The Top 100 Most Cited Articles on Anterior Cruciate Ligament Reconstruction

A Bibliometric Analysis

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Background: The concept of anterior cruciate ligament (ACL) reconstruction (ACLR) has become widely accepted, gaining increased attention in recent years and resulting in many research achievements in this field.

Purpose: The aim of this study was to determine which original articles on ACLR have been most influential in this field by identifying and analyzing the characteristics of the 100 most cited articles.

Study Design: Cross-sectional study.

Methods: Articles on ACLR were identified via the Thomson ISI Web of Science database on November 30, 2019. The 100 most cited articles were identified based on inclusion and exclusion criteria. The data extracted from each article for the subsequent analysis included title, date of publication, total citations, average citations per year (ACY), journal name, first author, institutions, themes, level of evidence, and keywords.

Results: The total number of citations was 29,629. The date of publication ranged from 1975 to 2015. A majority of the articles originated from the United States (58%) and were published in the 1990s (32%) and 2000s (48%). The mean ACY was 18.43 ± 9.51. Of the selected articles, nearly one-half were published in the *American Journal of Sports Medicine* (42%). The most prolific coauthor and first author were Freddie H. Fu ($n = 13$) and K. Donald Shelbourne ($n = 5$), respectively. The most productive institution was the University of Pittsburgh (14%). Material comparison (19%) and technique comparison (16%) were the 2 most popular themes. More than one-quarter of articles were level 4 evidence (37%). Moreover, the keywords *ACL*, *ACL reconstruction*, *ACL rupture*, *knee joint*, *knee injuries*, and *human* showed the highest degree of centrality.

Conclusion: By analyzing the characteristics of articles, this study demonstrated that ACLR is a growing and popular area of research, with the focus of research varying through timeline trends. Studies on anatomic reconstruction and biomechanics might be areas of future trends.

Keywords: anterior cruciate ligament; ACL; reconstruction; bibliometric analysis; knee; most cited articles; citations

The anterior cruciate ligament (ACL) is the most commonly injured ligament in the knee. Treatment for ACL injuries has evolved from nonoperative treatment, to extracapsular augmentation and primary ligament repair, to ACL reconstruction (ACLR).[14,15] ACL surgery has progressed from the first repair by Mayo-Robson in 1895 to the first recorded reconstruction using a free strip of iliotibial band by Grekow in 1914.[39] Surgeons experimented with various tissue grafts in the subsequent 50 years. In this period, a large number of innovative surgical techniques were produced given the unsatisfactory efficacy of existing techniques. A better understanding of spatial arrangement and functional behavior of different ACL bundles combined with improved knowledge of biomechanics and kinematics led to the development of modern ACLR in the latter half of

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the 20th century.[39] Since then, ACLR has matured from open arthrotomy to minimally invasive arthroscopic procedures.[40] In the United States, the incidence of ACLR per 100,000 person-years increased from 61.4 in 2002 to 74.6 in 2014 (a 22% increase); in particular, adolescents had the greatest absolute increases.[19] The concept of ACLR became widely accepted and has gained increased attention in recent years, resulting in a plethora of research in this field.

Synthesizing past research is an essential ingredient in advancing each specific line of research. Bibliometric analysis is a helpful tool to map publications in a particular research area, and it is being increasingly used across various research fields.[18,46,50] In contrast to narrative literature reviews, which are susceptible to the prejudice of researchers,[17] bibliometric analyses use quantitative analysis and statistics to evaluate and estimate the structure and development of scientific disciplines.[32]

In the past several years, bibliometric analysis has been used to determine which published articles are the most often cited; some researchers have assessed ACL injuries,[17] whereas others have attempted to demonstrate the trends in published literature in the past decade.[49] The 100 most cited articles on ACLR between 1950 and November 2019 remain to be elucidated. In this study, we analyzed data from the 100 most cited articles on ACLR, describing the characteristics of articles, providing a reference for better comprehending the worldwide research, and highlighting potential directions for future research on ACLR.

METHODS

Collection and Allocation of Articles

We searched for all relevant articles on ACLR by using the Thomson ISI Web of Science database including Web of Science Core Collection, MEDLINE, KCI-Korean Journal Database, Russian Science Citation Index, BIOSIS Citation Index, and SciELO Citation Index. Two researchers (N.T. and W.Z.) independently identified articles for inclusion to enhance the search sensitivity. The search terms were "anterior cruciate ligament reconstruction" OR "ACL reconstruction" OR "ACLR" OR "reconstruction of anterior cruciate ligament."

The search was performed on November 30, 2019, and yielded 17,146 results in total, which contained all articles published since 1950. Filtering the search results via "journal articles" resulted in 15,667 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 <120 citations were excluded to reduce the workload. This resulted in 523 publications included for analysis. After review, the title and abstract of each article were categorized by 2 independent investigators (N.T. and W.Z.) based on the inclusion criteria. The categories were (1) basic science, animal research, anatomic studies, and clinical trials that were relevant to any aspect of ACLR; (2) epidemiologic, prognostic, diagnostic, therapeutic, and rehabilitation studies of ACLR; (3) registry data related to ACLR; (4) and articles researching grafts or tissue engineering related to ACLR. Duplicates were removed, and any disagreements were discussed between 2 authors (N.T. and W.Z.) until a consensus was reached. After the review of all included studies, 319 articles remained. These articles were arranged according to number of citations, and the top 100 most cited articles were included in the final analysis (Figure 1).

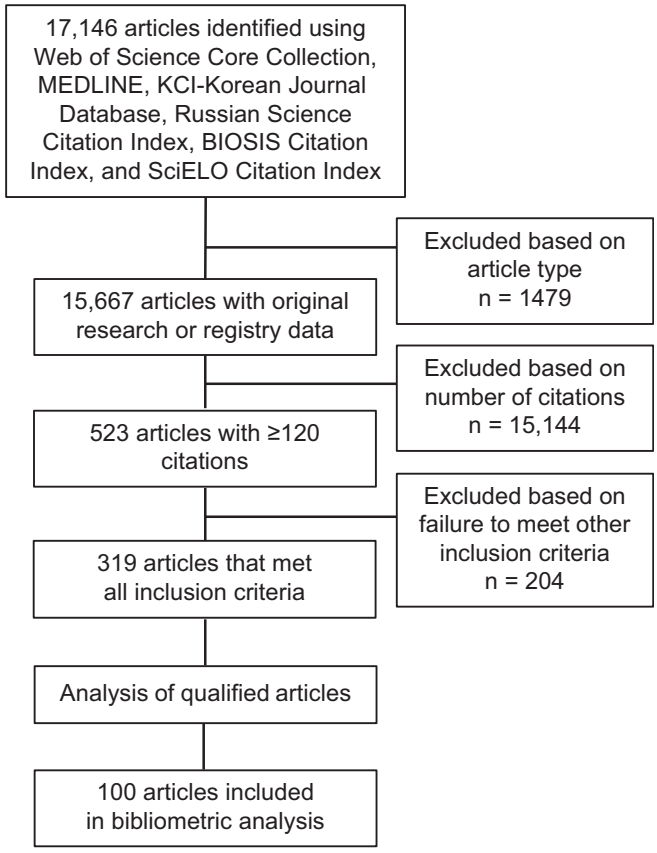

Figure 1. Flowchart illustrating the procedure of allocation of articles.

Data Extraction

All of the selected articles were reviewed independently by the same 2 authors as above. The following information was listed for all articles: title, first author's name, journal name, year of publication, impact factor of the journal in 2018, total number of citations of the article, average citations per year, geographic origin, institutions, research theme, level of evidence, and keywords.[4]

Statistical Analysis

Normality of individual variables was tested using the Shapiro-Wilk test. Comparison between means was made using 1-way analysis of variance (ANOVA). Time-dependent trends were tested using the Mann-Kendall trend test. Correlation between variables was determined

TABLE 1
Top 10 Articles With the Largest Number of Average Citations Per Year[a]

Rank	Study	Citations	Citation Rank	ACY
1	Mall et al,[29] *Am J Sports Med* (2014)	258	52	51.60
2	Sonnery-Cottet et al,[44] *Am J Sports Med* (2015)	200	88	50.00
3	Paterno et al,[34] *Am J Sports Med* (2010)	440	10	48.89
4	Paterno et al,[33] *Am J Sports Med* (2014)	197	93	39.40
5	Altman et al,[1] *Biomaterials* (2002)	662	4	38.94
6	Frobell et al,[12] *N Engl J Med* (2010)	345	22	38.33
7	Yagi et al,[47] *Am J Sports Med* (2002)	646	5	38.00
8	Magnussen et al,[28] *Arthroscopy* (2012)	232	68	33.14
9	Pinczewski et al,[35] *Am J Sports Med* (2007)	374	15	31.17
10	Ardern et al,[2] *Am J Sports Med* (2011)	249	58	31.13

[a]ACY, average citations per year.

using Spearman rank or Pearson product-moment tests, and $P < .05$ was considered statistically significant. Analysis was performed via IBM SPSS Statistics, Version 20.0 (IBM Corp). A total of 11 articles did not include keywords, and the remaining 89 articles were analyzed using network analysis. Network analysis was performed by use of Ucinet for Windows, Version 6.212.[6]

RESULTS

The 100 most cited articles arranged by citation rank are shown in Appendix Table A1. The total number of citations was 29,629 (mean [SD] = 296.29 [123.27]), including 3584 citations (398.22 [189.91]) before 1990, 9724 citations (303.97 [128.62]) in the 1990s, 13,594 citations (398.22 [189.91]) in the 2000s, and 2727 citations (247.91 [77.94]) in the 2010s. Of note, 5 articles were cited >500 times.

Characteristics of the Top 10 Most Cited Articles

The top 10 most cited articles by average citations per year (ACY) are listed in Table 1. The number of ACY ranged from 51.60 to 31.13. Most of these articles (n = 7) were published in the 2010s. The mean number of total citations was 360.3, and the mean citation rank was 41.5.

The article with most overall citations (n = 859) involved the anatomic features of the ACL and was published in *Clinical Orthopaedics and Related Research* in 1975 by Girgis et al.[16] This cadaveric study demonstrated that the ACL consisted of an anteromedial band and a posterolateral band. The second top-cited article was by Rodeo et al[36] and was published in the *Journal of Bone and Joint Surgery–American Volume (JBJS)* in 1993; it was a biomechanical and histological study on tendon-to-bone healing using a dog model. The third most cited article was published in the most popular journal, the *American Journal of Sports Medicine (AJSM)* by the most productive author, K. Donald Shelbourne, in 1990.[42] This article examined a new method of rehabilitation termed "accelerated rehabilitation." The smallest number of citations in the top 100 articles was 193. The research topics and conclusions of the top 10 most cited articles are presented in Table 2.

Characteristics of the Top 100 Most Cited Articles

The year of publication ranged from 1975 to 2015, and the majority of the articles were published in the 1990s (32%) and 2000s (48%). However, articles published before 1990 and those published after 2010 accounted for 9% and 11%, respectively (Figure 2). The years with the greatest number of articles were 2004 (n = 8) and 2007 (n = 8), followed by 2002 (n = 7). The results showed no time-dependent trend of publication year for these articles when using the Mann-Kendall trend test ($P < .001$). The citation density revealed a trend toward increasing frequency of citations for the more recent articles (Figure 3).

The top 100 most cited articles originated from 12 countries. The country with the greatest number of published articles was the United States (n = 58), followed by Japan (n = 11), Australia and Germany (n = 7 each), and Sweden (n = 6). Finland, Italy, Norway, and the United Kingdom each contributed 2 articles, whereas Canada, France, and New Zealand each contributed 1 article (Figure 4). The majority of the articles were from North America and Western Europe. Japan was the only Asian country to publish articles included in the top 100 citations. In the United States, Pennsylvania was the state that published the most articles (n = 14), followed by California and Ohio (n = 6 each); Indiana (n = 5); Massachusetts and New York (n = 4 each); Michigan (n = 3); and New Jersey, Minnesota, and Illinois (n = 2 each). The remaining states had no more than 1 article in the list.

All of the top-cited articles were published in 14 journals, led by *AJSM* (n = 42), followed by *JBJS* (n = 16), *Arthroscopy* (n = 14), and *Knee Surgery, Sports Traumatology, Arthroscopy* (n = 9). The remainder are described in Table 3.

The most productive research institution was the University of Pittsburgh (n = 14), followed by Hokkaido University (n = 5) and the Cincinnati Children's Hospital Medical Center and the Methodist Sports Medicine Center (n = 4 each). The remaining institutions, according to the number of the most cited articles, are listed in Figure 5.

A total of 11 first authors have published ≥2 publications within the top 100 most cited articles (Table 4). The most prolific first author was K. Donald Shelbourne (n = 5) from the Methodist Sports Medicine Center (Indianapolis, IN). Freddie H. Fu from the University of Pittsburgh (Pittsburgh, PA) was the co-author with the most total publications (n = 13).

TABLE 2
Topics and Conclusions of the Overall Top 10 Cited Articles[a]

Rank	Article	First Author	Topics and Conclusions
1	The cruciate ligaments of the knee joint: anatomical, functional and experimental analysis	Girgis[16]	Cadaveric study demonstrating that the ACL consists of an anteromedial band and a posterolateral band. The geometry of the ACL and its relationship to bony landmarks were also elaborated.
2	Tendon-healing in a bone tunnel: a biomechanical and histological study in the dog	Rodeo[36]	A biomechanical and histological study on tendon-to-bone healing in a dog model. The results demonstrated progressive re-establishment of collagen fiber continuity between the tendon and the bone.
3	Accelerated rehabilitation after anterior cruciate ligament reconstruction	Shelbourne[42]	Study of a new method of rehabilitation called "accelerated rehabilitation." The results indicated that an accelerated rehabilitation program was relatively advantageous in terms of patient satisfaction and compliance and graft viability.
4	Silk matrix for tissue engineered anterior cruciate ligaments	Altman[1]	A silk-fiber matrix was successfully designed to match the complex and demanding mechanical requirements of a native human ACL.
5	Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction	Yagi[47]	Study exploring a new technique for ACLR. Anatomic 2-bundle reconstruction restored knee kinematics more closely to normal than did single-bundle reconstruction.
6	Knee stability and graft function following anterior cruciate ligament reconstruction: comparison between 11 o'clock and 10 o'clock femoral tunnel placement	Loh[27]	Outcomes of ACL graft fixed at the 10- and 11-o'clock positions. The 10-o'clock position more effectively resisted rotatory loads compared with the 11-o'clock position.
7	Abnormal rotational knee motion during running after anterior cruciate ligament reconstruction	Tashman[45]	Differences in 3-dimensional kinematics between the ACL-reconstructed knee and the contralateral, uninjured knee. ACL reconstruction failed to restore normal rotational knee kinematics during dynamic loading.
8	Patellofemoral problems after anterior cruciate ligament reconstruction	Sachs[37]	1-y Follow-up reviewing complications after ACLR. The most prevalent complications were quadriceps weakness, flexion contracture, and patellofemoral pain.
9	A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction	Kurosaka[24]	Study examining the effects of different surgical methods of graft fixation in ACLR. The method of surgical fixation was the major factor influencing the graft's mechanical properties in the immediate postoperative period.
10	Biomechanical measures during landing and postural stability predict second anterior cruciate ligament injury after anterior cruciate ligament reconstruction and return to sport	Paterno[34]	Study that assessed predictors for risk of second ACL injury. Altered neuromuscular control of the hip and knee during a dynamic landing task and postural stability deficits after ACLR were predictors of a second ACL injury.

[a]ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction.

The top-cited articles focused on 12 themes: material comparison (n = 19), technique comparison (n = 16), prognosis (n = 16), anatomy (n = 10), epidemiology (n = 9), surgical techniques (n = 8), histology (n = 6), rehabilitation (n = 6), new techniques (n = 3), surgical materials (n = 3), complications (n = 2), and therapy methods (n = 2) (Figure 6). Of the most cited articles, 35% referred to the comparison of surgical materials or techniques. One-way ANOVA ($P = .107$) showed no significant difference in citations of article based on the themes.

There were 71 clinical articles. The majority of them were level 4 evidence (n = 26; mean ± SD number of citations, 269.85 ± 75.94), followed by level 1 (n = 16; 270.31 ± 43.08), level 2 (n = 15; 293.27 ± 127.72), level 3 (n = 13; 241.23 ± 48.94), and level 5 (n = 1; 258 citations) (Figure 7). No significant difference was found among the levels of evidence using the 1-way ANOVA ($P = .574$).

Keywords of each article (n = 89) were analyzed via network analysis, as demonstrated in Figure 8. The result of the analysis showed that except for *ACL*, *ACL reconstruction*, *ACL rupture*, *knee joint*, *knee injuries*, and *human*, the keywords *patellar tendon graft*, *biomechanics*, *double-bundle*, *follow-up*, and *autografts* had a higher degree of centrality; *biomechanics*, *cadaver*, and *complications* were the highest degree keywords before 2000 (Appendix Figure A1); and *grafts*, *double-bundle*, and

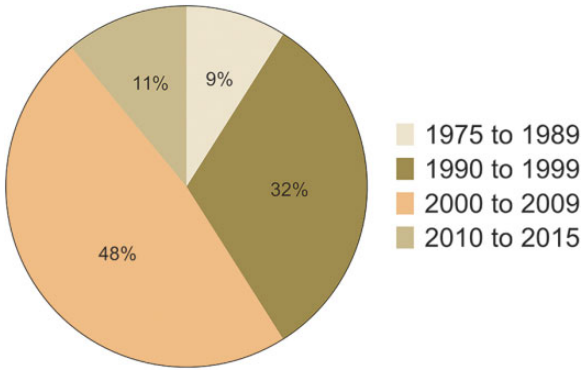

Figure 2. Time distribution of the top 100 most cited articles in anterior cruciate ligament reconstruction.

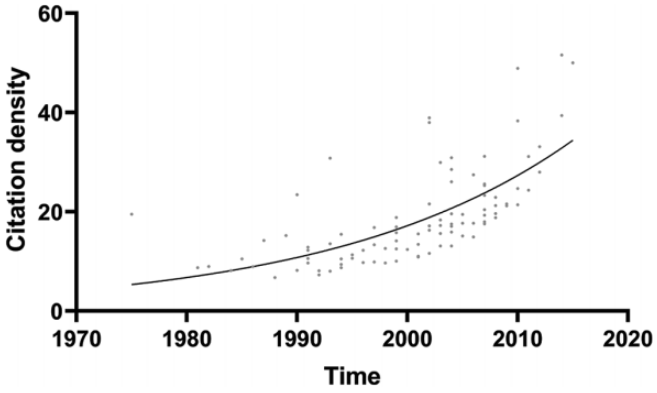

Figure 3. Time-dependent citation density trend.

follow-up were the most popular keywords after 2000 (Appendix Figure A2).

DISCUSSION

The number of citations, which is one of the important bibliometric indicators, is a useful tool to measure the influence of publications,[32] and the methods of bibliometric analysis are various. In this study, we aimed to provide a better understanding of the historical knowledge for surgeons surrounding ACLR. Moreover, our purpose was to determine which original articles in the field of ACLR have played the most important role by identifying and analyzing the characteristics of the 100 most cited articles.

The top 100 articles in the field of ACLR were cited a mean of 296.29 (123.27) times (range, 193-859), which is more than the number of citations in other fields, such as spine deformity (mean, 243),[51] burns (mean, 178),[21] limb prosthetics (mean, 24),[10] and cervical spine surgery (mean, 203).[43] It can be interpreted that ACLR has been studied more frequently than have other topics within the field of orthopaedic surgery.

The majority of articles were published in the 1990s (32%) and the 2000s (49%), but only 9% and 10% were published before 1990 and after 2010, respectively. That the number of articles published before 1990 accounted for only 9% can be explained by a phenomenon known as "obliteration by incorporation," where concepts that originated from an early influential article are absorbed into common knowledge, reducing the citations of the original article.[51] Some researchers consider that the true value of articles cannot be judged until at least 20 years after the date of publication.[3] However, older articles, independent

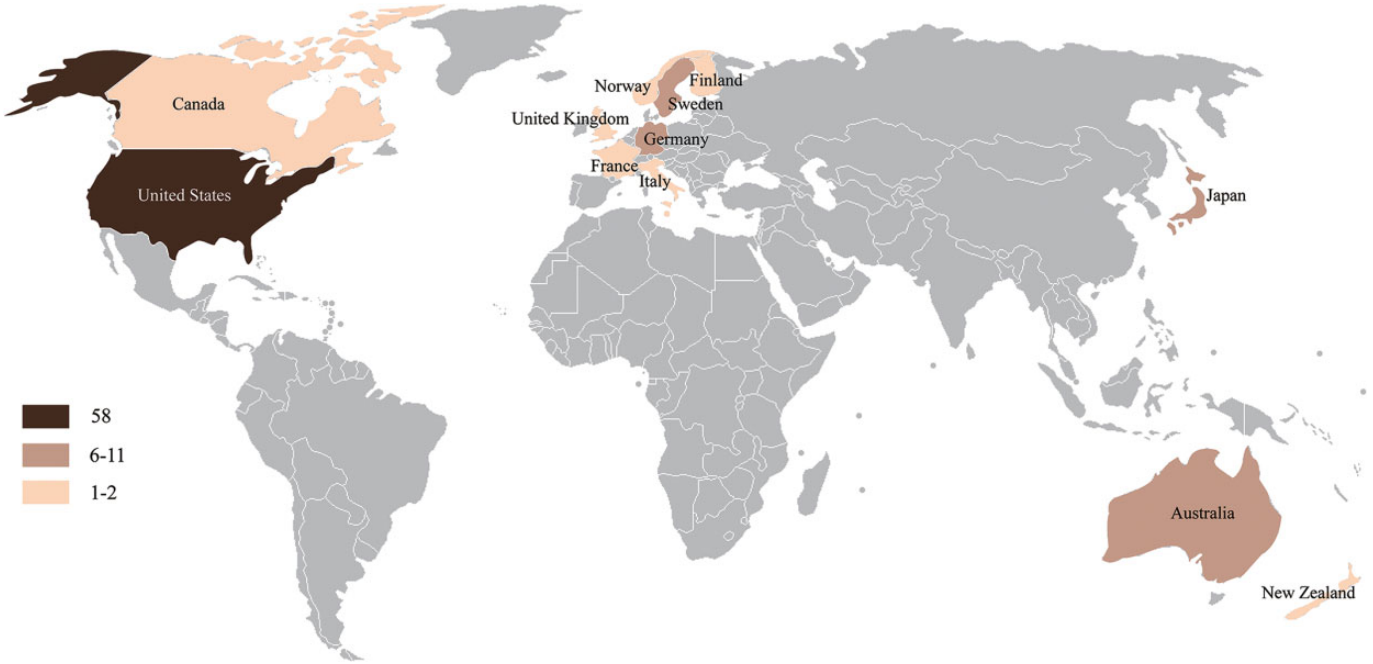

Figure 4. Geographic distribution of the top 100 most cited articles.

TABLE 3
Journals in Which the Top 100 Most Cited Articles Were Published

Journal	Country	Impact Factor (2018)	No. of Articles	No. of Citations
American Journal of Sports Medicine	USA	6.093	42	12,514
Journal of Bone and Joint Surgery–American Volume	USA	4.716	16	4163
Arthroscopy	USA	4.433	14	3959
Knee Surgery, Sports Traumatology, Arthroscopy	Germany	3.149	9	2174
Clinical Orthopaedics and Related Research	USA	4.154	4	731
Journal of Orthopaedic Research	UK	3.043	4	1302
Journal of Bone and Joint Surgery–British Volume[a]	UK	4.301	3	731
Biomaterials	The Netherlands	10.273	2	910
Clinical Biomechanics	UK	1.977	1	274
Clinical Journal of Sport Medicine	USA	2.702	1	196
Journal of Orthopaedic & Sports Physical Therapy	USA	3.058	1	230
New England Journal of Medicine	USA	70.67	1	345
Physical Therapy	USA	3.043	1	245
Sports Health	USA	2.649	1	195

[a]Renamed *Bone & Joint Journal* after 2013.

of their current effect, are cited more frequently, whereas emerging publications often underestimate their influence.[5,11] This can explain the number of articles published in the 1990s and 2000s compared with the 2010s as well as why the most recent article included in our list was published in 2015. Studies published more recently need more time to accumulate citations in order to demonstrate their significance.

A substantial shift is produced when articles are ranked by ACY, and the citation density revealed an increasing trend toward more recent articles being cited more frequently. The majority of the top 10 articles ranked by ACY were published after 2010.

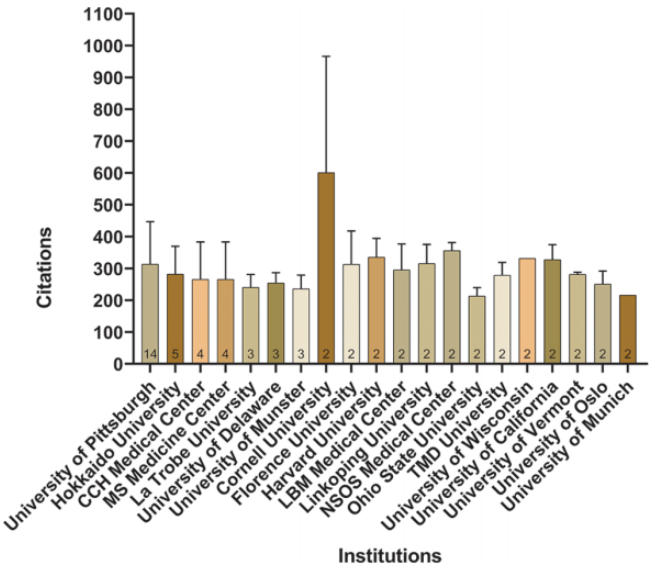

Figure 5. Institutional distribution of all articles (number of articles at bottom of bar). CCH, Cincinnati Children's Hospital; LBM, Long Beach Memorial; MS, Methodist Sports; NSOS, North Sydney Orthopaedic & Sports; TMD, Tokyo Medical & Dental.

We believe that ACY is more reflective of the effect of an article and its influence on future trends. When articles have a high number of citations but a low ACY, this likely results from historical accumulation. The concept of anatomic reconstruction appeared within the past 2 decades, and 1 of the top 10 articles ranked by ACY[47] reported that anatomic reconstruction may produce better outcomes; therefore, anatomic reconstruction may continue to gain popularity in the future. Ligament grafts are scarce, leading to tissue engineering of ACL replacements; however, artificial ligaments have yet to provide acceptable long-term results and may continue to be a research trend in the future. The article with the highest ACY was "Incidence and Trends of Anterior Cruciate Ligament Reconstruction in the United States," published by Mall et al[29] in 2014, which was a descriptive epidemiologic study performed using the National Survey of Ambulatory Surgery and the National Hospital Discharge Survey.

The majority of articles (58%) and journals (64.3%) originated in the United States; this phenomenon is consistent with the fields of total hip arthroplasty,[50] hand surgery,[20] and burns.[21] First, it is accepted that the United States is the most developed country and the leader of various disciplines. Second, US authors are more likely to publish in US journals and usually prefer to cite US articles.[7] Third, reviewers in the United States show a preference for US-based articles.[26]

AJSM was the most popular journal in the 100 most cited articles; 42 articles have been published in the journal, and 2 of these articles have >500 citations. *AJSM* is one of the most well-known and relatively older journals in the field of sports medicine, which may explain why it attracts important articles and receives more citations. The latest impact

TABLE 4
Authors With 2 or More Top-Cited Articles

Author	No. of Articles	Institution	Rank of Articles	Total No. of Citations
K. Donald Shelbourne	5	Methodist Sports Medicine Center, Indianapolis, IN, USA	3, 30, 36, 64, 77	1720
Kazunori Yasuda	3	University of Hokkaido, Sapporo, Hokkaido, Japan	12, 20, 54	1003
Thore Zantop	3	University of Munster, Munster, Germany	41, 66, 99	708
Christopher D. Harner	2	University of Pittsburgh, Pittsburgh, PA, USA	27, 92	513
Scott Tashman	2	University of Pittsburgh, Pittsburgh, PA, USA	7, 80	674
William G. Clancy	2	University of Wisconsin, Madison, WI, USA	25, 26	664
Mark V. Paterno	2	Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA	10, 97	636
Leo A. Pinczewski	2	North Sydney Orthopaedic & Sports Medical Centre, Sydney, New South Wales, Australia	15, 90	572
Paolo Aglietti	2	University of Florence, Florence, Italy	13, 62	626
Lynn Snyder-Mackler	2	University of Delaware, Newark, DE, USA	47, 74	490
Douglas W. Jackson	2	Long Beach Memorial Medical Center, Long Beach, CA, USA	21, 63	591

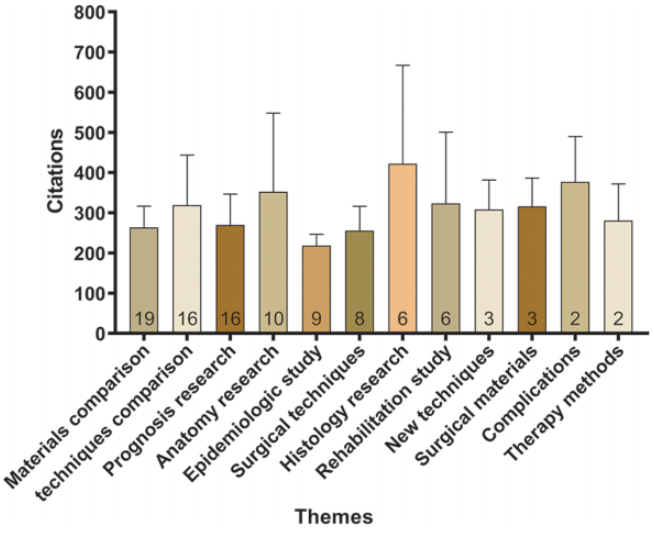

Figure 6. The theme distribution of all articles (number of articles within bottom of bar).

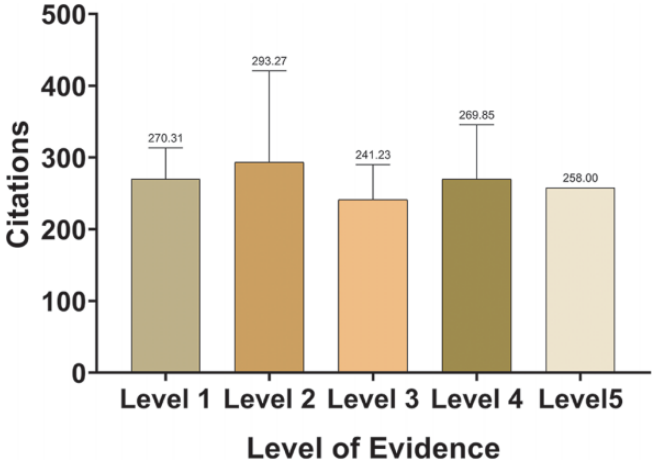

Figure 7. Mean citations per article based on level of evidence.

factor of the *AJSM* at the time of reporting was 6.093 (2018).

The University of Pittsburgh was the most productive research institution, publishing 14 of the 100 most cited articles. Freddie H. Fu was a co-author for all 13 articles, making him the researcher with the most total publications on the top 100 list. Dr Fu and his team have made significant achievements in furthering our collective knowledge about anatomy and biomechanics of the native and reconstructed ACL and have emphasized the importance of individualizing any reconstructive procedure.[40] K. Donald Shelbourne, another pioneer of ACL research, had the most first-author publications (n = 5) of any researcher on the list. His 5 articles, devoted to prognosis and rehabilitation, have collectively been cited 1720 times (mean, 344.00 ± 191.02).

As expected, the most common keywords were *ACL*, *ACL reconstruction*, *ACL rupture*, *knee joint*, *knee injuries*, and *human*. Apart from these keywords, we found that *biomechanics*, *cadaver*, and *complications* were the most frequently used keywords before 2000. However, after 2000, researchers paid more attention to the topics of graft research, double-bundle, rehabilitation, and long-term follow-up.

A knowledge of anatomy is necessary for performing any corrective surgery, and a comprehensive understanding of anatomy is required to obtain competency in any surgical field.[9] Anatomy research based on cadavers was much more common before 2000. Biomechanics was also a trending research topic before 2000, but this topic was featured less often in the top 100 most cited articles after 2000. However, in 2019, Yucens and Aydemir[49] reported that biomechanics was the most popular title word in the past decade. This discrepancy could be explained by cyclical trends in the topics of significance, whereby significant milestone articles are likely to re-emerge in importance. Our analysis of the top 100 most cited articles demonstrated that graft comparison was the trending topic after 2000, and the most

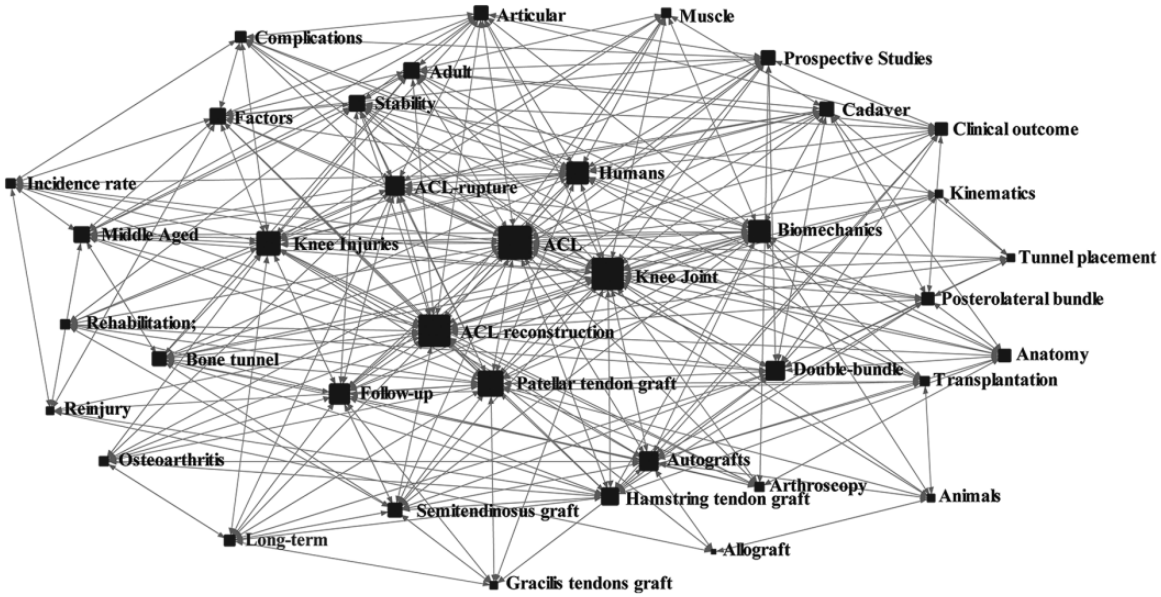

Figure 8. Degree of centrality analysis of keywords in all articles (89 articles had keywords). ACL, anterior cruciate ligament.

popular graft used in research was patellar tendon, followed by hamstring tendon and semitendinosus. However, the trending topic also varied over time, and hamstring tendons have become the most popular graft used in research over the past decade.[49] The concept of double-bundle reconstruction appeared in the past 2 decades so that every article studying double-bundle techniques in this analysis was published after 2000.

Two of the most popular research themes were material comparison (n = 19) and technique comparison (n = 16). There are 6 sharp controversies in the literature:

1. Surgical versus nonsurgical treatment
2. Arthrotomy versus arthroscopy
3. Graft type: autograft, allograft, xenograft, or artificial grafts
4. Autograft type: gracilis, semitendinosus, quadriceps tendon, or patellar tendon
5. Single bundle versus double bundle
6. Isometric versus anatomic reconstruction

Consensus has been reached on the first 2 issues. Although some researchers have considered rehabilitation to be the primary treatment option after an acute ACL tear,[13] one-third of patients with nonsurgical treatment had an ACLR later because of instability. Early ACLR can reduce the risk of secondary meniscal tears and reduce the negative effects of osteoarthritis[23]; there is indirect evidence supporting surgical treatment as advantageous for long-term outcomes.[31] One of the significant achievements in ACL surgery has been the movement from open surgery to arthroscopy. The first arthroscopic ACLR was performed by David Dandy in 1980.[39,40] Since then, arthroscopic ACLR has been embraced by most surgeons, particularly by the end of the 1990s.[40,49]

For the third and fourth issues, it was reported that the risk of ACL graft failure was increased in allograft reconstruction,[22] and the synthetic ligament graft and xenografts may also lead to poor outcome.[40] Therefore, autograft is regarded as the best option in ACLR.[8] Allograft is often reserved for complex primary or revision cases where autologous tissue is unavailable.[40] Surgeons have explored a variety of autologous tissues, involving the patellar, quadriceps, and hamstring tendons; the meniscus; and the cutis.[39] It has been reported that hamstring grafts have been the most preferred grafts in the past decade[39,49]; however, the best autograft remains to be elucidated from these publications.

Regarding the fifth and sixth issues, over the past 2 decades, Freddie H. Fu has emphasized the benefits of anatomic reconstruction and its potential to provide promising short- to medium-term outcome.[40] Additionally, anatomic double-bundle ACLR has shown benefit in preventing osteoarthritis in the long term because this type of reconstruction provides more stable knee joint kinematics compared with single-bundle ACLR.[47] However, Samuelsson et al[38] reported that the differences in outcomes between single-bundle and double-bundle ACLR were observed only in experimental models and not in patients. Hence, the long-term efficacy of anatomic reconstruction and double-bundle reconstruction remains unclear.

Prognosis research was the most popular theme. There were 16 prognosis studies and 6 rehabilitation studies in the 100 most cited articles. With improvements in people's standard of living, patients and surgeons tend to pay more attention to the postoperative prognosis; thereby, some quantifiable standard of prognosis, such as in terms of biomechanics and kinematics, has become essential in recent years to evaluate the consequences of ACLR.

Comprehensive analysis of keywords, title, themes, and other important information in the top 10 articles, in terms of ACY, may provide useful evidence regarding research

trends. Possible trends in the future include anatomic reconstruction and biomechanics.

The level of evidence analysis showed that the majority of articles were level 4 evidence, followed by level 1, level 2, level 3, and level 5. Common sense might suggest that the higher the level of evidence, the higher the number of citations per article; however, we found no significant difference in the citations among different evidence levels. The level 2 studies were cited the most, whereas the level 3 studies ranked lowest in citations. Level 4 studies are mainly case series in evidence-based medicine, which entail research on multiple patients receiving the same therapy but with no comparison group or control group. These studies were more likely to be implemented in clinical practice in the past decades. Moreover, it has been reported that novel treatments or ideas were originally published as observational articles.[48]

There are several limitations of this bibliometric analysis. First, self-citation was not excluded. It has been reported that authors prefer to cite articles from the journal in which they intend to publish.[41] Second, articles with high numbers of citations tend to be considered classic articles,[3,20,30] but the threshold of citations among classic articles is elusive. In this study, the lowest number of citations was 193, and we included only original articles or registry data. Therefore, many excellent articles were excluded because they were reviews or meta-analyses. Third, in the phenomenon known as the "snowball effect," authors prefer to cite articles that already have a large number of citations rather than cite articles for their quality or content.[25,30] Fourth, the results of our network analysis could have been influenced by the 11 articles that did not contain keywords.

CONCLUSION

This article identified and bibliometrically analyzed the top 100 most cited articles on ACLR between 1950 and 2019. By highlighting the authors, institutions, journals, countries, themes, levels of evidence, and keywords, this study has demonstrated that ACLR is an ever-growing and popular research field, with topics of significance that fluctuate over time. Anatomic reconstruction and biomechanics might become research interests in the near future. This article provides insight into the worldwide research trends and potential directions for future research on ACLR.

ACKNOWLEDGMENT

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15. Fu FH, Bennett CH, Ma CB, Menetrey J, Lattermann C. Current trends in anterior cruciate ligament reconstruction, part II: operative procedures and clinical correlations. *Am J Sports Med*. 2000;28(1):124-130.
16. Girgis FG, Marshall JL, Monajem A. The cruciate ligaments of the knee joint: anatomical, functional and experimental analysis. *Clin Orthop Relat Res*. 1975;106:216-231.
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18. He L, Fang H, Wang X, et al. The 100 most-cited articles in urological surgery: a bibliometric analysis. *Int J Surg*. 2020;75:74-79.
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23. Kessler MA, Behrend H, Henz S, Stutz G, Rukavina A, Kuster MS. Function, osteoarthritis and activity after ACL-rupture: 11 years follow-up results of conservative versus reconstructive treatment. *Knee Surg Sports Traumatol Arthrosc*. 2008;16(5):442-448.
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26. Link AM. US and non-US submissions: an analysis of reviewer bias. *JAMA*. 1998;280(3):246-247.
27. Loh JC, Fukuda Y, Tsuda E, Steadman RJ, Fu FH, Woo SL-Y. Knee stability and graft function following anterior cruciate ligament

reconstruction: comparison between 11 o'clock and 10 o'clock femoral tunnel placement. *Arthroscopy*. 2003;19(3):297-304.
28. Magnussen RA, Lawrence JTR, West RL, Toth AP, Taylor DC, Garrett WE. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. *Arthroscopy*. 2012;28(4):526-531.
29. Mall NA, Chalmers PN, Moric M, et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. *Am J Sports Med*. 2014;42(10):2363-2370.
30. Mehlman CT, Wenger DR. The top 25 at 25: citation classics in the *Journal of Pediatric Orthopedics*. *J Pediatr Orthop*. 2006;26(5): 691-694.
31. Meunier A, Odensten M, Good L. Long-term results after primary repair or non-surgical treatment of anterior cruciate ligament rupture: a randomized study with a 15-year follow-up. *Scand J Med Sci Sports*. 2007;17(3):230-237.
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34. Paterno MV, Schmitt LC, Ford KR, et al. Biomechanical measures during landing and postural stability predict second anterior cruciate ligament injury after anterior cruciate ligament reconstruction and return to sport. *Am J Sports Med*. 2010;38(10):1968-1978.
35. Pinczewski LA, Lyman J, Salmon LJ, Russell VJ, Roe J, Linklater J. A 10-year comparison of anterior cruciate ligament reconstructions with hamstring tendon and patellar tendon autograft: a controlled, prospective trial. *Am J Sports Med*. 2007;35(4):564-574.
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40. Schindler OS. The story of anterior cruciate ligament reconstruction, part 2. *J Perioper Pract*. 2012;22(6):189-196.
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42. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1990;18(3):292-299.
43. Skovrlj B, Steinberger J, Guzman JZ, et al. The 100 most influential articles in cervical spine surgery. *Global Spine J*. 2016;6(1):69-79.
44. Sonnery-Cottet B, Thaunat M, Freychet B, Pupim BHB, Murphy CG, Claes S. Outcome of a combined anterior cruciate ligament and anterolateral ligament reconstruction technique with a minimum 2-year follow-up. *Am J Sports Med*. 2015;43(7):1598-1605.
45. Tashman S, Collon D, Anderson K, Kolowich P, Anderst W. Abnormal rotational knee motion during running after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2004;32(4):975-983.
46. Wang Y, Zhang H, Fang R, Tang K, Sun Q. The top 100 most cited articles in rosacea: a bibliometric analysis. *J Eur Acad Dermatol Venereol*. 2020;34(10):2177-2182.
47. Yagi M, Wong EK, Kanamori A, Debski RE, Fu FH, Woo SLY. Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. *Am J Sports Med*. 2002;30(5):660-666.
48. Yan-qing Huo, Xioa-han P, Qing-bo Li, et al. Fifty top-cited classic papers in orthopedic elbow surgery: a bibliometric analysis. *Int J Surg*. 2015;18:28-33.
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50. Zhang W, Tang N, Li X, George DM, He G, Huang T. The top 100 most cited articles on total hip arthroplasty: a bibliometric analysis. *J Orthop Surg Res*. 2019;14(1):412.
51. Zhang Y, Wumaier M, He D, Xiao B, Zhang J. The 100 top-cited articles on spinal deformity a bibliometric analysis. *Spine*. 2020; 45(4):275-283.

APPENDIX

TABLE A1
List of the 100 Most Cited Articles in Anterior Cruciate Ligament Reconstruction[a]

Rank	Paper	Country	ACY	No. of Citations
1	Girgis FG, Marshall JL, Al Monajem ARS. The cruciate ligaments of the knee joint: anatomical, functional and experimental analysis. *Clin Orthop Relat Res*. 1975;106:216-231.	USA	19.52	859
2	Rodeo SA, Arnoczky SP, Torzilli PA, Hidaka C, Warren RF. Tendon-healing in a bone tunnel: a biomechanical and histological study in the dog. *J Bone Joint Surg Am*. 1993;75(12):1795-1803.	USA	30.81	801
3	Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1990;18(3):292-299.	USA	23.45	680
4	Altman GH, Horan RL, Lu HH, et al. Silk matrix for tissue engineered anterior cruciate ligaments. *Biomaterials*. 2002;23(20):4131-4141.	USA	38.94	662
5	Yagi M, Wong EK, Kanamori A, Debski RE, Fu FH, Woo SL-Y. Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. *Am J Sports Med*. 2002;30(5):660-666.	USA	38.00	646
6	Loh JC, Fukuda Y, Tsuda E, Steadman RJ, Fu FH, Woo SL-Y. Knee stability and graft function following anterior cruciate ligament reconstruction: comparison between 11 o'clock and 10 o'clock femoral tunnel placement. *Arthroscopy*. 2003;19(3):297-304.	USA	29.94	479
7	Tashman S, Collon D, Anderson K, Kolowich P, Anderst W. Abnormal rotational knee motion during running after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2004;32(4):975-983.	USA	30.87	463

(continued)

TABLE A1 (continued)

Rank	Paper	Country	ACY	No. of Citations
8	Sachs RA, Daniel DM, Stone ML, Garfein RF. Patellofemoral problems after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1989;17(6):760-765.	USA	15.23	457
9	Kurosaka M, Yoshiya S, Andrish JT. A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction. *Am J Sports Med*. 1987;15(3):225-229.	Japan	14.25	456
10	Paterno MV, Schmitt LC, Ford KR, et al. Biomechanical measures during landing and postural stability predict second anterior cruciate ligament injury after anterior cruciate ligament reconstruction and return to sport. *Am J Sports Med*. 2010;38(10):1968-1978.	USA	48.89	440
11	Gabriel MT, Wong EK, Woo SL-Y, Yagi M, Debski RE. Distribution of in situ forces in the anterior cruciate ligament in response to rotatory loads. *J Orthop Res*. 2004;22(1):85-89.	USA	28.53	428
12	Yasuda K, Kondo E, Ichiyama H, et al. Anatomic reconstruction of the anteromedial and posterolateral bundles of the anterior cruciate ligament using hamstring tendon grafts. *Arthroscopy*. 2004;20(10):1015-1025.	Japan	26.07	391
13	Aglietti P, Buzzi R, Zaccherotti G, De Biase P. Patellar tendon versus doubled semitendinosus and gracilis tendons for anterior cruciate ligament reconstruction. *Am J Sports Med*. 1994;22(2):211-218.	Italy	15.48	387
14	Hamner DL, Brown CH Jr, Steiner ME, Hecker AT, Hayes WC. Hamstring tendon grafts for reconstruction of the anterior cruciate ligament: biomechanical evaluation of the use of multiple strands and tensioning techniques. *J Bone Joint Surg Am*. 1999;81(4):549-557.	USA	18.85	377
15	Pinczewski LA, Lyman J, Salmon LJ, Russell VJ, Roe J, Linklater J. A 10-year comparison of anterior cruciate ligament reconstructions with hamstring tendon and patellar tendon autograft: a controlled, prospective trial. *Am J Sports Med*. 2007;35(4):564-574.	Australia	31.17	374
16	Sakane M, Fox RJ, Woo SL-Y, Livesay GA, Li G, Fu FH. In situ forces in the anterior cruciate ligament and its bundles in response to anterior tibial loads. *J Orthop Res*. 1997;15(2):285-293.	USA	16.82	370
17	Woo SL-Y, Kanamori A, Zeminski J, Yagi M, Papageorgiou C, Fu FH. The effectiveness of reconstruction of the anterior cruciate ligament with hamstrings and patellar tendon: a cadaveric study comparing anterior tibial and rotational loads. *J Bone Joint Surg Am*. 2002;84(6):907-914.	USA	21.59	367
18	Marder RA, Raskind JR, Carroll M. Prospective evaluation of arthroscopically assisted anterior cruciate ligament reconstruction: patellar tendon versus semitendinosus and gracilis tendons. *Am J Sports Med*. 1991;19(5):478-484.	USA	12.89	361
19	Odensten M, Gillquist J. Functional anatomy of the anterior cruciate ligament and a rationale for reconstruction. *J Bone Joint Surg Am*. 1985;67(2):257-262.	Sweden	10.53	358
20	Yasuda K, Kondo E, Ichiyama H, Tanabe Y, Tohyama H. Clinical evaluation of anatomic double-bundle anterior cruciate ligament reconstruction procedure using hamstring tendon grafts: comparisons among 3 different procedures. *Arthroscopy*. 2006;22(3):240-251.	Japan	27.46	357
21	Jackson DW, Grood ES, Goldstein JD, et al. A comparison of patellar tendon autograft and allograft used for anterior cruciate ligament reconstruction in the goat model. *Am J Sports Med*. 1993;21(2):176-185.	USA	13.58	353
22	Frobell RB, Roos EM, Roos HP, Ranstam J, Lohmander LS. A randomized trial of treatment for acute anterior cruciate ligament tears. *New Engl J Med*. 2010;363(4):331-342.	Sweden	38.33	345
23	O'Brien SJ, Warren RF, Pavlov H, Panariello R, Wickiewicz TL. Reconstruction of the chronically insufficient anterior cruciate ligament with the central third of the patellar ligament. *J Bone Joint Surg Am*. 1991;73(2):278-286.	USA	12.25	343
24	Corry IS, Webb JM, Clingeleffer AJ, Pinczewski LA. Arthroscopic reconstruction of the anterior cruciate ligament: a comparison of patellar tendon autograft and four-strand hamstring tendon autograft. *Am J Sports Med*. 1999;27(4):444-454.	Australia	16.95	339
25	Clancy WG Jr, Narechania RG, Rosenberg TD, Gmeiner JG, Wisnefske DD, Lange TA. Anterior and posterior cruciate ligament reconstruction in rhesus monkeys: a histological, microangiographic, and biomechanical analysis. *J Bone Joint Surg Am*. 1981;63(8):1270-1284.	USA	8.74	332
26	Clancy WG Jr, Nelson DA, Reider B, Narechania RG. Anterior cruciate ligament reconstruction using one-third of the patellar ligament, augmented by extra-articular tendon transfers. *J Bone Joint Surg Am*. 1982;64(3):352-359.	USA	8.97	332
27	Harner CD, Goo HB, Vogrin TM, Carlin GJ, Kashiwaguchi S, Woo SL-Y. Quantitative analysis of human cruciate ligament insertions. *Arthroscopy*. 1999;15(7):741-749.	USA	15.80	316
28	Muneta T, Koga H, Mochizuki T, et al. A prospective randomized study of 4-strand semitendinosus tendon anterior cruciate ligament reconstruction comparing single-bundle and double-bundle techniques. *Arthroscopy*. 2007;23(6):618-628.	Japan	25.58	307
29	Yagi M, Kuroda R, Nagamune K, Yoshiya S, Kurosaka M. Double-bundle ACL reconstruction can improve rotational stability. *Clin Orthop Relat Res*. 2007;454:100-107.	Japan	25.33	304

(continued)

TABLE A1 (continued)

Rank	Paper	Country	ACY	No. of Citations
30	Shelbourne KD, Wilckens JH, Mollabashy A, Decarlo M. Arthrofibrosis in acute anterior cruciate ligament reconstruction: the effect of timing of reconstruction and rehabilitation. *Am J Sports Med*. 1991;19(4):332-336.	USA	10.61	297
31	Amiel D, Kleiner JB, Roux RD, Harwood FL, Akeson WH. The phenomenon of "ligamentization": anterior cruciate ligament reconstruction with autogenous patellar tendon. *J Orthop Res*. 1986;4(2):162-172.	USA	8.94	295
32	Georgoulis AD, Papadonikolakis A, Papageorgiou CD, Mitsou A, Stergiou N. Three-dimensional tibiofemoral kinematics of the anterior cruciate ligament-deficient and reconstructed knee during walking. *Am J Sports Med*. 2003;31(1):75-79.	USA	18.38	294
33	Kocher MS, Steadman JR, Briggs KK, Sterett WI, Hawkins RJ. Relationships between objective assessment of ligament stability and subjective assessment of symptoms and function after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2004;32(3):629-634.	USA	19.60	294
34	L'Insalata JC, Klatt B, Fu FH, Harner CD. Tunnel expansion following anterior cruciate ligament reconstruction: a comparison of hamstring and patellar tendon autografts. *Knee Surg Sports Traumatol Arthrosc*. 1997;5(4):234-238.	USA	13.36	294
35	Weiler A, Hoffmann RFG, Bail HJ, Rehm O, Südkamp NP. Tendon healing in a bone tunnel, part II: histologic analysis after biodegradable interference fit fixation in a model of anterior cruciate ligament reconstruction in sheep. *Arthroscopy*. 2002;18(2):124-135.	Germany	17.18	292
36	Shelbourne KD, Gray T. Anterior cruciate ligament reconstruction with autogenous patellar tendon graft followed by accelerated rehabilitation: a two- to nine-year followup. *Am J Sports Med*. 1997;25(6):786-795.	USA	13.23	291
37	Arms SW, Pope MH, Johnson RJ, Fischer RA, Arvidsson I, Eriksson E. The biomechanics of anterior cruciate ligament rehabilitation and reconstruction. *Am J Sports Med*. 1984;12(1):8-18.	Sweden	8.17	286
38	Clatworthy MG, Annear P, Bulow JU, Bartlett RJ. Tunnel widening in anterior cruciate ligament reconstruction: a prospective evaluation of hamstring and patella tendon grafts. *Knee Surg Sports Traumatol Arthrosc* 1999;7(3):138-145.	New Zealand	14.15	283
39	Bobić V. Arthroscopic osteochondral autograft transplantation in anterior cruciate ligament reconstruction: a preliminary clinical study. *Knee Surg Sports Traumatol Arthrosc*. 1996;3(4):262-264.	UK	12.26	282
40	Aune AK, Holm I, Risberg MA, Jensen HK, Steen H. Four-strand hamstring tendon autograft compared with patellar tendon-bone autograft for anterior cruciate ligament reconstruction: a randomized study with two-year follow-up. *Am J Sports Med*. 2001;29(6):722-728.	Norway	15.56	280
41	Zantop T, Herbort M, Raschke MJ, Fu FH, Petersen W. The role of the anteromedial and posterolateral bundles of the anterior cruciate ligament in anterior tibial translation and internal rotation. *Am J Sports Med*. 2007;35(2):223-227.	Germany	23.33	280
42	Beynnon BD, Johnson RJ, Fleming BC, et al. Anterior cruciate ligament replacement: comparison of bone-patellar tendon-bone grafts with two-strand hamstring grafts. A prospective, randomized study. *J Bone Joint Surg Am*. 2002;84(9):1503-1513.	USA	16.29	277
43	Feller JA, Webster KE. A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. *Am J Sports Med*. 2003;31(4):564-573.	Australia	17.25	276
44	Lewek M, Rudolph K, Axe M, Snyder-Mackler L. The effect of insufficient quadriceps strength on gait after anterior cruciate ligament reconstruction. *Clin Biomech (Bristol, Avon)*. 2002;17(1):56-63.	USA	16.12	274
45	Kvist J, Ek A, Sporrstedt K, Good L. Fear of re-injury: a hindrance for returning to sports after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2005;13(5):393-397.	Sweden	19.50	273
46	Barret DS. Proprioception and function after anterior cruciate reconstruction. *J Bone Joint Surg Br*. 1991;73(5):833-837.	UK	9.71	272
47	Snyder-Mackler L, Delitto A, Bailey SL, Stralka SW. Strength of the quadriceps femoris muscle and functional recovery after reconstruction of the anterior cruciate ligament: a prospective, randomized clinical trial of electrical stimulation. *J Bone Joint Surg Am*. 1995;77(8):1166-1173.	USA	11.33	272
48	Salmon L, Russell V, Musgrove T, Pinczewski L, Refshauge K. Incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction. *Arthroscopy*. 2005;21(8):948-957.	Australia	19.36	271
49	Bach BR Jr, Tradonsky S, Bojchuk J, Levy ME, Bush-Joseph CA, Khan NH. Arthroscopically assisted anterior cruciate ligament reconstruction using patellar tendon autograft: five- to nine-year follow-up evaluation. *Am J Sports Med*. 1998;26(1):20-29.	USA	12.62	265
50	Adachi N, Ochi M, Uchio Y, Iwasa J, Kuriwaka M, Ito Y. Reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br*. 2004;86(4):515-520.	Japan	17.53	263

(continued)

TABLE A1 (continued)

Rank	Paper	Country	ACY	No. of Citations
51	Steiner ME, Steiner ME, Hecker AT, Brown CH Jr, Hecker AT, Brown CH Jr. Anterior cruciate ligament graft fixation: comparison of hamstring and patellar tendon grafts. *Am J Sports Med*. 1994;22(2):240-247.	USA	10.52	263
52	Mall NA, Chalmers PN, Moric M, et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. *Am J Sports Med*. 2014;42(10):2363-2370.	USA	51.60	258
53	Yamamoto Y, Hsu W-H, Woo SL-Y, Van Scyoc AH, Takakura Y, Debski RE. Knee stability and graft function after anterior cruciate ligament reconstruction: a comparison of a lateral and an anatomical femoral tunnel placement. *Am J Sports Med*. 2004;32(8):1825-1832.	USA	17.07	256
54	Yasuda K, Tsujino J, Ohkoshi Y, Tanabe Y, Kaneda K. Graft site morbidity with autogenous semitendinosus and gracilis tendons. *Am J Sports Med*. 1995;23(6):706-714.	Japan	10.63	255
55	Siebold R, Dehler C, Ellert T. Prospective randomized comparison of double-bundle versus single-bundle anterior cruciate ligament reconstruction. *Arthroscopy*. 2008;24(2):137-145.	Germany	22.91	252
56	Muneta T, Sekiya I, Yagishita K, Ogiuchi T, Yamamoto H, Shinomiya K. Two-bundle reconstruction of the anterior cruciate ligament using semitendinosus tendon with Endobuttons: operative technique and preliminary results. *Arthroscopy*. 1999;15(6):618-624.	Japan	12.55	251
57	Ejerhed L, Kartus J, Sernert N, Köhler K, Karlsson J. Patellar tendon or semitendinosus tendon autografts for anterior cruciate ligament reconstruction? A prospective randomized study with a two-year follow-up. *Am J Sports Med*. 2003;31(1):19-25.	Sweden	15.63	250
58	Ardern CL, Webster KE, Taylor NF, Feller JA. Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery: two-thirds of patients have not returned by 12 months after surgery. *Am J Sports Med*. 2011;39(3):538-543.	Australia	31.13	249
59	Lu HH, Cooper JA Jr, Manuel S, et al. Anterior cruciate ligament regeneration using braided biodegradable scaffolds: in vitro optimization studies. *Biomaterials*. 2005;26(23):4805-4816.	USA	17.71	248
60	Reid A, Birmingham TB, Stratford PW, Alcock GK, Giffin JR. Hop testing provides a reliable and valid outcome measure during rehabilitation after anterior cruciate ligament reconstruction. *Phys Ther*. 2007;87(3):337-349.	Canada	20.42	245
61	Anderson AF, Snyder RB, Lipscomb AB Jr. Anterior cruciate ligament reconstruction: a prospective randomized study of three surgical methods. *Am J Sports Med*. 2001;29(3):272-279.	USA	13.44	242
62	Aglietti P, Giron F, Buzzi R, Biddau F, Sasso F. Anterior cruciate ligament reconstruction: bone-patellar tendon-bone compared with double semitendinosus and gracilis tendon grafts—a prospective, randomized clinical trial. *J Bone Joint Surg Am*. 2004;86(10):2143-2155.	Italy	15.93	239
63	Jackson DW, Windler GE, Simon TM. Intraarticular reaction associated with the use of freeze-dried, ethylene oxide-sterilized bone-patella tendon-bone allografts in the reconstruction of the anterior cruciate ligament. *Am J Sports Med*. 1990;18(1):1-11.	USA	8.21	238
64	Shelbourne KD, Gray T. Results of anterior cruciate ligament reconstruction based on meniscus and articular cartilage status at the time of surgery: five- to fifteen-year evaluations. *Am J Sports Med*. 2000;28(4):446-452.	USA	12.42	236
65	Grana WA, Egle DM, Mahnken R, Goodhart CW. An analysis of autograft fixation after anterior cruciate ligament reconstruction in a rabbit model. *Am J Sports Med*. 1994;22(3):344-351.	USA	9.40	235
66	Zantop T, Wellmann M, Fu FH, Petersen W. Tunnel positioning of anteromedial and posterolateral bundles in anatomic anterior cruciate ligament reconstruction: anatomic and radiographic findings. *Am J Sports Med*. 2008;36(1):65-72.	Germany	21.27	234
67	Järvelä T. Double-bundle versus single-bundle anterior cruciate ligament reconstruction: a prospective, randomize clinical study. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(5):500-507.	Finland	19.33	232
68	Magnussen RA, Lawrence JTR, West RL, Toth AP, Taylor DC, Garrett WE. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. *Arthroscopy*. 2012;28(4):526-531.	USA	33.14	232
69	Myer GD, Paterno MV, Ford KR, Quatman CE, Hewett TE. Rehabilitation after anterior cruciate ligament reconstruction: criteria-based progression through the return-to-sport phase. *J Orthop Sports Phys Ther*. 2006;36(6):385-402.	USA	17.69	230
70	O'Neill DB. Arthroscopically assisted reconstruction of the anterior cruciate ligament: a prospective randomized analysis of three techniques. *J Bone Joint Surg Am*. 1996;78(6):803-813.	USA	9.78	225
71	Øiestad BE, Holm I, Aune AK, et al. Knee function and prevalence of knee osteoarthritis after anterior cruciate ligament reconstruction: a prospective study with 10 to 15 years of follow-up. *Am J Sports Med*. 2010;38(11):2201-2210.	Norway	24.67	222

(continued)

TABLE A1 (continued)

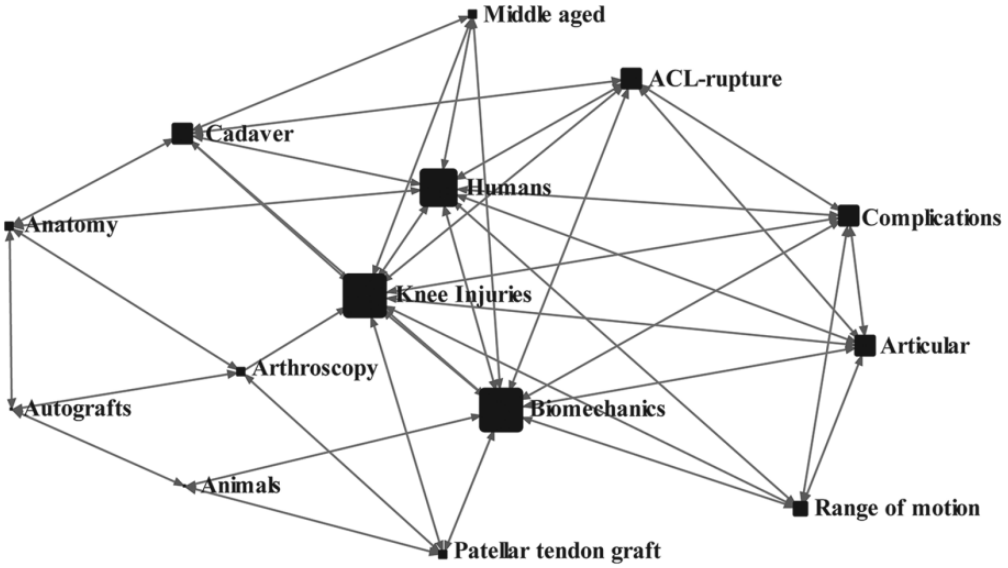
Rank	Paper	Country	ACY	No. of Citations
72	Rosenberg TD, Franklin JL, Baldwin GN, Nelson KA, Reider B. Extensor mechanism function after patellar tendon graft harvest for anterior cruciate ligament reconstruction. *Am J Sports Med*. 1992;20(5):519-526.	USA	8.11	219
73	Ishibashi Y, Rudy TW, Livesay GA, Stone JD, Fu FH, Woo SL-Y. The effect of anterior cruciate ligament graft fixation site at the tibia on knee stability: evaluation using a robotic testing system. *Arthroscopy*. 1997;13(2):177-182.	USA	9.91	218
74	Snyder-Mackler L, De Luca PF, Williams PR, Eastlack ME, Bartolozzi AR III. Reflex inhibition of the quadriceps femoris muscle after injury or reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Am*. 1994;76(4):555-560.	USA	8.72	218
75	Kessler MA, Behrend H, Henz S, Stutz G, Rukavina A, Kuster MS. Function, osteoarthritis and activity after ACL-rupture: 11 years follow-up results of conservative versus reconstructive treatment. *Knee Surg Sports Traumatol Arthrosc*. 2008;16(5):442-448.	Germany	19.64	216
76	Petersen W, Zantop T. Anatomy of the anterior cruciate ligament with regard to its two bundles. *Clin Orthop Relat Res*. 2007;454:35-47.	Germany	18.00	216
77	Shelbourne KD, Gray T, Haro M. Incidence of subsequent injury to either knee within 5 years after anterior cruciate ligament reconstruction with patellar tendon autograft. *Am J Sports Med*. 2009;37(2):246-251.	USA	21.60	216
78	Lyman S, Koulouvaris P, Sherman S, Do H, Mandl LA, Marx RG. Epidemiology of anterior cruciate ligament reconstruction: trends, readmissions, and subsequent knee surgery. *J Bone Joint Surg Am*. 2009;91(10):2321-2328.	USA	21.20	212
79	Musahl V, Plakseychuk A, VanScyoc A, et al. Varying femoral tunnels between the anatomical footprint and isometric positions: effect on kinematics of the anterior cruciate ligament-reconstructed knee. *Am J Sports Med*. 2005;33(5):712-718.	USA	15.14	212
80	Tashman S, Kolowich P, Collon D, Anderson K, Anderst W. Dynamic function of the ACL-reconstructed knee during running. *Clin Orthop Relat Res*. 2007;454:66-73.	USA	17.58	211
81	Kousa P, Järvinen TLN, Vihavainen M, Kannus P, Järvinen M. The fixation strength of six hamstring tendon graft fixation devices in anterior cruciate ligament reconstruction, part II: tibial site. *Am J Sports Med*. 2003;31(2):182-188.	Finland	13.13	210
82	Howell SM, Taylor MA. Failure of reconstruction of the anterior cruciate ligament due to impingement by the intercondylar roof. *J Bone Joint Surg Am*. 1993;75(7):1044-1055.	USA	8.04	209
83	Lutz GF, Palmitier RA, An KN, Chao EYS. Comparison of tibiofemoral joint forces during open-kinetic-chain and closed-kinetic-chain exercises. *J Bone Joint Surg Am*. 1993;75(5):732-739.	USA	8.04	209
84	Sidles JA, Larson RV, Garbini JL, Downey DJ, Matsen FA III. Ligament length relationships in the moving knee. *J Orthop Res*. 1988;6(4):593-610.	USA	6.74	209
85	Kondo E, Yasuda K, Azuma H, Tanabe Y, Yagi T. Prospective clinical comparisons of anatomic double-bundle versus single-bundle anterior cruciate ligament reconstruction procedures in 328 consecutive patients. *Am J Sports Med*. 2008;36(9):1675-1687.	Japan	18.82	207
86	Irrgang JJ, Ho H, Harner CD, Fu FH. Use of the International Knee Documentation Committee guidelines to assess outcome following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 1998;6(2):107-114.	USA	9.67	203
87	LaPrade RF, Resig S, Wentorf F, Lewis JL. The effects of grade III posterolateral knee complex injuries on anterior cruciate ligament graft force: a biomechanical analysis. *Am J Sports Med*. 1999;27(4):469-475.	USA	10.05	201
88	Sonnery-Cottet B, Thaunat M, Freychet B, Pupim BHB, Murphy CG, Claes S. Outcome of a combined anterior cruciate ligament and anterolateral ligament reconstruction technique with a minimum 2-year follow-up. *Am J Sports Med*. 2015;43(7):1598-1605.	France	50.00	200
89	Tomita F, Yasuda K, Mikami S, Sakai T, Yamazaki S, Tohyama H. Comparisons of intraosseous graft healing between the doubled flexor tendon graft and the bone-patellar tendon-bone graft in anterior cruciate ligament reconstruction. *Arthroscopy*. 2001;17(5):461-476.	Japan	11.06	199
90	Pinczewski LA, Deehan DJ, Salmon LJ, Russell VJ, Clingeleffer A. A five-year comparison of patellar tendon versus four-strand hamstring tendon autograft for arthroscopic reconstruction of the anterior cruciate ligament. *Am J Sports Med*. 2002;30(4):523-536.	Australia	11.65	198
91	Hamada M, Shino K, Horibe S, et al. Single- versus bi-socket anterior cruciate ligament reconstruction using autogenous multiple-stranded hamstring tendons with EndoButton femoral fixation: a prospective study. *Arthroscopy*. 2001;17(8):801-807.	Japan	10.94	197
92	Harner CD, Irrgang JJ, Paul J, Dearwater S, Fu FH. Loss of motion after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1992;20(5):499-506.	USA	7.30	197
93	Paterno MV, Rauh MJ, Schmitt LC, Ford KR, Hewett TE. Incidence of second ACL injuries 2 years after primary ACL reconstruction and return to sport. *Am J Sports Med*. 2014;42(7):1567-1573.	USA	39.40	197

(continued)

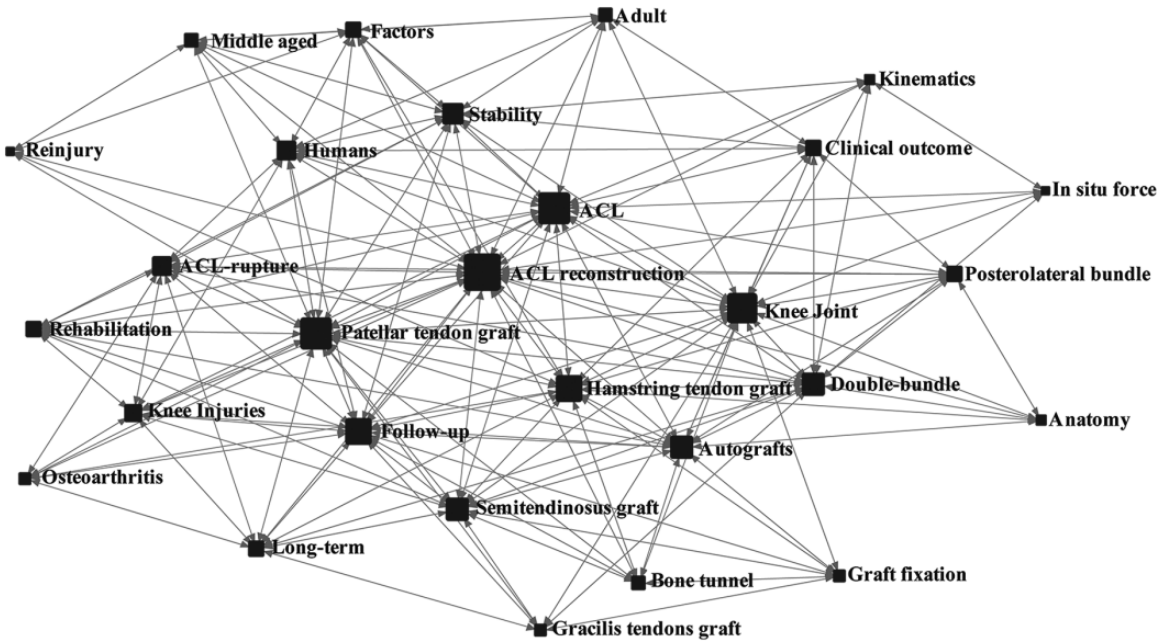
TABLE A1 (continued)

Rank	Paper	Country	ACY	No. of Citations
94	Scopp JM, Jasper LE, Belkoff SM, Moorman CT III. The effect of oblique femoral tunnel placement on rotational constraint of the knee reconstructed using patellar tendon autografts. *Arthroscopy*. 2004;20(3):294-299.	USA	13.13	197
95	Webster KE, Feller JA, Hameister KA. Bone tunnel enlargement following anterior cruciate ligament reconstruction: a randomised comparison of hamstring and patellar tendon grafts with 2-year follow-up. *Knee Surg Sports Traumatol Arthrosc*. 2001;9(2):86-91.	Australia	10.94	197
96	Eriksson K, Anderberg P, Hamberg P, et al. A comparison of quadruple semitendinosus and patellar tendon grafts in reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br*. 2001;83(3):348-354.	Sweden	10.89	196
97	Paterno MV, Rauh MJ, Schmitt LC, Ford KR, Hewett TE. Incidence of contralateral and ipsilateral anterior cruciate ligament (ACL) injury after primary ACL reconstruction and return to sport. *Clin J Sport Med*. 2012;22(2):116-121.	USA	28.00	196
98	Kaeding CC, Aros B, Pedroza A, et al. Allograft versus autograft anterior cruciate ligament reconstruction: predictors of failure from a MOON prospective longitudinal cohort. *Sports Health*. 2011;3(1):73-81.	USA	24.38	195
99	Zantop T, Petersen W, Sekiya JK, Musahl V, Fu FH. Anterior cruciate ligament anatomy and function relating to anatomical reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(10):982-992.	Germany	14.92	194
100	Forsythe B, Kopf S, Wong AK, et al. The location of femoral and tibial tunnels in anatomic double-bundle anterior cruciate ligament reconstruction analyzed by three-dimensional computed tomography models. *J Bone Joint Surg Am*. 2010;92(6):1418-1426.	USA	21.44	193

[a]ACY, average citations per year.



Appendix Figure A1. Degree of centrality analysis of keywords before 2000 (32 articles). ACL, anterior cruciate ligament.



Appendix Figure A2. Degree of centrality analysis of keywords in the 2000s and 2010s (57 articles). ACL, anterior cruciate ligament.