

General

Top-Cited Literature in Ankle Arthrodesis: Identifying Trends, Evidence Levels, and Future Directions

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Introduction

Ankle arthrodesis is a key surgical option for end-stage ankle arthritis when total ankle replacement is not feasible. Despite advancements, challenges like non-union and infection persist. While bibliometric analysis has been applied in other orthopaedic fields, no study has focused on ankle arthrodesis.

Methods

This study analysed the 50 most-cited articles to assess their impact and guide future research and clinical practice. A Web of Science search using the terms (“Ankle*” OR “Tibiotalar”) AND (“Arthrodesis” OR “Fusion”) identified 533 articles published up to October 2024, including only English-language, peer-reviewed studies on human subjects, while excluding non-peer-reviewed, non-English, or unrelated studies. After screening and data extraction, bibliometric techniques assessed publication trends, citation impact, and key research contributors.

Results

The 50 analysed articles, published between 1948 and 2017, accumulated 12,674 citations (average 678.8 per year), with Ankle Arthrodesis: Long-Term Follow-Up with Gait Analysis by Mazur et al. (1979) as the most cited. The Journal of Bone and Joint Surgery published the most articles (N=26), with the USA leading in research output (N=31). Research activity increased in the 1990s and 2000s, with most studies being observational (92%) and Level IV evidence (34%) prevailing.

Conclusion

This analysis highlights influential studies and research gaps, emphasizing the need for high-quality clinical trials to refine surgical techniques and improve patient outcomes in ankle arthrodesis. Future research should focus on robust methodologies and long-term functional outcomes to advance ankle arthrodesis practice.

INTRODUCTION

Ankle arthrodesis, alternatively called ankle fusion, is a reputable surgical procedure orthopaedic surgeons use to treat patients presenting with ankle arthritis or other related complications, including pain.^{1,2} The ankle arthrodesis procedure aims to attain fusion within the tibiotalar joint, relieving the pain in the area for extensive periods post-surgery.³ Using the procedure to treat ankle arthritis and related complications has been associated with move-

ment of the talonavicular post-surgery, leading to degenerations over time and changes to gait and hindfoot.^{4,5} As such, it is essential to acknowledge the application of the ankle arthrodesis procedure, its benefits, and post-op challenges. Applications of advanced ankle arthrodesis in patients with end-stage arthritis have gained prevalence among orthopaedic surgeons and have significantly improved patients' pain and disability-related symptoms.⁶ However, it is noteworthy to acknowledge that there are several challenges associated with the procedure that arise

due to non-union of the tibiotalar joint, which is exacerbated by patients' predisposing factors, including substance use or abuse, diabetes, and mental health disorders.^{6,7} This is contrary to the perception that the procedure is associated with a shorter fusion time due to the minimized stripping of tissue post-surgery.³ The post-operative challenges of ankle arthrodesis have led to the prioritization of other approaches, such as total ankle arthroplasty, because recorded post-operative pain and complications are lower.⁴ There are nuanced impacts of ankle arthrodesis on patients' health outcomes, with evidence of benefits^{3,6} and challenges^{3,4} as identified in the analysis of an extensive number of seminal studies. This overwhelmingly reveals the need to investigate how this discourse has been captured in literature to guide the understanding of the expectations of the clinical practice. Given the increasing volume of research in this domain, it is essential to identify the most influential studies that have shaped current clinical practices and research directions. One of the most effective ways to assess research impact is through bibliometric analysis, which examines citation trends and evaluates the influence of key publications.^{8,9} Citation analysis helps identify landmark studies that have guided clinical decision-making, surgical techniques, and patient outcomes in ankle arthrodesis. While bibliometric studies have been conducted in total knee and hip arthroplasty, spine surgery, and orthopaedic trauma, no dedicated bibliometric review has focused on ankle arthrodesis.¹⁰ This study aims to fill this gap by analysing the 50 most-cited articles on ankle arthrodesis, evaluating their methodological rigor, clinical relevance, and research impact. By identifying highly influential publications, this study seeks to provide valuable insights for clinicians, researchers, and policymakers, highlighting trends, strengths, and gaps in the existing literature.

MATERIALS AND METHOD

STUDY DESIGN

The current study is a structured bibliometric analysis to examine research trends and evaluate key contributors, including authors, institutions, and countries, in the ankle arthrodesis field through the analysis of the top 50 most-cited articles, guided by the bibliometric analysis reporting guidelines^{11,12}

DATA COLLECTION AND CLEANING

Science using a refined search query: (“Ankle*” OR “Tibiotalar”) AND (“Arthrodesis” OR “Fusion”), covering the literature from inception until October 2024. A total of 533 articles were identified through this search.

ELIGIBILITY CRITERIA

Studies were selected for analysis if they met the following inclusion criteria:

- Articles published without time frame limitations.

- Studies published in English-language.
- Only peer-reviewed journal articles that specifically focus on ankle arthrodesis and have been cited by other research publications.
- Human participants.

Studies were excluded based on the following criteria:

- Articles published in non-peer-reviewed sources such as conference proceedings, posters, editorials, or letters.
- Non-English language studies.
- Articles not focused on ankle arthrodesis as the primary topic.
- Studies that were not accessible in full text or could not be obtained through institutional access, open sources, or direct author requests were excluded from the analysis.

DATA EXTRACTION

The retrieved records were imported into Rayyan Software, where four independent reviewers screened titles and abstracts, with full-text review conducted where necessary. Data extraction and management followed a structured approach, with each author independently extracting relevant bibliographic details using a pre-designed Excel extraction form under the supervision of the first author. Extracted data included article title, authors, year of publication, country, institution, journal of publication, total number of citations, average annual citations, research design, funding source, study design, strength of evidence, primary topic, joint undergoing arthroplasty, name or brand of primary robotic device in the study, level of evidence, any industry funding or affiliation associated with the study, and country of origin and affiliated institution of both the first and last authors.

BIBLIOMETRIC ANALYSIS TECHNIQUES

Bibliometric analysis techniques were employed to assess publication trends, citation impact, and key research contributors in ankle arthrodesis research. Citation analysis identified the most influential papers, while co-authorship analysis mapped research networks at the author, institutional, and country levels. Keyword co-occurrence analysis was performed to highlight emerging research trends. For data processing, IBM SPSS Statistics 29.0 and Microsoft Excel 2021 were used to organize bibliographic data and generate citation frequency tables of research trends. Reference management and citation network mapping were conducted using Mendeley. The dataset was retrieved from Web of Science, Scopus, and PubMed, ensuring the inclusion of high-impact literature.

ETHICAL CONSIDERATIONS

Ethical obligations were satisfied by analysing publicly available bibliographic data. This methodology ensures a rigorous and reproducible approach to understanding the bibliometric landscape of ankle arthrodesis research, facili-

Table 1. Top 5 articles according to the total number of citations.

Title	Author (Year)	Total number of cites	CY Index
Ankle arthrodesis - long-term follow-up with gait analysis	John m mazur(1979)	1477	32.1
Long-term results following ankle arthrodesis for post-traumatic arthritis	Lisa M Coester(1989)	958	26.6
Intermediate and Long-Term Outcomes of Total Ankle Arthroplasty and Ankle Arthrodesis	S.L. Haddad(2007)	841	46.7
Prospective Controlled Trial of STAR Total Ankle Replacement Versus Ankle Fusion: Initial Results	Charles L. Saltzman(2009)	474	29.6
Quality of life 20 years after arthrodesis of the ankle	S. Fuchs(2003)	473	21.5

Table 2. Top 5 articles after adjusting the time elapsed since publication using the CY index.

Title	Author (Year)	Total number of cites	CY Index
Intermediate and Long-Term Outcomes of Total Ankle Arthroplasty and Ankle Arthrodesis	S.L. Haddad (2007)	841	46.7
Ankle arthrodesis - long-term follow-up with gait analysis	JOHN M Mazur (1979)	1477	32.1
Prospective Controlled Trial of STAR Total Ankle Replacement Versus Ankle Fusion: Initial Results	Charles L. Saltzman (2009)	474	29.6
Total ankle arthroplasty versus ankle arthrodesis—a comparison of outcomes over the last decade	Cort D. Lawton (2017)	226	28
Long-term results following ankle arthrodesis for post-traumatic arthritis	Lisa M Coester (1989)	958	26.6

tating the identification of influential works, research gaps, and emerging trends.

RESULTS AND FINDINGS

A total of 50 articles were retrieved from (Web of Science, Scopus, and PubMed). The years of publication ranged from 1948 to 2017. The number of citations ranged from 21 to 1477 cites. All articles were cited a total of 12674 times with total average of 678.8 cites per year. The paper with the highest citation frequency (1477) was Ankle arthrodesis. Long-term follow-up with gait analysis by Mazur et al. published in 1979. When corrected for the time the article had been published using the CY index, the article with the highest CY index (46.7) was the “Intermediate and Long-Term Outcomes of Total Ankle Arthroplasty and Ankle Arthrodesis” performed by S.L. Haddad et al., which published in (2007). **Tables 1 and 2** show the top 5 articles according to the total number of cites and CY index, respectively.

The most influential journal with the highest number of publications (N=26) was the Journal of the journal of Bone and Joint Surgery, followed by the Journal of Foot & Ankle International (N=14) and Clinical Orthopedics and Related Research (N=4) **Table 3**.

The distribution of publications over decades indicates a rising tendency in research activity throughout time. The first documented publication occurred in the 1948, featur-

Table 3. Top 3 journals in terms of the total number of publications.

Journal	Number of articles
The journal of bone and joint surgery	26
Foot & ankle international	14
Clinical orthopaedics and related research	4

Table 4. Number of publications with respect to decade.

Decade	Number of publications
1940-1949	1
1970-1979	1
1980-1989	5
1990-1999	16
2000-2009	16
2010-2019	11

ing a solitary investigation. Research production was rather low until the 1980s, when had a slight rise (5 publications). The decade with the highest number of publications was 2000-2009 with 16 articles **Table 4**.

Table 5. The top 5 most influential authors in terms of number of publications.

Author	Number of publications
Roger A. Mann	5
Charles L. Saltzman	4
Mark S. Myerson	4
Alastair S.E. Younger	3
Samuel B. Adams	3

Table 6. The top 5 most productive countries in terms of number of publications.

Country	Number of publications
US	31
Canada	4
England	4
Japan	2
France	2

Table 7. Proportions of the levels of evidence of the top 50 cited articles.

Level of Evidence	Number of publications
Level IV	34%
level III	14%
level II	12%

The greatest number of articles (N=5) were published in 2000. The most influential author in terms of the total contribution to the list was Roger A. Mann with 5 articles each, followed by Charles L. Saltzman and Mark S. Myerson with 4 publications for each. [Table 5](#).

The most productive country was the USA with a total of 31 publications, followed by Canada UK with 4 publications. [Table 6](#). The majority of the articles were observational studies (n=46; 92%), with the remaining being review articles.

With regards to the level of evidence, majority of the studies were Level IV (34%), followed by level III (14%) and level II (12%). [Table 7](#).

DISCUSSION

Ankle arthrodesis remains the benchmark surgical intervention for individuals with symptomatic end-stage ankle osteoarthritis. Indications for ankle arthrodesis encompass post-traumatic arthritis, significant deformity, neurogenic conditions, inflammatory arthropathy, congenital deformity, and patients unsuitable for total ankle arthroplasty (TAA) or those with unsuccessful outcomes.¹³ Historically, open methods have been employed for ankle arthrodesis. Numerous varieties and procedures have been delineated,

including trans-fibular, anterior, medial, and Mini arthro-tomy. Inherent drawbacks of these open methods encompass postoperative pain, delayed or non-union, wound problems, shortening, extended healing durations, and prolonged hospitalizations.¹⁴ This signifies a growing burden of societal and economic difficulties that our present and future populations will face. Therefore, to address the increasing burden of disease, research must be conducted in orthopaedics and related specialties to comprehend normal physiology and underlying diseases that can inform therapeutic management. This necessitates a unified contribution from comprehending the molecular pathophysiology of disease to the surgical measures that may enhance treatment.^{14,15} Thus, by conducting our study, we may discern the areas where research is concentrated within the discipline. Moreover, this may facilitate the identification of research deficiencies, allowing organizations to concentrate their research efforts in areas of necessity and interest by assessing the citation count of an article. Although an article that has been cited frequently may not be directly connected with its quality, it does indicate the work's popularity within the scientific community.¹⁶ By pinpointing the locations of frequently cited authors and papers, one may discern localities that exhibit a specific emphasis on a subject of interest. For example, based on our analysis, we found that most articles were published in the United States, which has been recognized in past studies as a leader in orthopaedics research. The primary cause for this was improved resource allocation and finance provision, facilitating studies in a supportive atmosphere.¹⁷ Additionally, our analysis revealed a significant increase transpired in the 1990s and 2000s, with each decade yielding 16 publications. This sustained growth indicates a systematic increase in research interest and effort within the topic area. The notable rise in publications since the 1990s can be ascribed to enhancements in research methodology, augmented financing sources, and an escalating scientific interest in the domain. The data indicates a continuous and intensified emphasis on research, especially over the past thirty years. This rising tendency signifies that the topic has attained considerable prominence within the academic world, enhancing the overall body of knowledge. The persistent increase in research output indicates enhanced multidisciplinary collaboration and policy backing, hence underscoring the topic's significance. Our review of these articles identified several landmark studies within the orthopaedic field, including the first and second most cited papers: "ankle arthrodesis - long-term follow-up with gait analysis"¹⁸ and "Long-term results following ankle arthrodesis for post-traumatic arthritis".¹⁹ Our research has many strengths, such as examining the impact of particular papers and associated demographics, providing an impartial, data-driven approach for evaluating research trends, influence, and collaboration networks. This method also employs citation-based metrics to pinpoint significant publications, emerging research areas, and interdisciplinary connections, offering critical insights for scholars and policymakers, enhancing research visibility, and facilitating studies like systematic reviews by identifying key contribu-

utors and seminal studies within a particular field. Nevertheless, it has multiple disadvantages. Field-specific citation norms, delays in citation accrual, and the potential for citation manipulation further compromise the reliability of bibliometric metrics. Citation-based metrics may not intrinsically reflect study quality, as high citation counts can result from controversial or flawed research. Despite these limitations, bibliometric analysis remains an essential tool when combined with qualitative assessments to provide a comprehensive appraisal of scientific impact and research directions.

CONCLUSION

This bibliometric analysis identifies key research trends in ankle arthrodesis by evaluating the top 50 most-cited articles. The majority were published in *The Journal of Bone*

and Joint Surgery, with the United States leading in research output. A significant rise in publications occurred in the 1990s and 2000s, reflecting advancements in surgical techniques. Most studies were observational, with Level IV evidence prevailing. Despite citation bias, this analysis highlights influential studies and research gaps. Future efforts should focus on high-quality trials to refine surgical techniques and improve patient outcomes, guiding advancements in ankle arthrodesis research and clinical practice.

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