RESEARCH ARTICLE

Femoroacetabular Impingement and Labral Tear: From the Most Highly Cited Articles to Research Interests

Ning Tang, M Med1, Wenchao Zhang, MD1, Yang Su, M Med1, Zhencan Han, B Med2, Lingwen Deng, B Med3, Yusheng Li, MD4, Tianlong Huang, MD1, Chunbao Li, MD5

1Department of Orthopaedic Surgery, The Second Xiangya Hospital, 2Xiangya School of Medicine and 4Department of Orthopedics, Xiangya Hospital, Central South University, Changsha, 3Medical Laboratory Department, Yongzhou First People’s Hospital and Affiliation Hospital of Yongzhou Vocational Technical College, Yongzhou and 5Department of Orthopedics, The Fourth Medical Center, Chinese PLA General Hospital, Beijing, China

Objective: To highlight the characteristics of the most highly cited articles and propose the research interests over the past decades in the field of femoroacetabular impingement (FAI) and labral tear.

Methods: The ISI Web of Science database (Clarivate Analytics, New York, the United States) was utilized for the identification of articles on 15 December 2020. FAI and labral tear-related articles (1138 articles) were retrieved, of which the 100 most-cited articles (top 100) were identified. Subsequent analysis included citation density (citations/article age), authorship, institution, journal, geographic distribution, level of evidence, and theme.

Results: The number of citations per article ranged from 66 to 1189 with a mean of 163.31. The majority of articles were published in the United States (all articles/top 100 = 655/57) and Switzerland (85/22). University of Bern (n = 10) was the most prolific institution. The journal with the most of articles was Arthroscopy: The Journal of Arthroscopic and Related Surgery. The most prolific coauthor (all articles) or first authors (top 100) was Domb (n = 109) and Philippon (n = 6), respectively. The evidence with the most articles is level IV (n = 41). The top three most popular topics of research article were outcomes of surgery (n = 23), imaging diagnosis (n = 18), and comparison of surgery (n = 8). The top four most prevalent themes of review were labral tears (n = 3), FAI (n = 3), comparison of surgery imaging diagnosis, and outcomes of surgery (both n = 2). Six keywords with the newest average publication year, including FAI syndrome (average publication year = 2019.50), patient-reported outcomes (2019.43), femoroplasty (2018.60), clinical outcomes (2018.17), borderline dysplasia (2018.00), and capsule (2018.00). Five keywords with the highest average citations, including outcome (average citations = 88.50), alpha angle (58.00), complications (55.86), revision hip arthroscopy (49.00), and systematic review (46.14).

Conclusions: Outcomes research is the most popular research interest and patient-reported outcome instruments might be further and widely used in the emerging articles in the near future. The field of FAI and labral tear has shown an obvious trend of development and is steadily evolving. It could be predicted that there will be an increasing number of publications in the following years, with the United States and Switzerland maintaining leadership in this field.

Key words: Femoroacetabular impingement; FAI; Labral tear; Research interests; Bibliometric analysis

Address for correspondence Tianlong Huang, MD, Department of Orthopaedic Surgery, The Second Xiangya Hospital, Central South University, 139 Renminzhonglu Road, Changsha, Hunan, China 410000 Tel: 0086073185295128; Fax: 073185294085; E-mail: tianlong.huang@csu.edu.cn; Disclosure: No benefits of any type has been, or will be, received from a commercial party related directly or indirectly to the subject of this manuscript. Received 17 January 2021; accepted 13 April 2021

Orthopaedic Surgery 2021;13:1922-1933 • DOI: 10.1111/os.13037
This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.
Introduction

Bibliometric analysis is a serviceable and efficient tool to quantitatively evaluate the performance and characteristics of publications. In the past several years, this method has been widely used in various research areas. Citation analysis is the main methodology of bibliometric analysis. A citation is the acknowledgement that one article uses another as a reference. The number of citations is not only an indicator of the impact of an article on the scientific community but also forms the basis of journal impact factor (IF) generation.

Femoroacetabular impingement (FAI) is a well-known clinical syndrome deriving from morphologic alterations of the acetabulum or femur and is the common cause of hip pain and limited hip range of motion. The prevalence of labral tears in patients with hip or groin pain has been reported to be 22%–55%. It has been reported that acetabular labral tears were closely related to FAI. Specifically, abnormal articular burden and increased pressure caused by FAI resulted in the development of labral tears, cartilage delamination, and eventual secondary osteoarthritis. The term FAI was firstly coined and developed by the Ganz group. Subsequently, an exponential rise of publications about FAI further extended its recognition.

The citation analysis, one of the key methodologies of bibliometrics, has been utilized to analyze the 50 most-cited articles for femoroacetabular impingement and hip arthroscopy by Simon et al. in 2014. However, a comprehensive bibliometric analysis on FAI and lateral tear remains scarce. Thus, in this study, we conducted the comprehensive bibliometric analysis to assess the 100 most-cited articles in the field of FAI, with the aim to highlight the characteristics of these highly cited articles and propose the research interests over the past decades.

Materials and Methods

Study Design

This study used a bibliometric method to analyze the articles on FAI and lateral tear. The 100 top cited articles were enrolled and analyzed in accordance with the method for bibliometrics and offer the doctors more classical compared to the bibliometric papers that only focused on the top 25 or 50 articles in a specific field.

Search Strategy

Articles related to FAI and lateral tear were retrieved by searching the ISI Web of Science database (Clarivate Analytics, NY, USA), comprising the Web of Science (WOS) Core Collection, BIOSIS Citation Index, MEDLINE, Russian Science Citation Index, ScIELO Citation Index, and KCI-Korean Journal Database. The search terms utilized were the following: (femoroacetabular impingement OR femoral acetabular impingement OR FAI) AND (labrum OR lateral) AND (tear OR tears OR lesion OR lesions). There is no language limitation in the search.

The search was implemented on 15 December 2020 and yielded 1138 results in total. Those articles were subsequently analyzed via VOS viewer 1.6.15 (a program operated by the Centre for Science and Technology Studies at Leiden University, Leiden, Netherlands). For further selection, two well-trained reviewers (the first author and the second author in the author list) reviewed and chose the eligible articles according to eligibility criteria, respectively. And the 100 most-cited papers were listed for data extraction. Any disagreements between the two reviewers were discussed by the group until a final consensus was reached. Finally, the previously mentioned two strategies were integrated into further analysis (Fig. 1).

Eligibility Criteria

The inclusion criteria were as follows: (i) basic or clinical research papers of any type (original article, review, meta-analysis, case report, and so on) which were associated with FAI and lateral tear. Exclusion criteria were as follows: (i) research theme or content not considered FAI and lateral tear as the main research subject.

Data Extraction

The following information was extracted for the 100 most-cited articles: (i) title; (ii) type of article; (iii) publication year; (iv) first author; (v) journal name and impact factor (IF) in 2019; (vi) country; (vii) institution; (viii) theme; (ix) level of evidence (the evidence review of Canadian Task Force on Preventive Health Care [the CTFPHC’s evidence review]); (x) citations; (xi) citation density (citations/article age). For the previously retrieved 1138 articles: (i) title; (ii) author keywords; (iii) publication year.

If an article has multiple countries or institutions, the affiliation of the first author was utilized. In the same way, if the first author has multiple institutions, the affiliation of the corresponding author was used.

Statistical Analysis

The bibliometric software Vosviewer was used to analyze the previously retrieved 1138 articles. Nine hundred and twenty-seven author keywords were extracted. To simplify the figure of the author’s keywords co-occurrence network, a limitation with minimum number of occurrences of the keywords was set (threshold = 4). The higher occurrence of keywords, the larger circle in the co-occurrence network. Moreover, a blue to yellow gradient was used to show the mean publication years of a certain author’s keywords.

The Shapiro–Wilk test was utilized to test the distribution of individual variables for normality. Normally distributed data were presented as mean ± standard deviation. The Kruskal–Wallis H test was used to evaluate differences between the publication year and the total number of citations. Comparison between means of citations was determined by using one-way analysis of variance (ANOVA), and post-hoc testing was implemented when necessary. The Mann–Kendall trend test was performed to test time-dependent trends. Spearman rank or Pearson tests correlation between variables. P < 0.05 was considered to be statistically significant. Analysis was performed using GraphPad Prism 8, R 4.0.2 (GraphPad Software inc., San Diego, CA, USA).
Diego, CA, USA) and IBM SPSS Statistics 22.0 (IBM inc., NY, USA).

Results

Top Articles
The 100 most-cited articles are shown in Table S1. The number of citations per article ranged from 66 to 1189 with a mean of 163.31. The Kruskal–Wallis H test showed a significant difference between the publication year and the total number of citations ($P \leq 0.001$). The publication items were obviously increased over the past decades (Fig. 2A). The publication years of the top 100 articles was showed in Fig. 2B, in which publication years with the most publications were 2011 ($n = 12$). Citation density ranged from 5.06 to 79.27 per article. The top 10 articles with largest citation density were listed in Table 1. A gentle increasing trend between the citation density and the publication year was demonstrated (Fig. 3), but no significant difference between the citation density and the publication year was found by Mann–Kendall test ($z = 1.0454$, $P = 0.2959$).

Journals
Twenty-two different journals in which the top 100 articles were published are listed in Table 2. Sixty-one percent of the articles were published in the top three journals in the table, including *Arthroscopy: The Journal of Arthroscopic and Related Surgery* ($n = 28$, IF = 4.325), *American Journal of Sports Medicine* ($n = 17$, IF = 5.810), and *Clinical Orthopaedics and Related Research* ($n = 16$, IF = 4.329).

Countries
Within the 100 most-cited papers, there were eight countries of origin (Fig. 4B). The United States was leading the way ($n = 57$), followed by Switzerland ($n = 22$), Canada ($n = 9$), and the United Kingdom ($n = 8$). Australia, Italy, the Netherlands, and New Zealand each only contributed one paper, respectively. Countries with five or more papers on the field of FAI and lateral tear were shown in Fig. 4A. The top four countries of papers’ origin were the United States ($n = 655$), Switzerland ($n = 85$), the United Kingdom ($n = 83$), and Canada ($n = 69$).

Institutions
The 100 most-cited articles were published by a total of 53 institutions independently or cooperatively. Among these articles, 18 institutions contributed two or more articles. The most prolific institution was University of Bern ($n = 10$), and other institutions were shown in Fig. 5.

Authors
Coauthors with the top 10 number of highly cited papers and first authors with two or more articles in the 100 most-cited articles were listed in Table 3. The most prolific coauthor or first authors was Domb ($n = 109$) and Philippon ($n = 6$), respectively.

Level of Evidence
There were 73 clinical articles identified, and the levels of evidence among them were showed in Fig. 6. The evidence with the most articles in the 100 most-cited articles was level IV ($n = 41$, mean citations = 197.6). Followed by level III ($n = 23$, mean citations = 157.9), level II ($n = 5$, 104.0), and level V ($n = 4$, 188.5). Interestingly, no clinical article had...
level I evidence. No significant difference has been found among these levels of evidence in the one-way ANOVA ($P = 0.5649$).

**Themes and Keywords Analysis**

As for the article type, there were 77 articles, 22 reviews, and one meta-analysis among the 100 most-cited papers. The top four most prevalent themes of review were labral tear (n = 3), FAI (n = 3), comparison of surgery, imaging diagnosis, and outcomes of surgery (both n = 2). The top three most popular topics of research article were outcomes of surgery (n = 23), imaging diagnosis (n = 18), and comparison of surgery (n = 8). And details of the themes among specific articles or reviews were presented in Fig. 7.

One hundred and five keywords have occurred at least four times. These keywords were clustered into 11 subsets...
with different colors in Fig. 8A and Fig. 8B. Femoroacetabular impingement, labral tear, and hip arthroscopy were at the convergence point. The top 30 keywords ranked by average publication year were listed in Table S2. Six keywords had an average publication year larger than or equal to 2018, including femoroacetabular impingement syndrome (average publication year = 2019.50), patient-reported outcomes (2019.43), femoroplasty (2018.60), clinical outcomes (2018.17), borderline dysplasia (2018.00), and capsule (2018.00). Top 30 keywords in all articles ranked by average citations were listed in Table S3. Five keywords with average citations greater than 45, including outcome (average citations = 88.50), alpha angle (58.00), complications (55.86), revision hip arthroscopy (49.00), and systematic review (46.14).

Discussion

The number of citations of a specific article is often regarded as a bibliometric indicator of influence within authors, journals, and themes of research27–30. In this study, we evaluated all articles, especially the 100 most-cited articles, on FAI and labral tear by using the bibliometric analysis, aiming to highlight the characteristics of the higher citations articles and provide research interests on the field of FAI and labral tear in the past or currently.

The 100 most-cited articles in the field of FAI and labral tear were identified with a mean of 163.31 citations (range, 66 to 1189), which is smaller than the fields of orthopaedic surgery12, burns3, and spine deformity8. As is showed in Fig. 2A, the earliest papers on the topic were published in 1998. And since 2003, the number of articles per year was increased obviously. This was because that FAI is a relatively young research field and was prosperous after the concept of FAI was fully developed by Ganz et al. in 200323. Even though the citation density is increased every year, time accumulation effect is not enough for these articles to accumulate the citations compared with mean citations of the top 100 articles in other fields.

The oldest article in the top 50 articles on FAI and arthroscopy was published in 1987, while the oldest paper in the 100 most-cited articles on FAI and labral tear was

![Fig. 3 Time-dependent citation density trend. The citation density showed a gentle increasing trend.](image)
published in 2001. FAI and labral tear is a relatively new area of research. The mean of citation of top 50 articles between the older list and our study is increased from 182.7 to 242.9. *Arthroscopy: The Journal of Arthroscopic and Related Surgery* became the journal with the most number of articles in the new list, while *Clinical Orthopaedics and Related Research*, which was the most prolific journal in the previous list, only ranked three.

This study revealed that the United States is the greatest contributor of articles and Switzerland ranked number two both in all articles (Fig. 4A) and in the top 100 articles (Fig. 4B). The same phenomenon of the contribution of the United States can be seen in other fields, The consideration of leadership of the United States in various scientific research fields is an expected result. Notably, 16 of the involved 22 journals are from United States (Table 2), while it is reported that U.S. reviewers having a significant preference for U.S. papers.

*Arthroscopy: The Journal of Arthroscopic and Related Surgery* came to be the journal that published the maximum number of papers (n = 28), which was different from the previous study. Two influential journals in the field of FAI and labral tear, *American Journal of Sports Medicine* and *Clinical Orthopaedics and Related Research*, published a comparable number of papers on the top 100 articles (17 vs 16 papers).

The University of Bern was the institution with the most articles in top 100 cited articles, followed by Switzerland (Fig. 5). Interestingly, the top eight articles in our list all originated from Switzerland and five of these articles were affiliated with the University of Bern. It can be explained by the fact that Ganz, as a pioneer in the field of FAI, was from Switzerland and was affiliated to the University of Bern. He and his team have made the concept of FAI...
becoming internationally accepted as a common cause of hip pain and dysfunction\(^{15,23,40,41}\).

The article with the largest citations (\(n = 1189\)) and the largest citation density (\(n = 79.27\)) was written in Switzerland by Beck, titled “Hip morphology influences the pattern of damage to the acetabular cartilage – Femoroacetabular impingement as a cause of early osteoarthritis of the hip” which was published on *Journal of Bone and Joint Surgery-British Volume* in 2005. This case research article mainly focused on the damage mechanisms of FAI, stating that “During movement the labrum is crushed between the acetabular rim and the femoral neck causing degeneration and ossification. Both cam and pincer impingement lead to osteoarthritis of the hip. Labral damage indicates ongoing impingement and rarely occurs alone.”\(^{18}\)

The article with the second largest citation density is a consensus statement on the diagnosis, treatment principles, and key terminology relating to FAI syndrome and was published in the *British Journal of Sports Medicine* in 2016. The third largest citation density paper was published in Arthroscopy: The Journal of Arthroscopic and Related Surgery in 2015\(^{42}\). By reviewing the findings of radiographic, CT, or MRI scans, it was concluded that FAI morphologic features and labral injuries were common in asymptomatic patients\(^{43}\). The rest of the top 10 articles with largest citation density is listed in Table 1.

Philippon was the only first author owning as many as six items on the 100 most-cited articles list and ranked second as the coauthor among all authors in this field. He reported a new technique for arthroscopic rim trimming of pincer-type femoroacetabular impingement and labral repair through the lateral arthroscopic portal in 2006\(^{44}\), reviewed the management of femoroacetabular impingement–osteoplasty technique, reported 37 revisions of hip arthroscopies in 2007\(^{16,45}\), analyzed the outcomes of 28 professional hockey players who underwent arthroscopic labral repair and were treated for femoroacetabular impingement in 2010\(^{46}\), shared increased alpha angles as a measure of cam-type impingement in 2013\(^{47}\), and evaluated the hip fluid seal of acetabular labrum in several pathological conditions in 2014\(^{48}\). Domb, another pioneer in this area, was the author with the greatest number of articles with co-authorship in the all-articles list and possessed two articles on the 100 most-cited articles list\(^{49,50}\).

| TABLE 3 Coauthors with the top 10 number of papers in all articles and first authors with two or more articles in the 100 most-cited articles |
|---|---|---|---|
| Rank | Author | Number of papers | Rank | Author | Number of papers |
| 1 | Domb, B. G. | 109 | 1 | Philippon, M. J. | 6 |
| 2 | Philippon, M. J. | 76 | 2 | Beck, M. | 1, 3 |
| 3 | Nho, S. J. | 45 | 3 | Ito, K. | 2, 42 |
| 4 | Kelly, B. T. | 42 | 4 | Espinosa, N. | 2, 5, 49 |
| 5 | Leunig, M. | 33 | 5 | Beaule, P. E. | 2, 19, 30 |
| 6 | Maldonado, D. R. | 34 | 6 | Frank, R. M. | 2, 39, 88 |
| 7 | Briggs, K. K. | 33 | 7 | Nepple, J. J. | 2, 70, 97 |
| 8 | Perets, I. | 32 | 8 | Domb, B. G. | 2, 98, 99 |
| 9 | Ganz, R. | 30 | 9 | | |
| 10 | Lall, A. C. | 31 | 10 | | |

* Rank of paper in the 100 most-cited articles.
The most popular level of evidence was level IV, with 41 of the 73 clinical studies belonging to this classification. The same result was reported in other orthopaedic studies. However, there is no publication belonging to level of evidence I in the 100 top-cited articles list. The possible reason is that the earlier studies usually applied uncontrolled case series or observational research as the main approaches to explore clinical questions. There have been a number of articles published on high-level evidence in recent years, but not enough time accumulation for these articles to possess higher citations to become one of the 100 most-cited articles. It also suggests
Fig. 8 Network analysis of keywords among all articles. (A) overlay visualization, (B) cluster visualization. Of the 927 keywords in 1138 articles, 105 keywords occurred at least four times as shown in the Figure. The size of the circles presents the occurrences of terms. A blue-yellow gradient showed the keywords changed over time.
that more high-level evidence studies are required to be
designed in the field.

The 100 most-cited articles consist of 77 research arti-
cles, 22 review articles (including 15 reviews and seven sys-
tematic reviews), and one meta-analysis. The mean citation
per article for review articles was 119.68 times, while for
research articles were 176.43 times. Research articles have
higher mean citations than that of review articles. The seven
systematic reviews respectively ranked 24, 31, 56, 64, 92, and
96 in the top 100 most-cited articles. While systematic
reviews are highly cited more than original research papers,
this was not apparent in this study. Surgery research (includ-
ing outcomes of surgery and comparison of surgery) was
the most popular theme in both the research articles and review
articles. The research objective was mainly focused on surgi-
cal dislocation, microfracture, labral debridement, labral
repair, proximal femoral osteoplasty, predictors of poor
prognosis, and periacetabular osteotomy.

Surgical dislocation technique was first introduced by
Ganz in 2001 and it provided an all-round view of femoral
head, labrum, and acetabulum without the risk of avascular
necrosis. Three articles mainly focused on this approach in
our list. Taking advantage of this technique, surgeons can
easily probe the location of labral lesion.

The first documented surgical treatment for labral tears
was labral debridement. Surgical debridement was reported
to relieve symptoms and slow or halt progression toward
degenerative joint disease in patients with FAI and the
selective debridement reported a favorable outcome by both
5-year and 10-year follow-up. However, several studies
reported that patients with labral debridement probably end
up with osteoarthritis and a high reoperation rate due to the
loss of the labrum to sustain the joint stability.

After the significance of the labrum was fully recog-
nized and the techniques were developed, the preservation of
torn labrum has become the better choice for patients in
most cases. Labral repair is reported significantly better than
debridement among Harris Hip Score, 12-item short form
survey, and visual analogue pain scores. Meanwhile,
labral tears are often associated with femoral or acetabular
chondral injuries. This may explain why three articles in
our list mainly focused on microfracture.

It was reported that patients who underwent arthro-
sopic debridement with femoral osteoplasty (excision of
impingement lesion) had a higher proportion of excellent/
good results compared with the controls and a significant
improvement in the overall quality of life. In addition,
periacetabular osteotomy was also reported as an effective way
to treat the acetabulum with symptomatic anterior femoral
acetabular impingement because of acetabular retroversion.

Diagnosis is the second popular theme for articles and
reviews in the 100 most-cited papers. Arthroscopy, as the
gold standard, is a diagnostic therapeutic approach for FAI
and labral tear, but it is only used for patients without an
explicit diagnosis after careful history assessment, physical
test, and radiographic exam. Therefore, diagnostic imaging
usually is widely used, mainly including magnetic resonance
arthrography (MRA), magnetic resonance imaging (MRI),
computed tomography (CT), and conventional radiography
(anteroposterior view of the pelvis, Dunn view, and cross-
table lateral view).

Conventional radiography can perform a specific mea-
surement of femoral head and acetabulum to diagnose FAI
and subtle developmental dysplasia of the hip (DDH). Alpha
angle is regarded as an important radiological measure-
sment to determine cam-type impingement. It was
reported that alpha angle was a prognostic variable and
increased alpha angle could be used to predict progression of
FAI to labral tear. However, it has faced questions of its
utility to diagnose FAI and is no longer used in isolation.
CT scans are unable to detect labral tears reliably, but the
cross-over sign along with ischial spine projection is used
to diagnose acetabular retroversion being diagnosed by 3D
CT scans.

Standard MRI has only 30% sensitivity and 36% accu-
ry on diagnosis of labral tears due to it producing underes-
timation of labral pathology and false-positive results. But
while the radial-sequence MRI of single hip has been
used to diagnose the labral tear, the sensitivity and accuracy
has been improved.

Compared to MRI, MRA can produce better results,
sensitivity and accuracy increased to 90% and 91% after
joint distention, respectively. However, compared with
surgical findings, MRA still have a limited sensitivity (range
from 60% to 100%) and accuracy (range from 44% to
100%) after joint distention. These studies showed that arthroscopy is still the
gold standard of diagnosis.

A network analysis of all the articles showed the inter-
est of research relevant to the field of FAI and labral tear
(Fig. 8). “Overlay visualization” was applied to identify
author keywords of importance and give relative impact to
each keyword based on its calculated value. The keywords
could be considered as substitutions of scientific ideas.

“Patient-reported outcomes” is the keyword with the
newest average publication year rather than femorocetabular
impingement syndrome. “Clinical outcomes” is one of the
newest keywords and “Outcome” is the keyword with highest
citations in the network analysis. Meanwhile, the outcomes
of surgery are the most popular theme in the 100 most-cited
articles. In addition, “Femoroplasty,” “Borderline dysplasia,”
and “Capsule” are also some of the newest keywords and
“Alpha angle,” “Complications,” “Revision hip arthroscopy,”
and “Systematic review” are the keywords with the higher
citations in the network analysis.

With the development of surgical techniques and an
increase in the patients treated with these techniques, it is
important to evaluate the outcomes of current interven-
tions. The higher number of articles with outcomes
research, the higher requirements for instruments to evaluate
the index of outcomes.

Patient-reported outcome instruments are widely used
to evaluate the patients’ activities of daily life and hip pain
and functional outcomes, mainly including Harris Hip Score (HHS), Modified HHS, Merle d’Aubigne Hip Score, 12-item modified Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index, Non-Arthritic Hip Score (NAHS), and Hip Outcome Score (HOS)\(^5\)\(^6\).

It was reported that only three patient-reported outcome instruments (the HOS, NAHS, and the modified WOMAC Osteoarthritis Index) have shown “clinimetric evidence” (rigor of rating scales and indexes for the description of clinical phenomena) to support their use in measuring outcomes of patients with FAI and labral pathology and that HOS is the most proven instrument\(^7\). Patient-reported outcome instruments allow surgeons to pay more attention to the problems of patients and have been widely utilized in research and clinical practice\(^8\)\(^9\).

In this study, we present a comprehensive bibliometric analysis of the network analysis of keywords among all articles, themes of the 100 most-cited articles, and other important information in these articles that may provide useful evidence in revealing scientific research interests. In summary, outcomes research is the most popular interest of past and current research, and patient-reported outcome instruments might be further and widely used in the emerging articles in the near future.

There are several limitations to this study. Firstly, although a bibliometric analysis has been utilized to identify the 100 most-cited articles, some influential articles published recently have not had enough time to accumulate high citations and were therefore not included. Second, the 100 most-cited articles were identified in the Web of Science database, while citations from other databases, such as the world’s largest academic search engine Google Scholar\(^27\), were not included. Third, the number of citations of articles could be affected by its publication year because of time-accumulation effect, with the most recent articles being at a disadvantage\(^1\)\(^11\). Fourth, “the snowball effect”\(^1\)\(^11\) and self-citations may have influenced the citations. Finally, remote papers were less possible to be cited because of the “obliteration by incorporation” phenomenon.

**Conclusion**

This article performed a comprehensive bibliometric analysis of publication time, geographical distribution, authorship, research themes, keywords, and levels of evidence of articles in the field of FAI and labral tear research. And it is demonstrated that outcomes research is the most popular interest of research and patient-reported outcome instruments might be further and widely used in emerging articles in the near future. The field of FAI and labral tear has been shown as an obvious trend that is steadily evolving. It could be predicted that there will be an increasing number of publications in the following years, with the United States and Switzerland maintaining leadership in this field.

**Acknowledgments**

This study was supported by Hunan Provincial Innovation Foundation for Postgraduate (No. 2020zzts8885). We acknowledge that all authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and that all authors are in agreement with the manuscript.

**Supporting Information**

Additional Supporting Information may be found in the online version of this article on the publisher’s web-site:

- **Table S1.** The 100 most-cited articles on FAI and lateral tear.
- **Table S2.** Top 30 keywords in all articles ranked by average publication year.
- **Table S3.** Top 30 keywords in all articles ranked by average citations.

**References**

**1.** Moed HF. New developments in the use of citation analysis in research evaluation. Arch Immunol Ther Exp (Warsz), 2009, 57: 13–18.

**2.** Zupic I, Cater T. Bibliometric methods in management and organization. Organ Res Methods, 2015, 18: 420–472.

**3.** Joyce OW, Kelly JC, Sugrue C. A bibliometric analysis of the 100 most influential papers in burns. Burns, 2014, 40: 30–37.

**4.** Huo Y-Q, Pan X-H, Li Q-B, et al. Fifty top-cited classic papers in orthopedic elbow surgery: a bibliometric analysis. Int J Surg, 2015, 18: 28–33.

**5.** Kim HJ, Yoon DY, Kim ES, Lee K, Bae JS, Lee JH. The 100 most-cited articles in neuroimaging: a bibliometric analysis. Neuroimage, 2016, 139: 149–156.

**6.** Bang CS, Lee JJ, Baik GH. The most influential articles in helicobacter pylori research: a bibliometric analysis. Helicobacter, 2019, 24(4): e12589.

**7.** Zang 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.

**8.** Zhang Y, Wumaier M, He D, Xiao B, Zhang J. The 100 top-cited articles on spinal deformity a Bibliometric analysis. Spine, 2020, 45: 275–283.

**9.** Holzer LA, Holzer G. The 50 highest cited papers in hip and Knee Arthroplasty. J Arthroplasty, 2014, 29: 453–457.

**10.** Baldwin K, Namdari S, Donegan D, Kovatch K, Ahn J, Mehta S. 100 most cited articles in fracture surgery. Am J Orthop (Bellevue Mead, NJ), 2013, 42: 547–552.

**11.** Lefalvra KA, Shaqgfan B, O’Brien PJ. 100 Most cited articles in Orthopaedic surgery. Clin Orthop Relat Res, 2011, 469: 1487–1497.

**12.** Lum ZC, Pereira GC, Giordani M, Meehan JP. Top 100 most cited articles in orthopaedic surgery: an update. J Orthop, 2020, 19: 132–137.

**13.** Wang W, Don Y, Huf Z, Hong W, Zir L. Clinical diagnosis and arthroscopic treatment of acetabular labral tears. Orthop Surg, 2011, 3: 28–34.

**14.** Kuhns BD, Weber AE, Levy DM, Wuerz TH. The natural history of Femoroacetabular impingement. Front Surg, 2015, 2: 58.

**15.** Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement a cause for osteoarthritis of the hip. Clin Orthop Relat Res, 2003, 417: 112–120.

**16.** Philippin MJ, Stubb AJ, Schenker ML, Maxwell RB, Ganz R, Leunig M. Arthroscopic management of femoroacetabular impingement - Osteoplasty technique and literature review. Am J Sports med, 2007, 35: 1571–1580.

**17.** Leunig M, Podeszwa D, Beck M, Werlen S, Ganz R. Magnetic resonance arthrography of labral disorders in hips with dysplasia and impingement. Clin Orthop Relat Res, 2004, 418: 74–80.

**18.** Beck M, Kalhorn M, Leunig M, Ganz R. Hip morphology influences the pattern of damage to the acetabular cartilage - Femoroacetabular impingement as a cause of early osteoarthritis of the hip. J Bone Joint Surg, 2005, 87B: 1012–1018.

**19.** Groth MM, Herrera J. A comprehensive review of hip labral tears. Curr Rev Musculoskelet med, 2009, 2: 105–117.

**20.** Wengr DE, Kewell KR, Miner MR, Trousdale RT. Acetabular labral tears rarely occur in the absence of bony abnormalities. Clin Orthop Relat Res, 2004, 426: 145–150.
