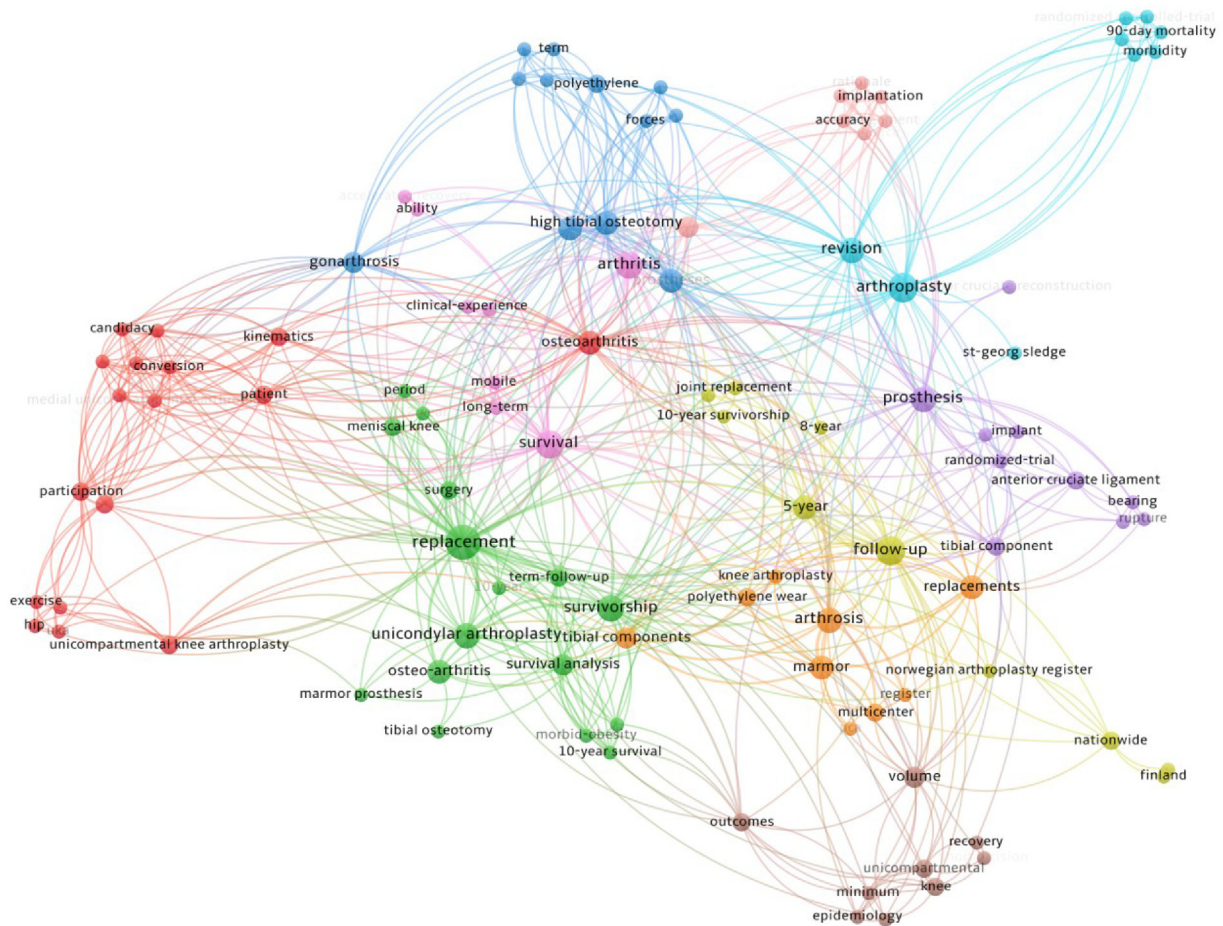


Figure 9. Cosine-normalized map demonstrating key word associations.

influence based on recognition by peers in the field [8–10]. It is important to recognize that more recent publications are at a disadvantage in a bibliographic analysis because of the fact that they simply have not had enough time to accumulate a total number of citations when compared with older articles. We believe this is highlighted in Figure 2, which demonstrates an increasing number of cited articles in each subsequent decade starting from 1970 onward. The exception is the most recent decade, owing to the fact that these articles likely have not had time to reach high total numbers of citations. Looking at Figure 3, it is evident that articles published from 2010 to 2019 have the highest density of citation per year, particularly from 2013 and onward, potentially indicating that the impact of these particular articles is more significant than the ranking by the total number of citations would lead one to believe.

The article ‘Adverse outcomes after total and unicondylar knee replacement in 101,330 matched patients: a study of data from the National Joint Registry for England and Wales’ was published in 2014 and is the most recently published article in our top 50 list. It is also the article with the highest rate of citations per year, 25.67 (Table 1). This is a landmark article comparing the survival rates and complications between UKA and TKA. The authors used propensity scores to match patients who underwent UKA to patients who underwent TKA and demonstrated that UKA had higher revision/reoperation rates at 8-year follow-up but lower complication rates, readmission rates, and mortality rates than TKA. Of note, this is the only publication among our list that was published in *The Lancet* [11].

The journals most commonly represented are the *Journal of Bone and Joint Surgery* followed by the *Journal of Arthroplasty* and the *Clinical Orthopaedics and Related Research*. This is likely due to the fact that the interest in UKA is not limited to a specific subspecialty and is prevalent among general orthopaedists, fellowship-trained joint replacement surgeons, and sports surgeons.

Looking at the LOE of the published articles in our list, there are only 3 level I studies within the top 50 most cited articles on UKA. This is likely due to the fact that the general indications for UKA are very stringent, making it difficult to randomize patients to UKA vs TKA. The first randomized controlled trial (number 8 on our list) that compares UKA and TKA was published in 1998, where 102 matched knees were randomized to either a UKA or TKA. Newman et al. concluded that 5 years after surgery, the UKA group had less perioperative morbidity and shorter hospital stays and regained knee movement more rapidly when compared with the TKA group [12]. The second randomized controlled trial on our list (number 13) was a follow-up study to the first randomized controlled trial and showed that at 15-year follow-up, the early perioperative advantages shown in the UKA group were maintained over a longer period, with no greater failure rate than in the TKA group [13]. The final randomized controlled trial compared robotic Acrobot surgery with a more traditional UKA technique, where the authors demonstrated that the robotic surgical system allowed surgeons to more accurately reproduce the preoperative plan than a traditional UKA procedure [14]. There are only 5 level II studies on the list, with most of the studies being level III or IV, although level I studies are the most impactful and garnered the largest mean number of

citations. The top 5 most cited publications are all level III or IV studies; one of these studies is a review of the literature. This demonstrates that historically, there has been a relative lack of high-quality level I and II studies guiding clinical practice, with focus placed only on a handful of high-quality evidence. It is our belief that there may be more level I and II studies that have been published more recently and are not included in this list because they have not achieved the total level of citations necessary to be part of the top 50 most cited publications.

It is evident from the bibliometric analysis that the overwhelming majority of the articles cited heavily in the literature, and which have subsequently made the most impact in clinical practice, evaluate the long-term survivorship of UKA. Twenty-six of the 50 articles in our list answer a clinical question regarding long-term survivorship. The second most common topic of the study involved the comparison of outcomes among different surgical techniques regarding UKA, and the third most common topic evaluated UKA outcomes in comparison with TKA. These trends highlight that surgeons are most interested in providing a safe, effective implant that performs at least as well in the long term as the gold standard TKA.

### Limitations

There are limitations to conducting a bibliometric analysis that are inherent with ranking articles by the absolute number of citations. Citation numbers, which demonstrate impact and not necessarily quality, can potentially be affected by certain practices such as self-citations or subpublications. Citations can also be adversely affected if published in nonindexed journals, textbooks, lectures, or digital media, which the Institute for Scientific Information Web of Knowledge database does not take into account. Another concern is that novel studies may be cited more frequently than replication studies, which are important for validation of previous findings, although extremely important in the scientific process, may not garner as much attention because of the lack of novelty. Finally, articles that are most often cited may be due to said articles being published for the longest amount of time, whereas potentially impactful articles published more recently may have simply not had enough time to accrue citations.

However, our analysis does alleviate some of these limitations. We do provide an analysis of the LOE in relation to our top 50 list, allowing the reader to see the overall quality of the articles that are cited the most heavily. Validation studies do have the potential to be cited heavily, as seen with 'Results of unicompartmental knee arthroplasty at a minimum of ten years of follow-up,' published years after the first long-term outcome studies were made available. [7]. It is also worth noting that our most heavily cited article is not the oldest, and our inclusion of citation density since the date of publication gives the reader the ability to find the most recent impactful UKA literature.

### Conclusions

The literature landscape surrounding UKA is rapidly changing as the interest and advances regarding UKA grow. This review allows surgeons, fellows, and residents to better understand the historic literature pertaining to this topic. Both practicing surgeons and surgeons in training should be familiar with UKA, as its use is likely to increase in popularity. However, there is a paucity of impactful LOE studies on this topic, which should prompt clinicians to add higher LOE research. This review can assist future researchers in identifying trends in UKA and help clinicians navigate this body of literature.

### Conflict of interests

V.H. Hernandez is a paid consultant for Stryker, Consensus, and Pfizer and is an International Committee AAHKS voting member; all other authors declare no potential conflicts of interest.

### References

- [1] Zhang Y, Jordan JM. Epidemiology of osteoarthritis. *Clin Geriatr Med* 2010;26(3):355.
- [2] Wilson HA, Middleton R, Abram SG, et al. Patient relevant outcomes of unicompartmental versus total knee replacement: systematic review and meta-analysis. *BMJ* 2019;364:1352.
- [3] Vasso M, Antoniadis A, Helmy N. Update on unicompartmental knee arthroplasty: current indications and failure modes. *EFORT Open Rev* 2018;3(8):442.
- [4] Boniforti F. Medial unicompartmental knee arthroplasty: technical pearls. *Joints* 2015;3(2):82.
- [5] Aydemir AN, Yucens M. Trends in unicompartmental knee arthroplasty. *Acta Ortop Bras* 2020;28(1):19.
- [6] Murray DW, Goodfellow JW, O'Connor JJ. The Oxford medial unicompartmental arthroplasty: a ten-year survival study. *J Bone Joint Surg Br* 1998;80(6):983.
- [7] Berger RA, Meneghini RM, Jacobs JJ, et al. Results of unicompartmental knee arthroplasty at a minimum of ten years of follow-up. *J Bone Joint Surg Am* 2005;87(5):999.
- [8] Cheek J, Garnham B, Quan J. What's in a number? Issues in providing evidence of impact and quality of research(ers). *Qual Health Res* 2006;16(3):423.
- [9] Garfield E. Citation analysis as a tool in journal evaluation. *Science* 1972;178(4060):471.
- [10] Lefaivre KA, Shadgan B, O'Brien PJ. 100 most cited articles in orthopaedic surgery. *Clin Orthop Relat Res* 2011;469(5):1487.
- [11] Liddle AD, Judge A, Pandit H, Murray DW. Adverse outcomes after total and unicompartmental knee replacement in 101,330 matched patients: a study of data from the National Joint Registry for England and Wales. *Lancet* 2014;384(9952):1437.
- [12] Newman JH, Ackroyd CE, Shah NA. Unicompartmental or total knee replacement? Five-year results of a prospective, randomised trial of 102 osteoarthritic knees with unicompartmental arthritis. *J Bone Joint Surg Br* 1998;80(5):862.
- [13] Newman J, Pydisetty RV, Ackroyd C. Unicompartmental or total knee replacement: the 15-year results of a prospective randomised controlled trial. *J Bone Joint Surg Br* 2009;91(1):52.
- [14] Cobb J, Henckel J, Gomes P, et al. Hands-on robotic unicompartmental knee replacement: a prospective, randomised controlled study of the acrobot system. *J Bone Joint Surg Br* 2006;88(2):188.