

# THE ACADEMIC EVOLUTION OF LAPIDUS SURGERY: TRENDS, INNOVATIONS, AND FUTURE DIRECTIONS

## Lapidus Cerrahisinin Akademik Evrimi: Trendler, Yenilikler ve Gelecek Yönelimleri

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### ABSTRACT

**Objective:** This study aims to perform a bibliometric analysis of Lapidus-related research to identify trends, key contributors, and emerging innovations in the field.

**Material and Methods:** Data were extracted from the Web of Science Core Collection database, focusing on publications containing the keyword “Lapidus” in orthopaedic journals up to December 2024. Bibliometric tools such as VOSviewer were used to analyze publication trends, collaboration networks, and keyword co-occurrence. Metrics like citation counts, influential authors, and institutional contributions were evaluated to uncover the academic landscape of Lapidus-related research.

**Results:** A total of 310 articles from 35 countries were included, with the United States leading in publications and citations. The Journal of Foot & Ankle Surgery was identified as the most productive journal. Key contributors, including Coughlin, Dayton, and Hyer, were highlighted for their significant impact, particularly in advancing the modified Lapidus procedure. Keywords such as “hallux valgus,” “modified Lapidus,” and “bunion” were the most frequent, with a noticeable rise in studies focusing on multiplanar corrections and modern fixation techniques since 2020.

**Conclusion:** This bibliometric analysis underscores the growing prominence of the modified Lapidus procedure, driven by technological advancements and improved surgical outcomes. The findings reveal notable gaps in global collaboration, emphasizing the need for international partnerships. This study provides a comprehensive overview of current trends, offering a foundation for future clinical research and innovation in hallux valgus correction.

**Keywords:** *Lapidus Procedure; Hallux Valgus; Bibliometric Analysis; Modified Lapidus Technique*

### ÖZET

**Amaç:** Bu çalışmanın amacı, Lapidus ile ilgili araştırmaların bibliyometrik analizini yaparak bu alandaki eğilimleri, önemli katkıda bulunanları ve ortaya çıkan yenilikleri tespit etmektir.

**Gereç ve Yöntemler:** Veriler, Aralık 2024'e kadar ortopedi dergilerinde “Lapidus” anahtar kelimesini içeren yayınlara odaklanarak Web of Science Core Collection veri tabanından çıkarılmıştır. VOSviewer gibi bibliyometrik araçlar yayın eğilimlerini, işbirliği ağlarını ve anahtar kelime birlikte kullanımını analiz etmek için kullanılmıştır. Lapidus ile ilgili araştırmaların akademik manzarasını ortaya çıkarmak için atf sayıları, etkili yazarlar ve kurumsal katkılar gibi metrikler değerlendirildi.

**Bulgular:** Çalışmaya 35 ülkeden toplam 310 makale dahil edilmiş olup, yayın ve atıflarda Amerika Birleşik Devletleri başı çekmektedir. The Journal of Foot & Ankle Surgery en üretken dergi olarak belirlendi. Coughlin, Dayton ve Hyer gibi önemli katkıda bulunanlar, özellikle modifiye Lapidus prosedürünün geliştirilmesindeki önemli etkileri nedeniyle vurgulandı. “Halluks valgus”, “modifiye Lapidus” ve “bunyon” gibi anahtar kelimeler en sık kullanılanlar olurken, 2020'den bu yana multiplanar düzeltmelere ve modern fiksasyon tekniklerine odaklanan çalışmalarda gözle görülür bir artış oldu.

**Sonuç:** Bu bibliyometrik analiz, modifiye Lapidus prosedürünün teknolojik gelişmeler ve iyileştirilmiş cerrahi sonuçlarla artan öneminin altını çizmektedir. Bulgular, küresel işbirliğindeki önemli boşlukları ortaya koymakta ve uluslararası ortaklıklara duyulan ihtiyacı vurgulamaktadır. Bu çalışma, mevcut trendlere kapsamlı bir genel bakış sunarak halluks valgus düzeltmesinde gelecekteki klinik araştırmalar ve yenilikler için bir temel oluşturmaktadır.

**Anahtar Kelimeler:** *Lapidus Prosedürü; Halluks Valgus; Bibliyometrik Analiz; Modifiye Lapidus Tekniği*

## INTRODUCTION

The hallux valgus deformity was managed by fusing the first tarsometatarsal (TMT) joint utilizing a technique described by Paul W. Lapidus in 1934. It stabilizes the medial column of the foot while correcting metatarsus primus varus and thus is the criteria standard for distal joint extremes and for recurrent hallux valgus (1,2). The original Lapidus procedure has undergone decades of evolution based on clinical outcome data to both improve efficacy and reduce complications. The recent research around this modality with the use of minimally invasive techniques and improved fixation methods has shown improved union rates and patient satisfaction (3-5). While the procedure has its benefits, it's not without risks. Concerns such as nonunion, malunion, and transfer metatarsalgia remain potential complications. However, modern devices for fixation, such as plantar plating and intramedullary screws, have very much decreased these complications (5,6). Bibliometric analysis has steadily emerged as an essential tool in gaining insight into the research landscape surrounding medical procedures, including the Lapidus technique. Citation network mapping and influential study identification allow these analyses to highlight research trends, knowledge gaps, and repercussions in academia (7,8).

As such, researchers have recently concentrated on predictors of long-term outcomes and functional success following Lapidus. Its durability and effectiveness, especially for moderate-severe deformities, are confirmed with long-term studies (9,10). This bibliometric study examines trends of publications on the Lapidus procedure to date, utilization, and outcomes of the procedure to help better understand how it has evolved academically and clinically.

## MATERIAL AND METHOD

The Web of Science Core Collection (WoSCC, Clarivate Analytics, Boston, MA, USA) served as the main data source for bibliometric analysis in this study. Keywords retrieval focused on the term "Lapidus"

to narrow the scope. The search included not just articles but also editorials, letters, and review articles published in English-language orthopaedic journals prior to December 21, 2024. This dataset consisted of publications containing relevant terms that were orthopaedic in nature.

Data were categorized based on the annual number of publications, participating countries, and orthopaedic journals that included "Lapidus" in their titles or keywords. Furthermore, whenever possible, both the contributing article records and their citations were converted into plain text, enabling large-scale analyses of international collaborations among contributors and the frequency of keyword co-occurrences within the respective field.

Bibliometric analysis is a quantitative analysis of scholarly literature that can measure patterns and relationships in the scientific literature. It includes analyzing things like the number of publications, collaboration between authors, and citation networks. The VOSviewer software, developed by Leiden University in the Netherlands, is used for creating and visualizing bibliometric networks (11). Information collection and a qualitative analysis are conducted in a visualized investigation to identify the relational dynamics of the data (12). It has six components: authors, countries, websites, keywords, and institutions. The size of the node indicates the number or frequency of articles (13). The colours of the nodes represented different groups or years, and the linkages between the nodes represented associations, including co-authorship or co-occurrence (14). Total link score was used to indicate the strength of the relationship.

An analysis of author and institutional contributions was done using full-counting bibliographic coupling. Keywords full-counting co-occurrence analysis was performed for the determination of research hot themes. The relationship between the authors cited was established using co-citation analysis. The analysis of nations' collaboration was performed using a web-

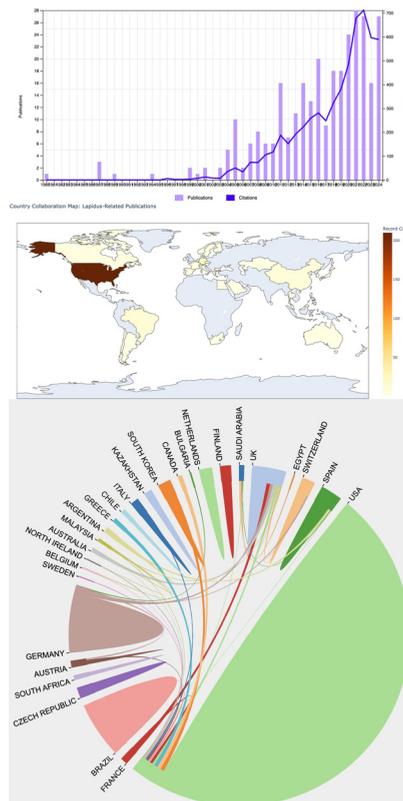
based bibliometric platform (<https://bibliometric.com/>). A public database was used to download the data of this investigation. This research does not need any kind of ethical approval.

### RESULTS

We filled out the topic area with the keyword “Lapidus” to initiate the scanning process. In the search, we selected the document type to be “All,” type “Orthopaedics,” type “Surgery” in the “research areas” section, and type “English” in the “Language” section.

The lapidus-related orthopaedic research publications originated from 35 different countries and encompassed a total of 310 papers. 5,890 is the number of citations of these articles. While the

initial paper referenced in the research originates from 1980, the latest publications were published in 2024, with further studies anticipated for publication in 2025 (15). The number of orthopaedic research articles pertaining to lapidus has been steadily rising since 2015, as shown in Figure 1. Analysis of data from various nations revealed that the USA had the largest number of publications, exceeding Germany, the second-ranked country, by a factor of 10. Subsequent to Germany, England and Switzerland ranked third and fourth, respectively (Table 1). Figure 1 also illustrates global research production and collaboration patterns, highlighting the United States as the leading contributor and the central hub of international collaboration in Lapidus-related studies.



**Figure 1.** This figure illustrates annual trends in Lapidus-related publications and citations between 1980 and 2024, highlighting a marked rise after 2015. It also includes a world map showing country-level contributions and a collaboration network revealing the United States as a central hub in global research partnerships

**Table 1.** Countries/regions contribution

Countries/regions	Record count	% of 310
USA	210	67.742
Germany	23	7.419
England	19	6.129
Switzerland	13	4.194
Brazil	11	3.548
Peoples R China	8	2.581
Italy	6	1.935
South Korea	6	1.935
Spain	6	1.935
Austria	5	1.613

There are a total of 42 orthopaedic journals that have published publications about lapidus-related research. With eighty-four papers published, the Journal of Foot & Ankle Surgery was the most productive of these journals. Foot & Ankle International published 62 articles, while the Foot and Ankle Clinics contributed 23 articles (Table 2) (Figure 2). The Hospital for Special Surgery attained the highest ranking among academic institutions, publishing a total of 22 papers. Table 3 presents the clinics ranked in the top 10 according to their total publication count. Out of them, 14 institutions achieved the criteria of a minimum of five articles. The top three institutions were the Des Moines University (n=195 citations), Hospital for Special Surgery (n=194 citations), and the Orthopaedic

Foot & Ankle Center (n=164 citations) (Figure 2). Out of the 971 authors, only 18 reached the minimum threshold of five articles (Figure 3). Top of the list for citations were Coughlin with 805, Dayton with 182, and Hyer with 139. We rank ordered these keywords in our analysis of 591 in which we analyzed these keywords' occurrence rank. 41 keywords pass the filter with a minimum number of observations of five. The most frequently used keywords were "hallux valgus" (n=158), "lapidus" (n=80), and "bunion" (n=64) (Figure 3). Figure 3 shows a more granular time-series analysis; since 2020, the "modified lapidus procedure" has been mentioned with increasing frequency.

**Table 2.** The top 10 journals by total number of articles

Journal name	Total number of articles	Total citations	Average citation count
Journal of Foot & Ankle Surgery	84	583	6.94
Foot & Ankle International	62	906	14.61
Foot and Ankle Clinics	23	113	4.91
Foot and Ankle Surgery	21	80	3.81
Clinics in Podiatric Medicine and Surgery	17	34	2.0
Techniques in Foot and Ankle Surgery	15	11	0.73
Foot & Ankle Specialist	12	12	1.0

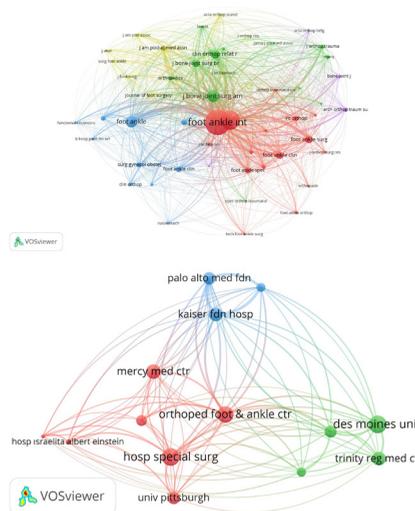
**Table 2.** Continued

Journal of Bone and Joint Surgery-American Volume	10	178	17.8
Archives of Orthopaedic and Trauma Surgery	7	16	2.29
International Orthopaedics	6	40	6.67

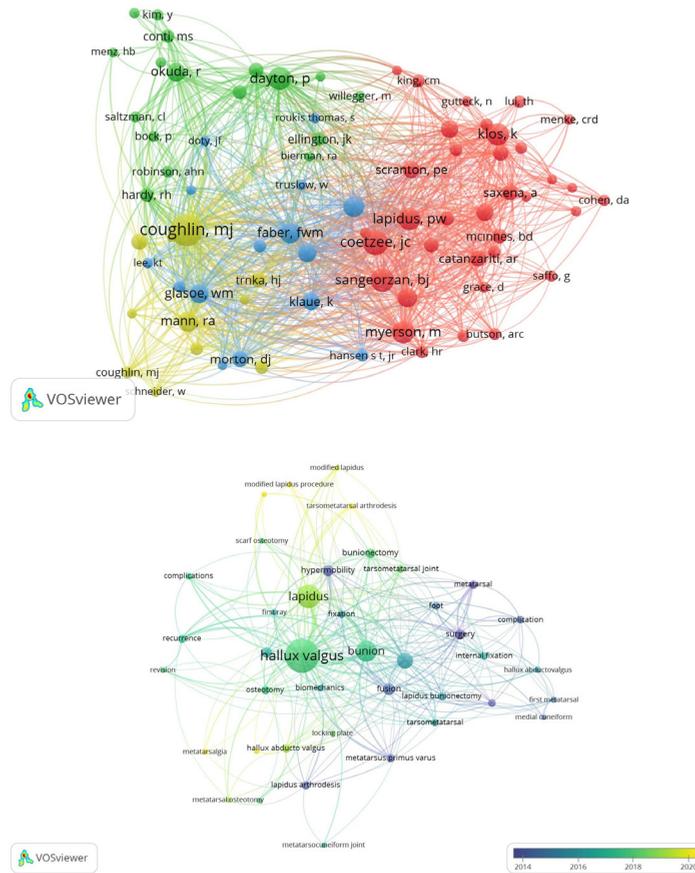
**Table 3.** Top 10 institutes ranked by total number of published articles

Organization name	Total number of articles	Total citations	Average citation count	Total number of first works	Number of citations by first author	Average citations per first author
Hosp Special Surg	22	106	4.82	12	42	3.5
Kaiser Fdn Hosp	13	160	12.31	3	33	11.0
Orthoped Foot & Ankle Ctr	13	87	6.69	6	63	10.5
Des Moines University	12	122	10.17	2	27	13.5
West Virginia University	11	83	7.55	2	29	14.5
Palo Alto Med Fdn	9	52	5.78	2	44	22.0
Univ South Carolina	9	40	4.44	3	12	4.0
University of Toledo	8	8	1.0	0	0	0.0
Temple Univ	7	40	5.71	2	4	2.0
Univ Pittsburgh	7	30	4.29	1	3	3.0

Hosp Special Surg: Hospital Special Surgery, Kaiser Fdn Hosp: Kaiser Foundation Hospitals, Orthoped Foot & Ankle Ctr: Orthopedic Foot & Ankle Center, Palo Alto Med Fdn: Palo Alto Medical Foundation, Univ South Carolina: University of South Carolina, Temple Univ: Temple University, Univ Pittsburgh: University of Pittsburgh



**Figure 2.** Shown here are collaboration patterns across journals and institutions in Lapidus research. Key journals such as Foot & Ankle International and major centers like the Hospital for Special Surgery are central to co-authorship and institutional networks



**Figure 3.** This figure presents the author collaboration network, with leading figures like Coughlin and Dayton, alongside a keyword co-occurrence map emphasizing major research themes such as hallux valgus, the Lapidus procedure, and tarsometatarsal joint surgery

**DISCUSSION**

Most importantly, the current study is a bibliometric analysis of lapidus-related orthopaedic articles, filling a gap in the current literature. This study reveals the growing prominence of the lapidus procedure in research in orthopaedics; we have noticed an upward trend in the number of papers regarding this concept and its growing contribution to the field of medicine. First TMT arthrodesis, first described by Paul W. Lapidus in 1934, has been used in the treatment of hallux valgus deformity. Lapidus performed this procedure in patients predisposed to hallux valgus due

to metatarsus primus varus. Interestingly, although this procedure was first proposed by Albrecht in 1911, it was Lapidus who popularised the method. In an article published in 1960, Lapidus reviewed his 30 years of experience and stated that his surgical technique remained “essentially as first described” (16). Sangeorzan et al. described the traditional modern Lapidus technique that involves internal fixation at the first TMT joint utilising crossed screws (17). An intermetatarsal screw was used to avert diastasis between the first and second metatarsals. Appropriate joint preparation necessitates comprehensive

debridement to reveal the subchondral bone (18). To enhance the likelihood of union, a burr is employed to pierce the subchondral bone, leading to the resulting burrings remaining in situ as osteogenic bone dust, a method defined by Wheeler et al. (19). The evidence does not clarify whether preoccupation with an excessively rigid concept results in improved outcomes and reduced nonunion rates. Langan et al. proposed the use of a medial locking plate supported by a crossing intermediate cuneiform screw originating from the base of the first metatarsal (20). Cohen et al. conducted a cadaveric study that revealed the crossed-screw approach yielded improved outcomes due to enhanced compression compared to a locking plate (21). Over the last several years, there has been tremendous interest in minimally invasive approaches to Lapidus arthrodesis in foot and ankle surgery. In 2020, Chaparro et al., showed that intramedullary nails provide better fixation advantages compared to plates by presenting lesser soft tissue complications and more favorable radiographic outcomes (22). Similarly, research by Fuimaono-Asafo et al. in 2022 found that patients were very satisfied with their outcomes, even though there was a small 4.2% risk of nonunion with the crossed-screw approach (23). These discoveries highlight why it's so important to keep exploring and refining the best ways to perform these procedures for better patient care.

In total, 35 countries contributed to those publications. As predicted, the US was the most productive of all nations worldwide, a phenomenon that has shown similar results in other domains of inquiry, such as the development of dysplasia of the hips and syndrome of the carpal tunnel (24-26). This dominance could be explained in part by the fact that there are well-established orthopaedic organizations, such as the Hospital for Special Surgery, that regularly generate high-impact research. Such institutions include Kaiser Foundation Hospital and Orthopedic Foot & Ankle Center. We can clearly identify their contributions

through their high number of papers and citations and the importance of their role in the clinical and academic evolution of this technique. Additionally, other countries have lower overall levels of globalization compared to the United States. The United States is expected to reach this conclusion due to its better technology, skilled researchers, and ample funds.

This analysis included countries and institutions, where the USA and Germany were the two most researched countries. However, they did not appear to work together internationally. This area needs to be more collaborative on a global scale for us to make progress together. Previous studies report that this is explained by US writers preferring to publish and cite publications within their own country (27,28). Moreover, one study, for example, which analyzed papers published in the *New England Journal of Medicine*, found evidence of home country bias, a tendency to give preference to research based in the U.S. (29). That style of working may be restrictive in terms of the range of perspectives that can be incorporated and the progress that can be achieved in global medical research. There needs to be much more international cooperation on "orthopaedic multidisciplinary techniques" such as the Lapidus method in order to make use of the different strengths of various communities around the world.

Only 18 of the 971 authors examined crossed the hurdle of publishing five or more articles. Not surprisingly, Coughlin, Dayton, and Hyer are prominent names among the leading authors, and their works are among those that have received the highest number of citations. These investigators have not only significantly contributed to the understanding of the Lapidus procedure but have also published alterations of this procedure that provided for further improvement in surgical outcomes and minimizing complications. Among these, Michael J. Coughlin ranks among the most influential. "Hallux valgus: demographics, etiology, and radiographic assessment" (Coughlin & Jones, 2007) is cited over 300 times and remains a

keystone work in the study of hallux valgus deformities and was published in *Foot & Ankle International* (30). This study has provided thorough insights into the demographics and radiographic characteristics of hallux valgus, which will enhance progress in clinical decision-making with regard to surgical management. Paul Dayton's important contributions to the Lapidus procedure (especially his highly cited article related to frontal plane rotational correction) have greatly enhanced the understanding of hallux valgus as a triplane deformity (31). His research highlights the need to focus on the oft-ignored rotational aspect for full correction, specifically improving proximal articular set angle and sesamoid alignment. Dayton further recommends modern fixation modes like locking plates and intramedullary screws, which theoretically provide greater biomechanical stability and minimize the complication of nonunion. His research advocates a paradigm of triplane corrective techniques to improve outcomes in hallux valgus surgery.

Hallux valgus, lapidus, and bunion are the most common keywords in Lapidus-related research, indicating that the procedure is highly significant in treating forefoot deformities and medial column instability. With developments in multiplanar correction and fixation methods since 2020, the modified lapidus procedure has been gaining interest, with an increasing number of publications describing and advocating this technique. Thompson et al., including Hyer, highlighted the appropriateness of the "spot weld" technique, which involves the use of a first-to-second intermetatarsal screw to stabilize the intermetatarsal angle (32). With this technique, a better radiographic outcome was achieved, with a mean correction loss of  $0.87^\circ$  in the group with this technique compared with  $1.88^\circ$  in ones without this technique. Long-term, multiplanar correction with stabilization of adjacent metatarsals minimizes recurrence and improves outcomes. Similarly, Riegger et al. corroborates these findings, showing biomechanical advantages afforded by more

contemporary means of fixation, such as plantar plating versus locking screws that improve stability and reduce the risk of complications (33). The totality of this reassembles a paradigm shift in the surgical treatment of hallux valgus, with increasing inclination towards more stable and thorough approaches to correction.

Importantly, while the bibliometric trends demonstrate a clear shift toward modified techniques, multiplanar correction strategies, and modern fixation constructs, the growing technical innovation is not yet paralleled by a proportional increase in high-level comparative clinical outcome studies. Much of the existing literature consists of case series, retrospective analyses, and biomechanical investigations, whereas randomized controlled trials and standardized long-term comparative studies remain limited. This discrepancy highlights an important direction for future research: the need to rigorously evaluate emerging surgical modifications through well-designed prospective trials and multicenter collaborations. Furthermore, the consolidation of outcome measures and consensus-based reporting standards may facilitate the development of evidence-based clinical guidelines. Bridging the gap between technical advancement and high-quality clinical evidence will be essential to optimize patient outcomes and ensure that innovation translates into measurable clinical benefit.

There are several limitations that should be acknowledged. First, only English-language publications were included, which may have led to the exclusion of relevant studies published in other languages. Second, the analysis relied exclusively on data retrieved from the Web of Science Core Collection, which may not fully capture all global research related to the Lapidus procedure. Third, bibliometric analyses primarily reflect research productivity and citation behavior rather than true clinical effectiveness or patient-level outcomes. Citation counts may be influenced by factors such as publication time, journal visibility, indexing

practices, and academic networking, and therefore do not necessarily indicate superior methodological quality or therapeutic efficacy. Furthermore, as this study is bibliometric in nature, it does not directly evaluate clinical outcomes or comparative effectiveness, limiting its direct applicability to surgical decision-making. Despite these limitations, this study represents the first comprehensive bibliometric evaluation of Lapidus-related research, providing valuable insights into publication trends, influential contributors, thematic developments, and international collaboration patterns, thereby offering a structured overview of the academic evolution of this surgical technique.

## CONCLUSION

This bibliometric analysis gives a comprehensive summary of the scientific and clinical evolution of the Lapidus approach to hallux valgus correction. Importantly, this highlights the increasing clinical relevance of the Lapidus construct itself since 2020, propelled by advances in multiplanar correction techniques and newer generation fixation. The USA is dominant in this regard, with noted contributors including Coughlin, Dayton, and Hyer making considerable contributions toward understanding and then optimizing this manoeuvre.

While the results reveal growing adoption and innovation of Lapidus-related studies, it also highlights notable gaps in evaluating evidence-based treatments and emphasizes the importance of a more worldwide collaborative effort to overcome these barriers. With this background, the paper provides a map of the research landscape surrounding both the current status as well as future work in the area of improving surgical outcomes and patient care.

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The authors declare that they have no competing interests.

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