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Research on Traumatic Knee Osteoarthritis: A Bibliometric and Visualized Study

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Abstract: *This investigation employs advanced bibliometric visualization techniques to elucidate key research foci and emerging trends in post-traumatic knee osteoarthritis (PTOA) while analyzing global research patterns. Using the Web of Science Core Collection (Science Citation Index-Expanded), we systematically extracted scholarly publications on PTOA from January 1, 1900, to April 16, 2025. Through rigorous bibliometric analysis and systematic indexing of source data, we implemented VOSviewer (v1.6.20) to conduct multidimensional assessments including collaborative network mapping,term co-occurrence analysis, bibliographic coupling, and citation network evaluation. Our comprehensive analysis of 1,488 peer-reviewed articles revealed consistent annual growth in global PTOA research output. The United States emerged as the dominant contributor, demonstrating the highest publication volume, citation counts, and h-index values. Osteoarthritis and Cartilage and Journal of Orthopaedic Research were identified as the most prolific journals, while four institutions—Harvard University, Lund University, the University of Calgary, and the Hospital for Special Surgery—stood out as leading research centers. Three primary research domains were identified:mechanistic studies, clinical investigations, and tissue regeneration research. Projections indicate that clinical translational research, particularly studies on total joint arthroplasty for PTOA management, will dominate future research directions. These findings establish the United States as the field's primary knowledge producer while highlighting clinical applications as the next research frontier in PTOA therapeutics.*

Keywords: *Post-Traumatic Knee Osteoarthritis; Global Trends; Bibliometrics; Visualization Analysis*

1. Introduction

Post-traumatic osteoarthritis (PTOA) most commonly occurs following trauma or accidents associated with sports or military activities. It primarily affects young individuals, although PTOA can occur across all age ranges[1]. Common clinical symptoms include gradual onset of knee pain exacerbated by activity, knee stiffness and swelling, pain after prolonged sitting or rest, and progressively worsening pain over time [2]. Studies have reported that TNF-α and IL-6 cytokines in synovial fluid following knee trauma serve as pathogenic factors, while IL-1 and IL-17 are reliable factors inducing disease progression in knee PTOA [3]. Additionally, factors such as gender, degree of anterior cruciate ligament (ACL) tear, ACL reconstruction technique (ACLR), age, body mass index, ACLR graft source, and concomitant cartilage injury with ACL damage may constitute risk factors for habitual PTOA [4,5].

Despite continuous advancements in PTOA research, its pathogenesis remains incompletely understood. While mechanical symptoms of PTOA (e.g., joint instability and knee locking) can be addressed surgically, significant gaps persist in halting disease progression, with a notable lack of effective preventive interventions. Particularly in anti-inflammatory therapies for PTOA, substantial knowledge deficits exist regarding its precise pathophysiological mechanisms and disease trajectory, necessitating further mechanistic studies to establish definitive research priorities [6]. Moreover, global trends in PTOA research remain underexplored. This underscores the need to synthesize current research landscapes and forecast emerging keywords and developmental trajectories. Bibliometric analysis (BA) has emerged as an indispensable tool for mapping disciplinary dynamics [7]. BA enables qualitative and quantitative evaluation of evolving research patterns by analyzing bibliographic databases and scientometric indicators [8]. It provides systematic approaches to track disciplinary advancements while comparing contributions across scholars, journals, institutions, and nations. Notably, BA has been

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instrumental in formulating evidence-based policies and clinical guidelines [9]. While this validated analytical framework has demonstrated efficacy in mapping research landscapes across osteoarthritis, hypertension, diabetes, and trauma-related conditions, existing literature reveals a paucity of systematic evaluations specifically quantifying scientific output metrics in knee post-traumatic osteoarthritis (PTOA). This investigation therefore seeks to systematically characterize the contemporary therapeutic research paradigm and emerging global patterns in PTOA management.

2. Experimental Design and Analytical Methods

2.1 Data Acquisition and Curation

Bibliometric investigations employed the Web of Science Core Collection (WOS-CC; Science Citation Index Expanded), the gold-standard database for scientometric investigations, ensuring methodological rigor in data acquisition [10].

2.2 Boolean Search Algorithm Construction

The systematic search protocol implemented Boolean operators with the following algorithm: ("traumatic knee osteoarthritis"[MeSH Terms]) AND temporal parameters (1900-2025) AND linguistic filter (English) AND publication modality (original research articles), with explicit inclusion criteria applied through April 2025.

2.3 Data Collection

Comprehensive bibliometric metadata encompassing titles, publication chronologies, authorship networks, institutional affiliations, geographic distributions, journal profiles, keyword taxonomies, and abstract content were systematically extracted from Web of Science (WOS) repositories and archived in WPS Office environments. Independent investigators executed standardized data curation protocols involving iterative processes of de-duplication, metadata validation, and structured database population, followed by consensus-driven analytical verification.

2.4 Quantitative Scientometric Evaluation

Scientometric evaluation has emerged as an indispensable analytical framework for global scientific landscape investigations, employing advanced quantitative methodologies to decipher knowledge evolution patterns across disciplinary boundaries [11]. The network visualization platform VOSviewer was strategically implemented to map core attributes of the curated literature corpus, enabling topological analysis of scientometric network topologies [12]. The h-index persists as a principal quantitative benchmark in research impact assessment, operationally defined as the maximum value h where h publications have each accumulated ≥h citations, reflecting consolidated scholarly influence [13]. The logistic growth model (f(x) = a / (1 + e^{b−cx})) exhibitis robust predictive validity in modeling knowledge diffusion trajectories, with parameter optimization achieved through maximum likelihood estimation [14]. Temporal publication trends were visualized via WPS statistical visualization modules, where temporal variable (x-axis) and cumulative publication output (f(x)) were subjected to polynomial regression analysis. Multidimensional scientometric indicators – including annual productivity metrics, global rankings (top 20 entities across nations/authors/institutions), funding portfolios, disciplinary distributions, citation dynamics (total/mean citations), and h-index distributions – were systematically computed using WPS analytical suites. For advanced knowledge domain mapping, VOSviewer (v1.6.18) facilitated four-dimensional network analyses: 1) bibliographic coupling, 2) co-citation clustering, 3) semantic co-occurrence profiling, and 4) collaborative network deconstruction [15].

3. Results

3.1 Trends in Global Publications

3.1.1 Total Global Publications

The results of global publication trends revealed that a total of 1,488 articles met the search criteria between January 1, 1900, and April 21, 2025. Annual publication volumes were examined, with the

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majority of studies published between 2017 and 2024 (889 articles, 59.74%). Recent years showed comparable publication numbers, with 2020 having the highest annual output (134 articles. As 2025 has not yet concluded, annual comparisons are omitted, but based on recent trends, it is predicted that the number of publications in 2025 will be similar to those of previous years. From 1900 to 2025, a clear upward trend in global publications related to post-traumatic osteoarthritis (PTOA) was observed (Figure 1a).

3.1.2 Contributions by Country

A total of 66 countries and regions contributed to this field. Among these, the United States published the highest number of related articles (608 articles, 40.860%), followed by China (149 articles, 10.013%), Canada (145 articles, 9.745), England (85 articles, 5.713%), and Australia (84 articles, 5.645%) (Figure 1b).

3.1.3 Global Publication Trends

A logistic growth model was applied to create a temporal curve of publication volumes, enabling predictions of future trends. Figure 1c displays the fitted curve of the growth trend model, projecting the anticipated increase in global publication numbers in the coming years.

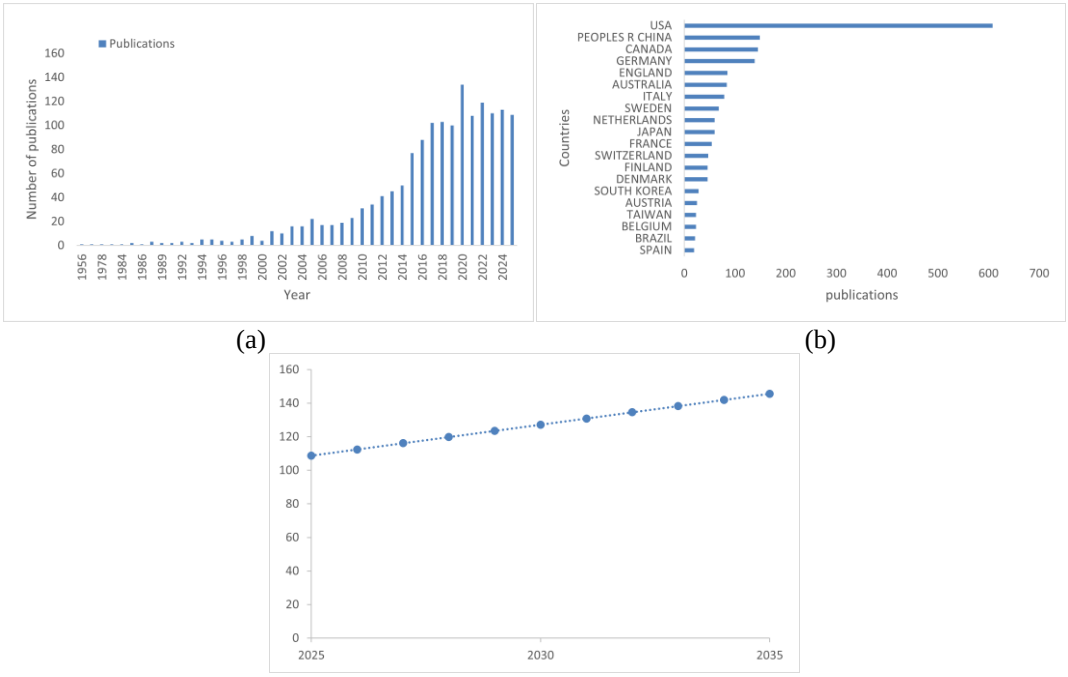

Figure 1: Global publication trends related to post-traumatic osteoarthritis (PTOA) and associated research: (a) Temporal publication dynamics in post-traumatic osteoarthritis (PTOA) and associated research domains; (b) Geospatial research productivity: National contribution metrics of top 20 PTOA knowledge producers; (c) Predictive growth modeling: Projected trajectory of global PTOA literature expansion

3.2 Publication Quality by Country

3.2.1 Aggregate Citation Impact Analysis

The United States demonstrated scholarly preeminence with a cumulative citation count of 21,499, establishing a dominant citation footprint. European contributors followed sequentially: Germany (4,426 citations), Sweden (3,908 citations), Canada (3,327 citations), and the Netherlands (3,321 citations), collectively illustrating geographical disparities in research influence (Figure 2a).

3.2.2 Normalized Citation Impact Assessment

Norway demonstrated superior citation efficiency (63.40 citations/publication), achieving the highest normalized impact ratio among surveyed nations. Scandinavian research systems maintained strong representation, with Sweden (57.47) and the Netherlands (54.59) exhibiting comparable citation parity. East Asian scientific output emerged through South Korea's competitive performance (53.81), while

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Belgium (49.59) completed the quintet of high-impact contributors, revealing distinct regional patterns in research caliber (Figure 2b).

3.2.3 H-index

The United States achieved the highest h-index (70), followed by Germany (35), Canada (32), Sweden (31), and Australia (31) (Figure 2c).

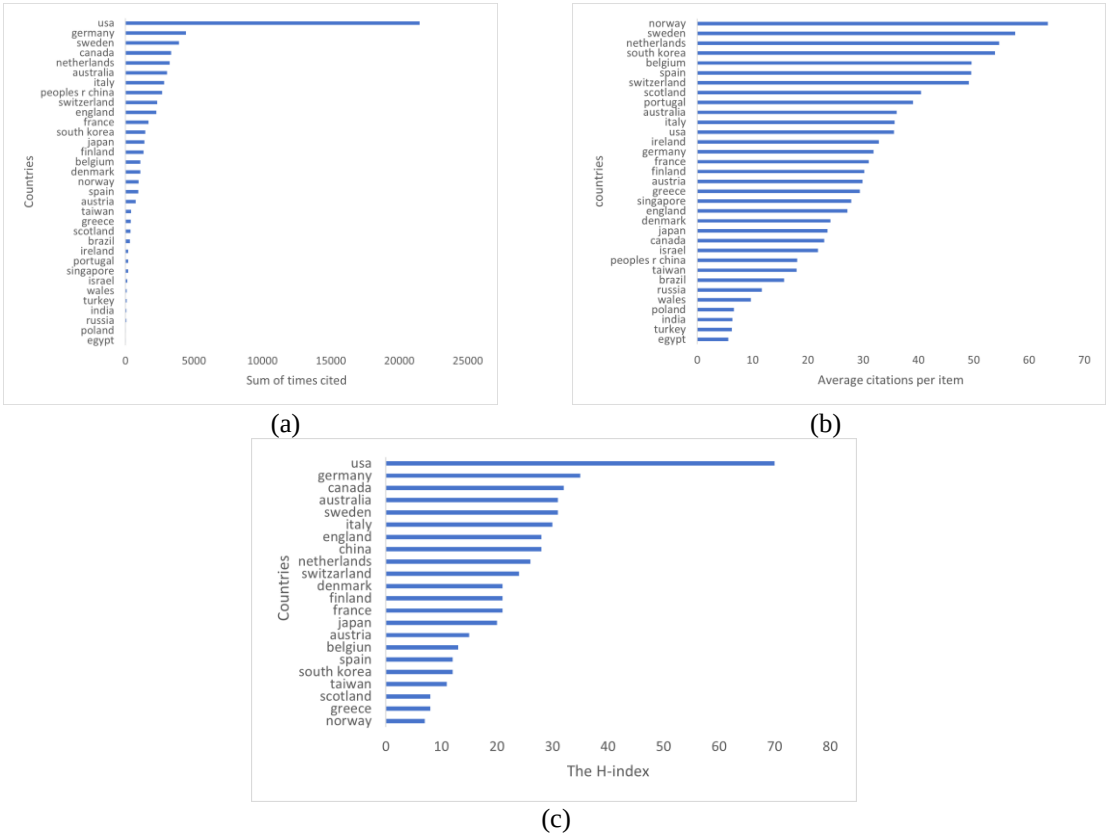

Figure 2: Geospatial Scientometric Profile of PTOA Research Impact: (a) Aggregate Citation Impact: National Contribution Patterns in PTOA Research; (b) Normalized Citation Efficiency: Per-Article Influence Metrics by Country; (c) Scholarly Influence Metrics: h-index Stratification Across Nations

3.3 Multidimensional Scientometric Assessment of International Scholarly Output

3.3.1 Journal Analysis

The journal Osteoarthritis and Cartilage (5-year impact factor [IF] = 5.118) ranked first, publishing 185 articles on PTOA research. Journal of Orthopaedic Research (5-year IF = 5.636) contained 93 articles,Knee Surgery Sports Traumatology Arthroscopy (5-year IF = 6.750) included 62 articles, and American Journal of Sports Medicine (5-year IF = 5.778) contributed 37 articles related to PTOA. The top 20 journals by publication volume are shown in Figure 3a.

3.3.2 Funding Sources

The U.S. Department of Health and Human Services led funding (245 studies), followed by the National Institutes of Health (240 studies). The top 20 sponsors are shown in Figure 3b.

3.3.3 Authors

The top 20 authors collectively published 322 articles, accounting for 21.64% of all publications in this field (Figure 3c). Whittaker, Jackie L. authored 24 articles on PTOA, followed by Emery, Carolyn A. (22 articles), Roos, E. M. (20 articles), and Christiansen, Blaine A. (19 articles).

3.3.4 Institutions

Leading academic entities demonstrated concentrated scholarly output, with the top 20 institutions collectively authoring 568 publications (38.17% of total corpus, Figure 3d). The University of Calgary

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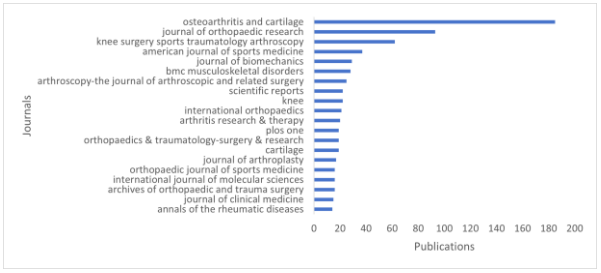
emerged as the predominant contributor (n=67), followed by Lund University (n=40), establishing these institutions as critical knowledge hubs in PTOA research.

3.3.5 Research Directions

The distribution of research directions related to PTOA is shown in Figure 3e. Orthopedics, Rheumatology, Sports Sciences, Surgery, and Engineering emerged as the most prominent fields.



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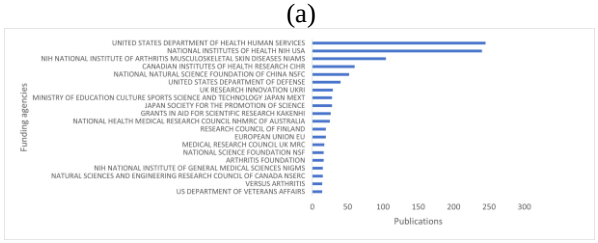

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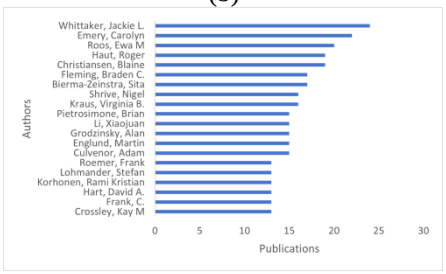

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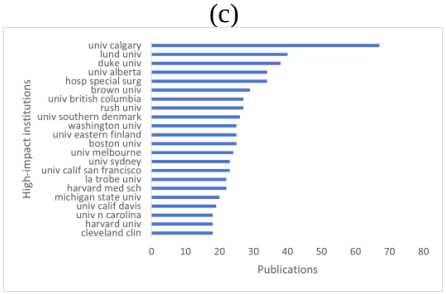

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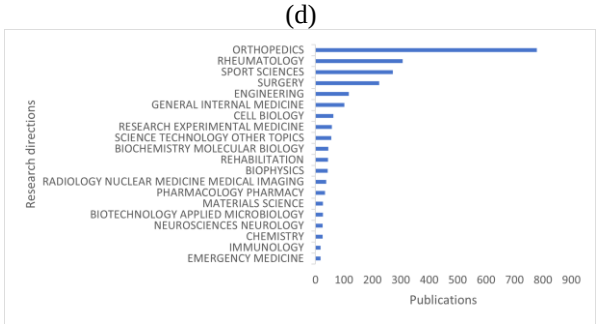

(e)

Figure 3: Evaluation of global publications on post-traumatic osteoarthritis (PTOA): (a) Journal Productivity Metrics: Top 20 Periodicals in PTOA Knowledge Dissemination; (b) Research Sponsorship Landscape: Principal Financial Underpinnings of PTOA Studies; (c) Scholarly Output Stratification: Leading Contributors in PTOA Individual Research Impact; (d) Institutional Research Capacities: Organizational Knowledge Production in PTOA Domain; (e) Top 20 research directions associated with PTOA.

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3.4 Bibliographic Coupling Analysis

3.4.1 Journals

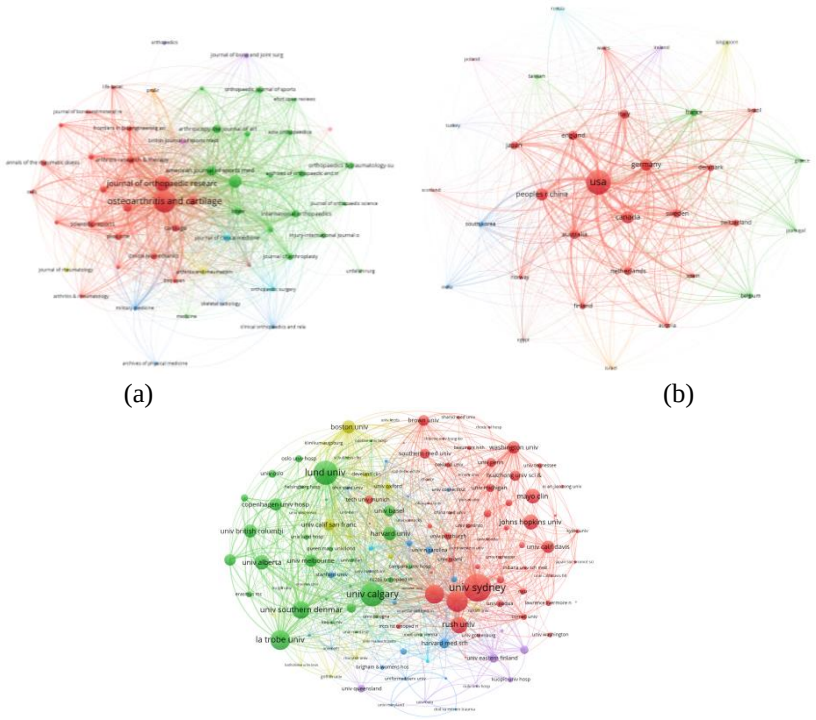
VOSviewer systematically evaluated journal networks (threshold: ≥5 articles) (Figure 4a), identifying 54 high-connectivity periodicals. The TLS-based hierarchy revealed Osteoarthritis and Cartilage (25,944) as the principal knowledge nexus, followed by Journal of Orthopaedic Research (20,199), Knee Surgery Sports Traumatology Arthroscopy (8,504), American Journal of Sports Medicine (6,221), and Arthritis Research & Therapy (5,128), demonstrating disciplinary leadership concentration.

3.4.2 Countries

VOSviewer analyzed 33 countries (defined as countries with a minimum of 5 articles) (Figure 4b). The top five countries by TLS were: United States (TLS = 151,115), Germany (TLS = 49,793), Canada (TLS = 41,758), Australia (TLS = 41,327), China (TLS = 37,997).

3.4.3 Institutions

VOSviewer analyzed 140 institutions (defined as institutions with a minimum of 5 articles) (Figure 4c). The top five institutions by TLS were: Lund University (TLS = 28,218), University of Calgary (TLS = 24,229), Duke University (TLS = 21,988), University of Southern Denmark (TLS = 19,182), Boston University (TLS = 18,600).



(a) (b)

(c)

Figure 4: Knowledge Convergence Mapping in PTOA Research: (a) Network visualization of 54 journals contributing to PTOA-related studies; (b) Network visualization of 33 countries contributing to PTOA-related research; (c) Network visualization of 140 institutions contributing to PTOA-related research

3.5 Co-author Analysis

3.5.1 Authors

Scientometric evaluation reveals a positive correlation between collaborative output and scientific impact, as quantified through co-authorship network analysis. Employing VOSviewer's network analytics, 89 prolific contributors (publication threshold: ≥5 articles) were mapped (Figure 5a). The TLS hierarchy identified Shrive NG (TLS=38) as the principal knowledge broker, followed by Hart DA (34), Frank CB (29), Buchanan TS (26), and Haut RC (26), establishing these researchers as central nodes in PTOA intellectual networks.

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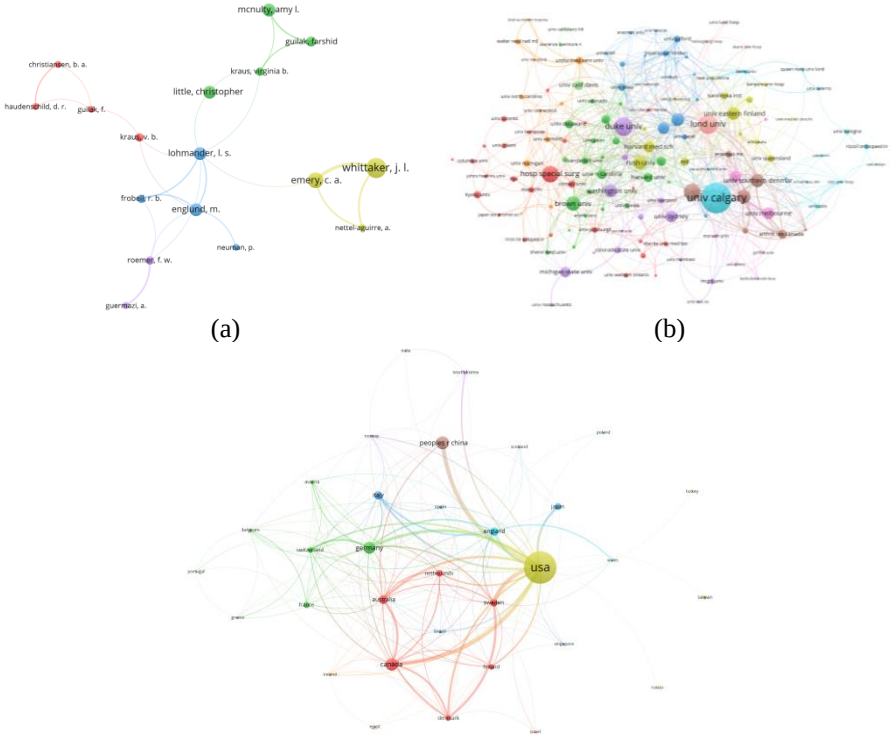
3.5.2 Institutions

Research contributions from 140 institutions were analyzed using VOSviewer (defined as a minimum of 5 articles per institution) (Figure 5b). The top five institutions by total link strength were as follows: Lund University (Total Link Strength = 99), University of British Columbia (Total Link Strength = 89), University of Calgary (Total Link Strength = 89), University of Southern Denmark (Total Link Strength = 87), and La Trobe University (Total Link Strength = 76).

3.5.3 Countries

International collaboration networks were mapped through VOSviewer analysis (threshold: ≥5 articles/country), encompassing 33 nations (Figure 5c). The TLS-based stratification revealed the United States (TLS=266) as the global collaboration nucleus, with Canada and Germany demonstrating equivalent partnership intensity (TLS=104), followed by Australia (96) and Sweden (93), delineating distinct geopolitical patterns in PTOA knowledge production.



(a) (b)

(c)

Figure 5: Co-author analysis of PTOA research: (a) Co-author network map of 89 authors engaged in PTOA studies; (b) Collaboration network map of 140 institutions contributing to PTOA research; (c) Collaboration network map of 33 countries involved in PTOA studies.

3.6 Co-citation Analysis

3.6.1 Articles

Co-citation analysis determines the relatedness between entities based on their frequency of being cited together. VOSviewer was used to analyze 112 articles (defined as references cited at least 20 times) (Figure 6a). The following are the top 5 studies with the highest total link strength (TLS): lohmander ls, 2007, am j sport med, v35, p1756, doi 10.1177/0363546507307396; brown td, 2006, j orthop trauma, v20, p739, doi 10.1097/01.bot.0000246468.80635.ef; anderson dd, 2011, j orthop res, v29, p802, doi 10.1002/jor.21359; lohmander ls, 2004, arthritis rheum-us, v50, p3145, doi 10.1002/art.20589; glasson ss, 2007, osteoarthr cartilage, v15, p1061, doi 10.1016/j.joca.2007.03.006

3.6.2 Journals

VOSviewer was employed for co-citation analysis of journals (defined as journals co-cited at least 20 times). As shown in Figure 6b, 377 journals were identified based on total link strength (TLS). The top 5 journals by TLS are as follows: Osteoarthritis and Cartilage (TLS = 245,819), American Journal of Sports Medicine (TLS = 171,851), Arthritis & Rheumatology (TLS = 101,783), Journal of Orthopaedic

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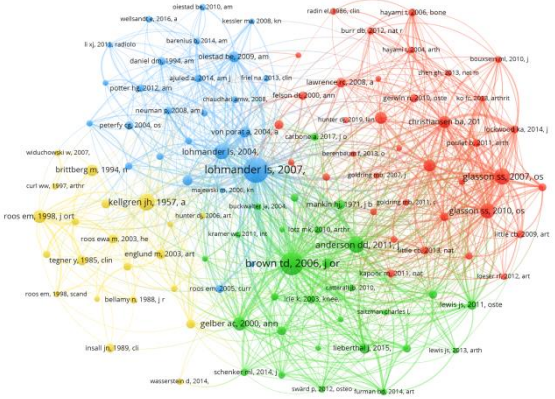
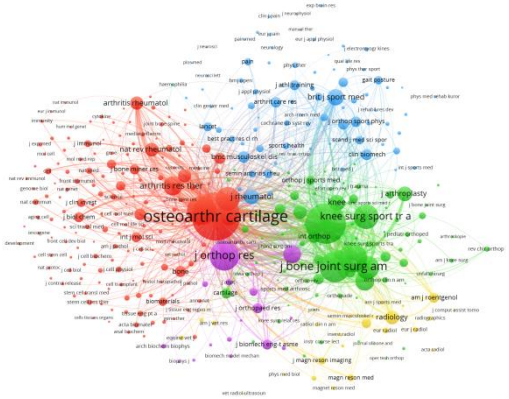
Research (TLS = 101,340), Journal of Bone and Joint Surgery (American Volume) (TLS = 91,563).



(a)



(b)

Figure 6: Co-citation networks in post-traumatic osteoarthritis (PTOA) research: (a) Network visualization of co-cited references within the field; (b) Network visualization of co-cited journals within the field.

3.7 Co-occurrence Analysis

Co-occurrence analysis systematically delineates knowledge domains and emergent thematic foci through keyword frequency profiling (threshold: ≥9 iterations), essential for mapping scientific evolution. Semantic network mapping (Figure 7a) identified 298 terminological nodes stratified into three conceptual clusters: 1. Pathophysiological Mechanisms: Signature terms included osteoarthritis pathogenesis, articular cartilage degradation, genomic regulation, risk stratification, and biomechanical modeling. 2. Regenerative Medicine Paradigms: Core terminologies centered on mesenchymal stromal cell therapy and autologous chondrocyte transplantation. 3. Therapeutic Innovations: Dominant lexicon comprised total knee arthroplasty outcomes, epidemiological surveillance, prosthetic optimization, and meniscal resection protocols. This tripartite taxonomy demonstrates the current intellectual architecture of PTOA research, with mechanistic inquiry, tissue engineering, and clinical translation forming interdependent knowledge pillars.

VOSviewer chronologically mapped keyword emergence through temporal gradient visualization (Figure 7b), with blue denoting foundational concepts and yellow signifying recent innovations, delineating the evolutionary trajectory of PTOA research themes. In the early stages of research (prior to 2016), studies predominantly focused on "Mechanistic Research" and "Tissue Engineering". Current trends suggest that the third cluster, "Clinical Research", will gain significant attention in the future.

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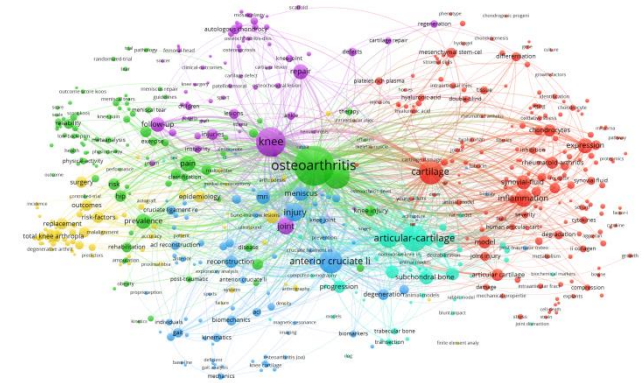
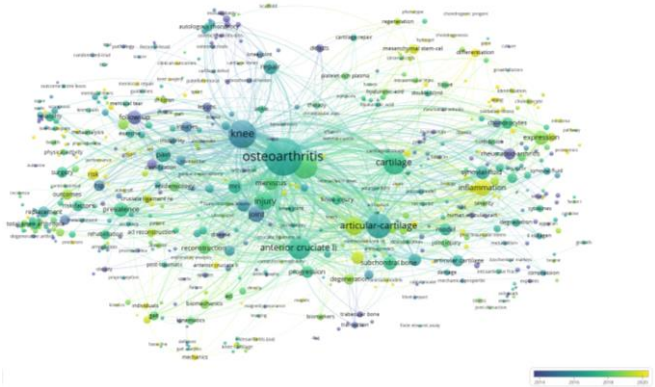


(a)



(b)

Figure 7: Co-occurrence analysis of post-traumatic osteoarthritis (PTOA) research: (a) Network visualization of keywords in PTOA research, categorized into clusters; (b) Temporal distribution network map of keywords, color-coded by average time of appearance (blue: earlier keywords; yellow: recent keywords).

4. Discussion

4.1 Global Publication Landscape and Quality

Scientometric evaluation of post-traumatic osteoarthritis (PTOA) research trajectories, employing systematic literature mapping and computational visualization techniques, offers critical insights into contemporary scientific advancements while facilitating predictive modeling of disciplinary evolution. This investigation systematically assesses the global intellectual architecture of PTOA scholarship through a multidimensional evaluation framework encompassing geopolitical contributions, institutional productivity, funding dynamics, and strategic research prioritization.

Recent advancements in PTOA therapeutics have positioned it as a dynamic and rapidly evolving field. As demonstrated in this study, the number of publications has increased significantly over time, though growth has plateaued in recent years with only marginal increases. Concurrently, research interest in PTOA has surged, with 66 countries contributing to publications in this domain. Based on current data, we project that future years will see a rise in studies offering deeper mechanistic insights into PTOA. The optimistic outcomes observed thus far will further empower researchers to pursue high-quality investigations.

4.2 Trends in PTOA Research

Based on the analysis of national contributions, the United States has produced the highest number of publications and leads in cutting-edge medical research. The study by lohmander ls, 2007, (am j sport med, v35, p1756, doi 10.1177/0363546507307396) exhibits the highest total link strength (TLS). The U.S. Department of Health and Human Services (DHHS) and National Institutes of Health (NIH) hold dominant positions in research investment and priority-setting, ranking first and second in funding influence. The United States maintains global leadership in PTOA research, excelling in publication

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volume, citation impact, and h-index metrics, cementing its pioneering role. China follows in publication output, with the National Natural Science Foundation of China (NSFC, ranked fifth; 52 studies, 3.2% of funded research) driving expanding investments and enhancing research quality toward international benchmarks.

Bibliographic coupling—quantifying conceptual proximity through shared reference networks—reveals critical knowledge pathways in PTOA research. Seminal journals driving disciplinary evolution include Osteoarthritis and Cartilage (publication leader), Journal of Orthopaedic Research, Knee Surgery Sports Traumatology Arthroscopy, American Journal of Sports Medicine, and Arthritis Research & Therapy, which collectively serve as primary dissemination platforms for novel discoveries. Institutional leadership is epitomized by Lund University, demonstrating maximal total link strength (TLS) in collaborative networks. Figure 3c identifies Whittaker JL, Emery CA, and Roos EM as intellectual anchors whose ongoing contributions are pivotal to advancing therapeutic paradigms.

Co-authorship analysis evaluates collaboration patterns among countries, institutions, and authors. Higher TLS values indicate stronger collaborative intent. For example, collaborations involving Whittaker, Jackie L., Lund University, and the United States represent optimal partnerships. Co-citation analysis identifies influential studies based on citation frequency. Current findings highlight landmark PTOA studies with high total citation frequencies, offering valuable insights for future research.

4.3 Research Priorities in PTOA

Co-occurrence network analysis of title-abstract terminologies identified three foundational PTOA research vectors: Mechanistic Studies (osteoarthritis pathways), Tissue Engineering (regenerative strategies), and Clinical Research (arthroplasty/meniscectomy outcomes) (Figture.7a). Dominant keywords—total knee arthroplasty, arthroplasty, meniscectomy—highlight clinical translation priorities, necessitating targeted investigations to advance therapeutic innovation.

Temporal overlay visualization (Fig.7b) employs chromatic gradients (blue→yellow) to map the evolution of PTOA research terminology, revealing a paradigmatic shift toward clinical investigations. Emerging analytical trends identify risk factor stratification as the impending research frontier, with surgical optimization protocols, outcome metrics, and PTOA pathogenesis determinants forming a tripartite focus driving future inquiry. Notably, established surgical modalities exhibit current dominance, positioning clinical-translational PTOA research as the discipline's impending central axis.

4.4 Strengths and Limitations

While this study evaluates the current landscape and trends in PTOA research through robust visual analyses, several limitations must be acknowledged. First, the analysis relied solely on English-language publications from the Web of Science (SCI-Expanded) database, potentially introducing language bias by excluding non-English literature. Second, discrepancies may exist between real-world research activity and the current results. For instance, recently published high-quality studies with low citation frequencies might not be highlighted due to the temporal lag in citation accrual. Thus, ongoing attention to emerging primary studies and non-English literature remains critical in daily research practices.

5. Conclusions

This analysis highlights global trends in post-traumatic knee osteoarthritis (PTOA) research. The U.S. leads in productivity, citations, and influence, with Osteoarthritis and Cartilage as the top journal. Clinical studies—focusing on surgical outcomes, risk factors, and interventions—are projected to dominate future research, guiding targeted funding and collaboration to address PTOA's growing clinical challenges.

Acknowledgement

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