ORIGINAL RESEARCH

Periprosthetic Fracture Literature Since 1990: A Bibliometric Analysis

1990'dan Beri Periprostetik Kırık Literatürü: Bibliyometrik Analiz

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Abstract

Objective: This study presents a comprehensive bibliometric analysis of the literature on periprosthetic fracture since 1990. The goal is to uncover prevalent themes, key authors, and geographical trends. Periprosthetic fractures are significant complications in patients undergoing geriatric arthroplasty. Although traditional literature reviews on this subject exist, bibliometric methods may uncover previously unseen trends and nuances that may have been overlooked.

Method: The Web of Science database was searched from January 1990 to December 2022, retrieved 2445 articles and reviews. Data were imported into CiteSpace and VOSviewer for keyword, authorship, citation burst analysis, and co-citation clustering.

Results: An exponential growth in periprosthetic fracture literature since the late 1990s was noted. The United States led in research output, followed by the United Kingdom and Germany. Prominent authors experiencing citation bursts included Lewallen, Berry, Duncan, Masri, and Abdel. Co-citation analysis revealed ten prominent clusters, with high silhouette values indicating strong thematic cohesion.

Conclusion: This study provides a holistic view of the evolution and current state of periprosthetic fracture research. The study highlights the United States of America, the United Kingdom, and Germany as leaders but notes increasing contributions from other countries. This study reveals the changing landscape as well as influential authors and thematic clusters in this field.

Keywords: Bibliometric analysis, cluster analysis, periprosthetic fractures

Öz

Amaç: Bu çalışma, 1990'dan bu yana periprostetik kırık literatürüne dair kapsamlı bir bibliyometrik analiz yapmaktadır. Amacı, yaygın temaları, ana yazarları ve coğrafi eğilimleri ortaya çıkarmaktır. Periprostetik kırıklar, geriatrik artroplasti popülasyonunda önemli bir komplikasyondur. Bu konuda geleneksel literatür incelemeleri mevcut olsa da, bibliyometrik yöntemler daha önce görülmemiş eğilimleri ve nüansları ortaya çıkarabilir.

Yöntem: Web of Science veritabanı, Ocak 1990'dan Aralık 2022'ye kadar taranmış, 2445 makale ve inceleme elde edilmiştir. Veriler, anahtar kelime, yazarlık ve alıntı patlaması analizi ile birlikte ko-sitasyon kümelemesi için CiteSpace ve VOSviewer'a aktarılmıştır.

Bulgular: 1990'ların sonlarından bu yana periprostetik kırık literatüründe üssel bir artış gözlemlenmiştir. Araştırma sonucunda Amerika Birleşik Devletleri önde gelmekte olup, ardından İngiltere ve Almanya gelmektedir. Alıntı patlaması yaşayan öne çıkan yazarlar arasında Lewallen, Berry, Duncan, Masri ve Abdel bulunmaktadır. Ko-sitasyon analizi, yüksek siluet değerleriyle güçlü tematik uyum gösteren on önemli küme ortaya çıkarmıştır.

Sonuç: Bu çalışma, periprostetik kırık araştırmalarının evrimini ve mevcut durumunu bütünsel bir bakış açısıyla sunmaktadır. Amerika Birleşik Devletleri, İngiltere ve Almanya'nın lider olduğu görülmekle beraber, diğer ülkelerden artan katkılar da son yıllarda dikkat çekmektedir. Bu çalışma, bu alandaki değişen literatürü, etkili yazarları ve tematik kümeleri ortaya koymuştur.

Anahtar kelimeler: Bibliyometrik analiz, küme analizi, periprostetik kırıklar

Introduction

Osteoarthritis (OA) is an important cause of disability in the elderly population (1). The number of joint replacements for OA performed annually has been increasing worldwide (2). Although hip and knee replacements have been the dominant surgical approach, shoulder arthroplasty has been associated with an even greater rate of growth (3). They are performed both in the elective and emergency settings, depending on the patient's presentation (4,5). With the ever-increasing number of surgeries, the number of reported complications has also increased. A major complication of joint replacement surgery is periprosthetic fracture. Periprosthetic fractures can occur intra- or postoperatively and can cause significant morbidity and mortality (6-8).

As the body of literature expands, it is often easier to identify the main issues of controversy, whereas minor trends or areas of interest, and geographical trends might go unnoticed. Bibliometric analysis is an approach that aids in recognizing patterns within a vast array of publications and in comprehending inherent data. This could involve pinpointing prevalent themes or keywords and creating visual representations of the citation network, relevant journals, and other significant data.

This study aimed to conduct a comprehensive bibliometric analysis of the literature on periprosthetic fractures published since 1990, with the objective of revealing prevalent themes, influential authors, and geographical trends in research output. The analysis aims to provide valuable insights into the evolution of this field and to identify key research contributions and potential directions for future research.

Materials and Methods

The Web of Science (WoS) database by Clarivate Analytics was searched in June 2023, covering the period from January 1990 to December 2022, using the following query in the title, abstract, or keywords: [TS=("periprosthetic fracture" OR "periprosthetic fracture*")] OR [TI=("periprosthetic fracture" OR "periprosthetic fracture*")] OR [AB=("periprosthetic fracture" OR "periprosthetic fracture*")]. The document type was an article or review article in English. Only the Science Citation Index Expanded and Emerging Sources Citation Index results were included. Overall, 2445 results were obtained. Titles, authors, abstracts, institutions, countries, journals, references, and citation information were recorded.

Statistical Analysis

The obtained data were imported into CiteSpace 6.1. R6, 64-Bit (Drexel University, Philadelphia, PA, USA) (9) and VOSviewer 1.6.15 (10). Keywords, authorship, and citation burst analysis were also performed. The network of keywords and organizations was analyzed and visualized using VOSviewer. Co-citation analysis and clustering were performed using CiteSpace. Clusters were analyzed using silhouette and centrality metrics and labeled using different algorithmic methods [latent semantic indexing (LSI), log-likelihood ratio (LLR), and mutual information (MI)]. A p-value of less than 0.05 was considered statistically significant.

Results

The literature regarding periprosthetic fractures has been published since the late 1990s (Figure 1). In the first decade, 50 publications were identified, of which the total number of citations was 69. In 2022 alone, there were 252 publications and 6591 citations on the topic, underlining the exponential growth of the subject area.

Country Analysis

Table 1 summarizes the top 10 countries with the highest number of publications. The United States of America (USA) leads with 873 articles and a centrality of 0.27. The United Kingdom (UK) and Germany also obtained centrality scores, indicating the influence of publications from these countries. The burst analysis results are presented in Figure 2. Figure 3 presents the co-authorship map of the countries. Thicker lines indicate stronger links, larger nodes indicate higher co-authorship counts, and lighter colors indicate more recent co-authorship.
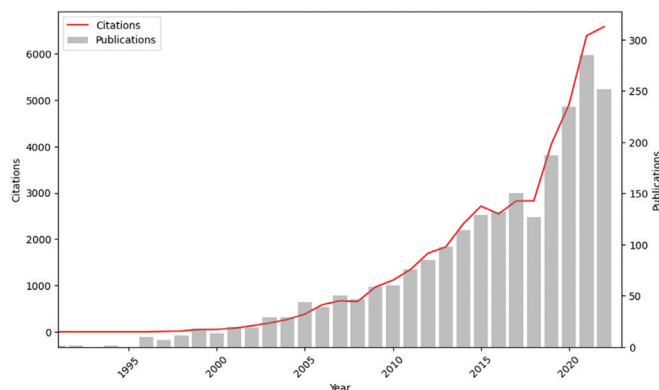

Figure 1. Number of publications and citations generated per year. The red line represents the number of citations

Author and Cited Author Burst Analysis

Figures 4 and 5 show the results of the burst analysis of the top 10 authors and cited authors in the dataset, respectively. The analysis of author bursts between 1990 and 2023 shows that certain authors experienced periods of significant productivity, as evidenced by a surge in the appearance of their works. Lewallen, DG, had a citation burst between 1996 and 2004, with a strength of 4.47. Berry, DJ, exhibited a similar burst between 1997 and 2003, with

a strength of 4.57. Duncan and Masri had citation bursts from 1999 to 2005 with a strength of 4.4. In the mid-2000s, Parvizi emerged as a prominent figure, with citation bursts occurring from 2006 to 2011, reaching a strength of 4.91. Wagner, Eric R. and Abdel, Matthew P. experienced bursts more recently, between 2015 and 2018 and 2017 and 2021, respectively, with strengths of 4.19 and 5.65.

Figure 5 presents the top 10 cited authors in the field who experienced the strongest citation bursts between 1990 and 2023. The three authors with the most recent and ongoing citation bursts are Abdel (2017-2023, strength 54.85),

Table 1. Top 10 most publishing countries between 1990-2022

Ranks	Country	No. of articles	Centrality
1	USA	873	0.27
2	United Kingdom	262	0.18
3	Germany	200	0.08
4	China	120	0.01
5	Canada	114	0.02
6	South Korea	77	0.00
7	Italy	64	0.06
8	Australia	53	0.02
9	France	52	0.02
10	Japan	41	0.01

USA: United States of America

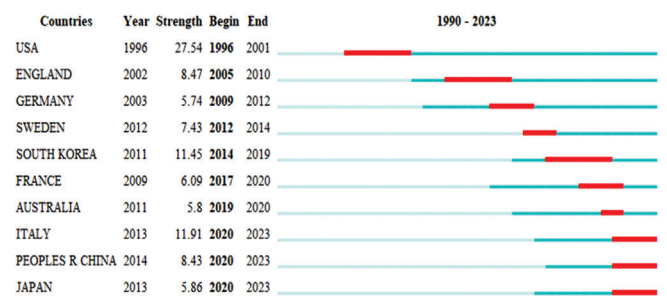| Countries	Year	Strength	Begin	End	1990 – 2023
USA	1996	27.54	1996	2001	
ENGLAND	2002	8.47	2005	2010	
GERMANY	2003	5.74	2009	2012	
SWEDEN	2012	7.43	2012	2014	
SOUTH KOREA	2011	11.45	2014	2019	
FRANCE	2009	6.09	2017	2020	
AUSTRALIA	2011	5.8	2019	2020	
ITALY	2013	11.91	2020	2023	
PEOPLES R CHINA	2014	8.43	2020	2023	
JAPAN	2013	5.86	2020	2023	

Figure 2. Top 10 countries with the strongest citation bursts
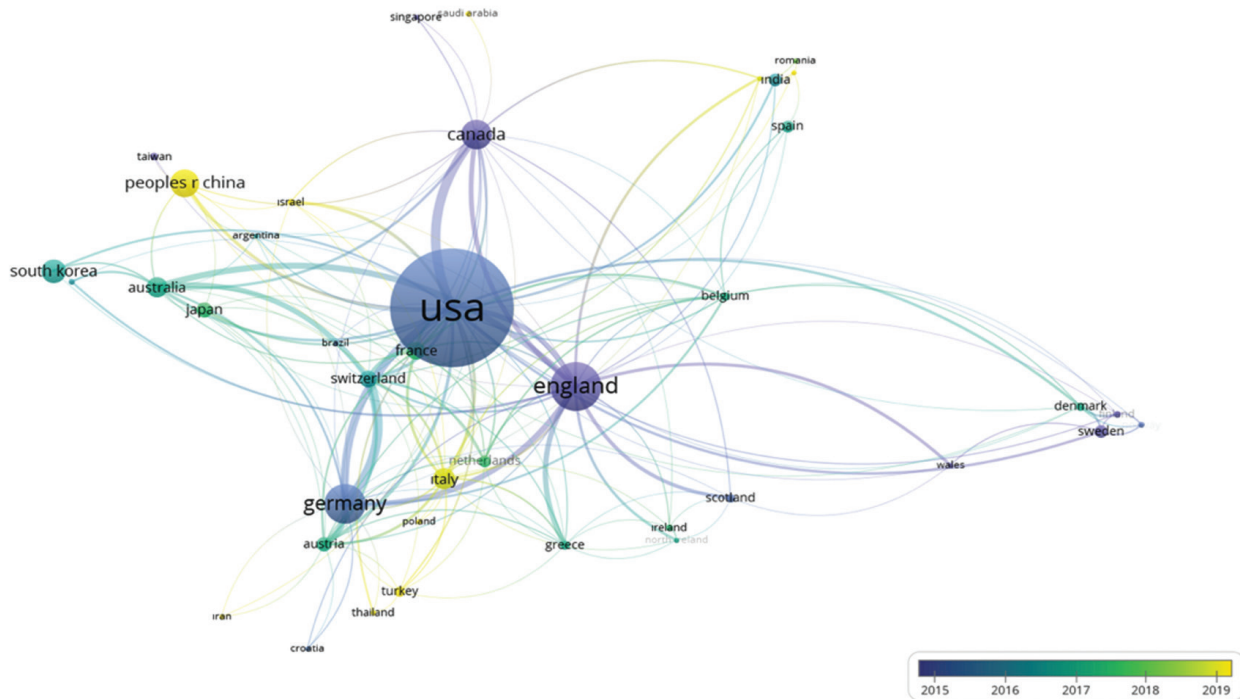
USA: United States of America

Figure 3. Network representation of country co-authorship. Thicker lines indicate stronger links between countries, while lighter colors indicate newer coauthorships
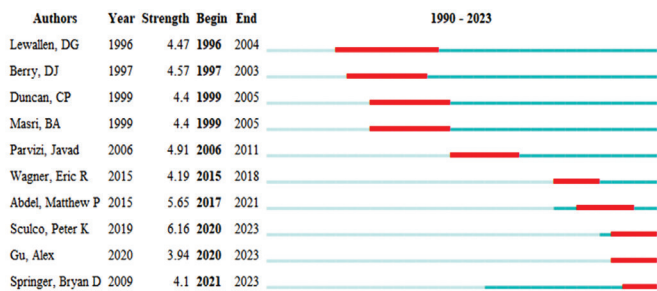
USA: United States of America

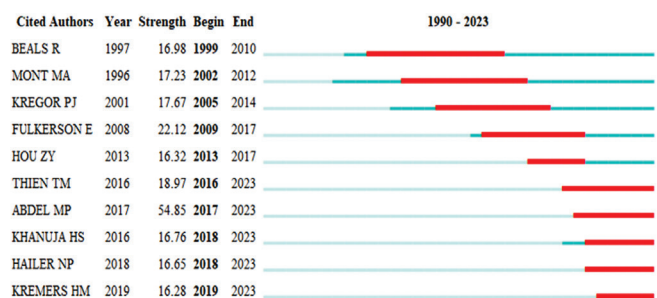**Figure 4.** Top 10 authors with the strongest citation bursts

Figure 5. Top 10 cited authors with the strongest citation bursts

Khanuja (2018-2023, strength 16.76), Hailer (2018-2023, strength 16.65), and Kremers (2019-2023, strength 16.28). Abdel's citation burst is particularly notable for its strength, which is 54.85 and is significantly greater than that of the other authors, indicating the significant impact of this author in the field.

Co-citation Analysis and Clustering

Co-citation network analysis was performed on the dataset. In total, 3237 distinct references were identified. These were graphed on a network with 4354 nodes and 17500 links. The ten largest connected clusters are visualized in Figure 6. Table 2 summarizes the 10 largest automatically labeled clusters identified using different algorithms. The most substantial cluster (cluster 0) contained 416 articles and had a silhouette value of 0.865, indicating a high level of internal consistency. The primary theme was periprosthetic fracture, which was identified using both LSI and MI methods, with interprosthetic femoral fracture emerging as a specific subtheme using the LLR method. This theme was also prominently manifested in clusters 1, 3, 5, and 8. Cluster 1 included 279 articles and had a high silhouette value of 0.909; additionally, the direct anterior approach
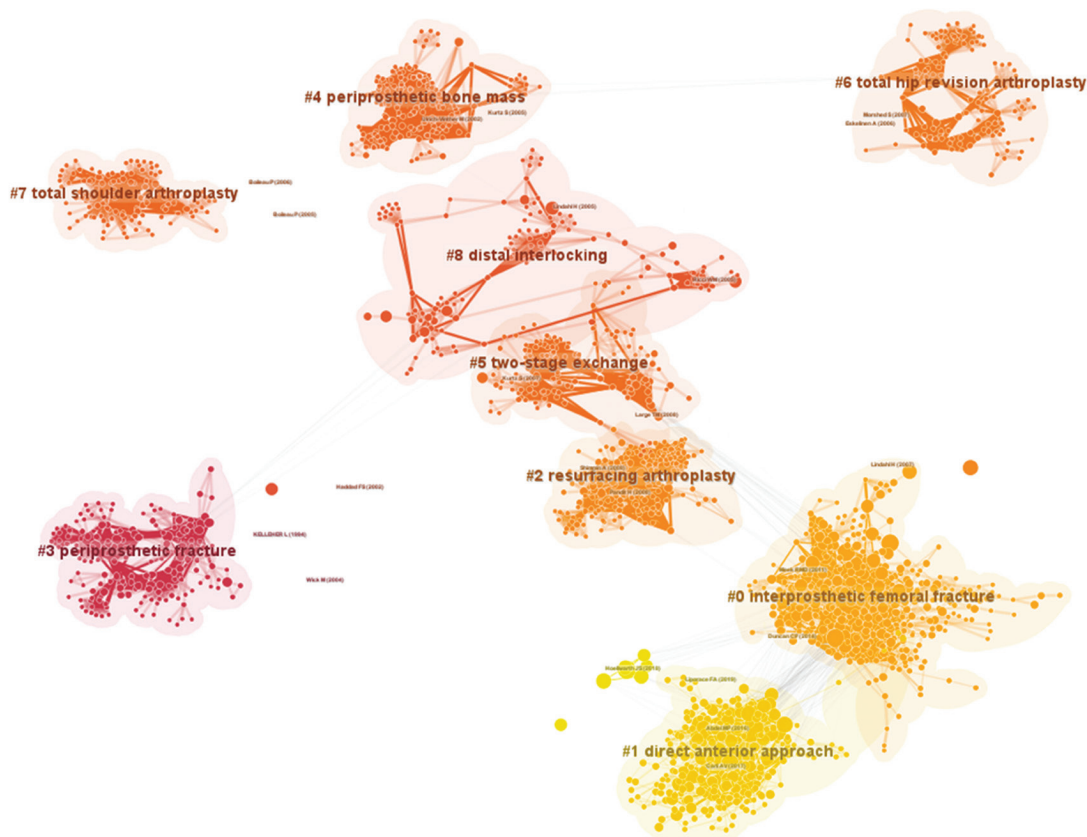

Figure 6. Clustered network map of located references for periprosthetic fractures

was also highlighted as a significant subtheme. Cluster 3 comprised 169 articles, again focusing on periprosthetic fractures, dating back to earlier research in 1995.

Table 3 presents the top-cited publications for each of the 10 largest clusters identified in the cogitation network. These papers represent influential contributions that have shaped the understanding and methodology of each cluster.

Discussion

This bibliometric study presents a comprehensive analysis of orthopedic research output from 1990 to 2022. The literature on periprosthetic fractures has been expanding rapidly, and given the increase in the number of arthroplasty procedures performed, it is safe to assume that this trend will continue in the near future.

Table 2. Summary of the largest 10 clusters in the co-citation network						
Cluster	Size	Silhouette	Label (LSI)	Label (LLR, p-value)	Label (MI score)	Average year
0	416	0.865	Periprosthetic fracture	Interprosthetic femoral fracture (855.44, <0.001)	Infected interprosthetic femoral shaft fracture (3.75)	2011
1	279	0.909	Periprosthetic fracture	Direct anterior approach (871.64, <0.001)	Infected interprosthetic femoral shaft fracture (4.54)	2016
2	189	0.99	Resurfacing arthroplasty	Resurfacing arthroplasty (170.41, <0.001)	Periprosthetic fracture (0.06)	2008
3	169	0.978	Periprosthetic fracture	Periprosthetic fracture (272.89, <0.001)	Periprosthetic fracture (0.05)	1995
4	168	0.991	Periprosthetic bone mass	Periprosthetic bone mass (81.17, <0.001)	Periprosthetic fracture (0.07)	2003
5	143	0.977	Periprosthetic fracture	Two-stage exchange (109.78, <0.001)	Periprosthetic fracture (0.06)	2005
6	125	0.991	Total hip arthroplasty	Total hip revision arthroplasty (57.12, <0.001)	Periprosthetic fracture (0.06)	2005
7	122	1	Total shoulder arthroplasty	Total shoulder arthroplasty (44.73, <0.001)	Periprosthetic fracture (0.07)	2004
8	122	0.991	Periprosthetic femoral fracture	Distal interlocking (167.61, <0.001)	Periprosthetic fracture (0.05)	2001
9	121	0.981	Systematic review	Distal femoral replacement (1082.97, <0.001)	Double-locked plating (0.65)	2018

LSI: Latent semantic indexing, LLR: Log-likelihood ratio, MI: Mutual information

Table 3. Top cited publication of each cluster		
Cluster	Cluster label	Authors, year, title
0	Interprosthetic femoral fracture	Meek et al., 2011, "The risk of peri-prosthetic fracture after primary and revision total hip and knee replacement"
1	Direct anterior approach	Abdel et al., 2016, "Epidemiology of periprosthetic fracture of the femur in 32 644 primary total hip arthroplasties: a 40-year experience"
2	Resurfacing arthroplasty	Shimmin et al., 2008, "Metal-on-metal hip resurfacing arthroplasty"
3	Periprosthetic fracture	Wick et al., 2004, "Periprosthetic supracondylar femoral fractures: LISS or retrograde intramedullary nailing? Problems with the use of minimally invasive technique"
4	Periprosthetic bone mass	Kurtz et al., 2005, "Prevalence of Primary and Revision Total Hip and Knee Arthroplasty in the United States From 1990 Through 2002"
5	Two-stage exchange	Kurtz et al., 2007, "Projections of Primary and Revision Hip and Knee Arthroplasty in the United States from 2005 to 2030"
6	Total hip revision arthroplasty	Morshed et al, 2007, "Comparison of cemented and uncemented fixation in total hip replacement"
7	Total shoulder arthroplasty	Boileau et al., 2006, "The Grammont reverse shoulder prosthesis: Results in cuff tear arthritis, fracture sequelae, and revision arthroplasty"
8	Distal interlocking	Lindahl et al., 2005, "Periprosthetic Femoral Fractures: Classification and Demographics of 1049 Periprosthetic Femoral Fractures from the Swedish National Hip Arthroplasty Register"
9	Distal femoral replacement	Hoellwarth et al., 2018, "Equivalent mortality and complication rates following periprosthetic distal femur fractures managed with either lateral locked plating or a distal femoral replacement"

Traditional citation analysis mainly relies on citation count, which measures the number of times a particular work or author is cited (11). While this is a good indicator of general influence, it does not necessarily reflect the content or context of the citations nor how works relate to each other.

Co-citation analysis is a bibliometric method that helps researchers discover influential publications and authors, offering a more detailed view than standard literature research (12). Specifically, if two documents are frequently cited together by other papers, they are likely to share a thematic relationship and contribute significantly to their field of research. This approach can highlight key publications or authors that may not necessarily have the highest citation count but are important in shaping the discourse in a given field. This approach is different from bibliographic coupling, which links papers sharing common references. Instead, it links papers that are cited together even though they may not share a common reference (13).

Burst analysis identifies any statistically significant variations in the appearance of a country, author, or title over a given time interval. This technique is essential for determining if and when the citation count for a specific reference has notably increased and offers a different view than traditional citation count lists, which may have a negative bias toward highly influential but recent titles (14). Burst analysis was performed for this study using CiteSpace, an algorithm developed by Kleinberg (15).

The silhouette metric, introduced in 1987 by Rousseeuw (16), is beneficial for estimating the uncertainty in defining a cluster's characteristics. The silhouette value for a cluster ranging from 1 to 1 indicates the level of uncertainty to be considered when examining the nature of the cluster. A value of 1 denotes an ideal distinction from other clusters.

Centrality measures the importance of a node (article, author or country) in a network based on its connections to other nodes. Articles with higher centrality values indicate that they are more central and influential within their clusters (17).

This bibliometric analysis provides insight into the landscape of the literature on periprosthetic fracture and hints at several geographical trends. Notably, the United States has emerged as the most productive country, publishing a staggering 873 articles with a centrality of 0.27. The UK and Germany had 262 and 200 articles, respectively. However, despite the small number of articles, these

countries maintained notable centrality, indicating their significant influence on orthopedic research.

When examining the citation burst data, the United States, England, and Germany stood out, suggesting that they had important influence on the literature during certain periods. The USA's citation burst peaked between 1996 and 2001, reflecting the high impact of their research during that time. UK and Germany exhibited significant citation bursts, peaking between 2002 and 2010 and between 2003 and 2012, respectively. Interestingly, countries with fewer overall publications, such as South Korea, Sweden, and Italy, also showed robust citation bursts, indicating a significant contribution to the global body of orthopedic knowledge during their peak periods. In recent years, Italy, the People's Republic of China, and Japan have demonstrated a surge in citation strength from 2020 to 2023. Despite their relatively lower number of publications, their research in the field of orthopedics was highly impactful during this period. These data suggest a growing diversification in influential orthopedic research, with countries beyond the traditionally dominant USA and the UK making significant contributions. It is also worth noting that, although not among the top 10 countries, Turkey is also a prominent newcomer in the field (Figure 3) in co-authorship, with relatively strong links to the United States and Italy.

In co-citation analysis, a cluster signifies a common theme among the references. The characteristics of a group of located references can be determined through cluster label-generated labels of the cluster (18). CiteSpace provides three selection methods based on LSI, the LLR, and MI. Each selection method may highlight different aspects of a cluster (9).

High silhouette values in the clusters (Table 2), ranging from 0.865 to 0.991, illustrate strong intracluster similarity and clear differentiation from other themes, bolstering the robustness of the clustering approach. The exploration of topics such as resurfacing arthroplasty, total hip and shoulder arthroplasty, and systematic reviews further enriches the diversity of research areas covered in the cogitation network.

These results are further contextualized by examining the top-cited publications of each cluster (Table 3). For instance, Meek et al.'s study on the risk of periprosthetic fracture associated with the cluster labeled "interprosthetic femoral fracture" showcases the significance of this research within the field. Similarly, Abdel et al.'s work on the epidemiology of periprosthetic fractures of the femur aligns

with the cluster labeled "direct anterior approach". These top-cited publications encapsulate the core themes of their respective clusters and guide researchers toward influential works on these topics. Because they are strongly linked to other studies in the cluster, understanding or analyzing these studies may provide insights into the entire cluster. These top-cited works may serve as important references for researchers, providing insight into key discussions, debates, and methodologies in the respective fields.

Study Limitations

A key limitation of this study was our reliance on the WoS database, which, although comprehensive, may not include all relevant literature on periprosthetic fractures and may not include significant studies indexed in other databases. Furthermore, bibliometric analysis primarily focuses on quantitative metrics such as citation counts and coauthorship networks. These may not fully capture the quality and impact of the studies, potentially leading to overestimation or underestimation. Lastly, this study may not have accounted for the most recent trends in the field, especially those that have not yet had time to be cited enough times to be picked by the bibliometric method.

Conclusion

This study provides a holistic view of the literature on periprosthetic fracture, tracking its evolution over the past few decades and outlining influential themes, authors, and geographical trends. The United States, the UK, and Germany have been instrumental in leading research output, with increasing contributions from countries such as South Korea, Sweden, Italy, China, Japan, and Turkey. Recognized authors such as Lewallen, Berry, Duncan, Masri, Parvizi, Wagner, and Abdel left significant imprints on the field with their citation bursts. The insights from this study can assist researchers and clinicians in understanding the landscape of periprosthetic fracture research, identifying influential contributors, and identifying future research directions in this rapidly evolving field.

Ethics

Ethics Committee Approval: Not necessary for this manuscript.

Informed Consent: Not necessary for this manuscript.

Authorship Contributions

Concept: E.Ö., S.Y., O.B., Design: E.Ö., S.Y., O.B., Data Collection or Processing: A.B., E.Ç., Analysis or Interpretation: E.Ç., Drafting Manuscript: E.Ö., A.B., E.Ç.,

Critical Revision of Manuscript: S.Y., O.B., Final Approval and Accountability: E.Ö., A.B., E.Ç., S.Y., O.B., Technical or Material Support: A.B., E.Ç., Supervision: S.Y., O.B., Writing: E.Ö., A.B., E.Ç., S.Y., O.B.

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