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 co-author 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
Since then, ACLR has matured from open arthrotomy to minimally invasive arthroscopic procedures. 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. 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. In contrast to narrative literature reviews, which are susceptible to the prejudice of researchers, bibliometric analyses use quantitative analysis and statistics to evaluate and estimate the structure and development of scientific disciplines.

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, whereas others have attempted to demonstrate the trends in published literature in the past decade. 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).

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.

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

| 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.33 *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.35 *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    | Magnusson et al.36 *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 |

*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 UCinert for Windows, Version 6.212.5

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.18 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.26 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

| Rank | Article | First Author | Topics and Conclusions |
|------|---------|--------------|------------------------|
| 1    | The cruciate ligaments of the knee joint: anatomical, functional and experimental analysis | Girgis16 | 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 | Rodeo36 | 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 | Shelbourne34 | 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 | Altman1 | 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 | Yagi47 | 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 | Loh27 | 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 | Tashman45 | 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 | Sachs37 | 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 | Kurosaka24 | 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 | Paterno34 | 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. |

*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...
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, 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), burns (mean, 178), limb prosthetics (mean, 24), and cervical spine surgery (mean, 203). 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. Some researchers consider that the true value of articles cannot be judged until at least 20 years after the date of publication. However, older articles, independent
of their current effect, are cited more frequently, whereas emerging publications often underestimate their influence.\textsuperscript{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.

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\textsuperscript{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\textsuperscript{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,\textsuperscript{50} hand surgery,\textsuperscript{20} and burns.\textsuperscript{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.\textsuperscript{7} Third, reviewers in the United States show a preference for US-based articles.\textsuperscript{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

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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\textsuperscript{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              |

\textsuperscript{a}Renamed Bone & Joint Journal after 2013.

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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.
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. 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 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

**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.
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. 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. Arthroscopy 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, 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; there is indirect evidence supporting surgical treatment as advantageous for long-term outcomes. 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. Since then, arthroscopic ACLR has been embraced by most surgeons, particularly by the end of the 1990s.

For the third and fourth issues, it was reported that the risk of ACL graft failure was increased in allograft reconstruction, and the synthetic ligament graft and xenografts may also lead to poor outcome. Therefore, autograft is regarded as the best option in ACLR. Allograft is often reserved for complex primary or revision cases where autologous tissue is unavailable. Surgeons have explored a variety of autologous tissues, involving the patellar, quadriceps, and hamstring tendons; the meniscus; and the cutis. It has been reported that hamstring grafts have been the most preferred grafts in the past decade; 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. 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. However, Samuelsson et al 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.28

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.

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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.
17. Gollan P, Kuruvicki J, Pierce TP, et al. The most cited original articles on anterior cruciate ligament injuries in the past 20 years. J Long Term Eff Med Implants. 2018;28(9):247-257.
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.
19. Herzog MM, Marshall SW, Lund JL, Pate V, Mack CD, Spang JT. Incidence of anterior cruciate ligament reconstruction among adolescent females in the United States, 2002 through 2014. JAMA Pediatr. 2017;171(8):808-810.
20. Joyce CW, Kelly JC, Carroll SM. The 100 top-cited classic papers in hand surgery. J Plast Surg Hand Surg. 2014;48(4):227-233.
21. Joyce CW, Kelly JC, Sugrue C. A bibliometric analysis of the 100 most influential papers in burns. Burns. 2014;40(1):30-37.
22. 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.
23. Kessler MA, Behrend H, Henz S, Stutz G, Rukavina A, Kuster MS. Function, osteoarthritis and activity after ACL-rapture: 11 years follow-up results of conservative versus reconstructive treatment. Knee Surg Sports Traumatol Arthrosc. 2008;16(5):442-448.
24. Kurosaka M, Yoshiba S, Andrich JT. A biomechanical comparison of different anterior surgical techniques of graft fixation in anterior cruciate ligament reconstruction. Am J Sports Med. 1987;15(3):225-229.
25. Lefaivre KA, Shadgan B, O’Brien PJ. 100 most cited articles in orthopaedic surgery. Clin Orthop Relat Res. 2011;469(5):1487-1497.
26. Link AM. US and non-US submissions: an analysis of reviewer bias. JAMA. 1998;280(3):246-247.
27. Loh JC, Fukuda Y, Tsueda E, Steadman RJ, Fu FH, Woo SL-Y. Knee stability and graft function following anterior cruciate ligament reconstruction.
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. Mehlmam CT, Wenger DR. The top 25 at 25: citation classics in the Journal of Pediatric Orthopedics. J Pediatr Orthop. 2006;26(6): 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.
32. Moed HF. New developments in the use of citation analysis in research evaluation. Arch Immunol Ther Exp (Warsz). 2009;57(1): 13-18.
33. 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.
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.
36. 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.
37. Sachs RA, Daniel DM, Stone ML, Garfein RF. Patellofemoral problems after anterior cruciate ligament reconstruction. Am J Sports Med. 1989;17(6):760-765.
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39. Schindler OS. The story of anterior cruciate ligament reconstruction, part 1. J Perioper Pract. 2012;22(5):163-171.
40. Schindler OS. The story of anterior cruciate ligament reconstruction, part 2. J Perioper Pract. 2012;22(6):189-196.
41. Seglen PO. Why the impact factor of journals should not be used for evaluating research. BMJ. 1997;314(7079):498-502.
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 L. 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.

APPENDIX

| 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)
| 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, Andrich 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, Debks 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, Tokuya 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 JS, 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, Sterrett 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, Klaft 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):767-795. | USA     | 13.23 | 291             |
| 37   | Arons 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   | Bobic ´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 hamstrings 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, Her bert 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   | Beynon 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, Bochuk 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;36(4):515-520. | Japan   | 17.53 | 263             |
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 T, 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, Kurtz 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, Bidlau 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   | Jarvela T. Double-bundle versus single-bundle anterior cruciate ligament reconstruction: a prospective, randomized clinical study. Knee Surg Sports Traumatol Arthrosc. 2007;15(5):500-507. | Finland | 19.33 | 232              |
| 68   | Magnusson 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)
| 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   | Ishihashi Y, Rudy TW, Livesay GA, Stone JD, Fu PH, 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, Mandli 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, VanScoy 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, Jarvinen TLN, Vihavainen M, Kannus P, Jarvinen 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 | 8.04 | 209 |
| 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, Palminteri 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 | 10.05 | 201 |
| 87   | LaPrade RF, Resig S, Wentorf F, Lewis JL. The effects of grade III postero-lateral knee complex injuries on anterior cruciate ligament graft force: a biomechanical analysis. *Am J Sports Med*. 1999;27(4):469-475. | Canada | 50.00 | 200 |
| 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 | 11.06 | 199 |
| 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, Clingleeffer 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.  
| 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             |

*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.