

Global research trends, citation impact, and collaboration networks in penile fracture: a bibliometric analysis

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ABSTRACT

Aims: Penile fracture is a rare but clinically significant urological emergency that may result in erectile dysfunction, penile curvature, and long-term complications if not promptly managed. Despite its clinical importance, the global research landscape on penile fracture remains fragmented and limited in scope. Bibliometric analysis provides an opportunity to systematically evaluate scientific productivity, citation impact, and collaboration networks in this field. The aim of this study was to conduct the first comprehensive bibliometric mapping of penile fracture research, focusing on publication productivity, citation performance, collaboration patterns, and emerging thematic trends.

Methods: A bibliometric analysis was conducted using the Web of Science Core Collection database covering the period 1980–2024. A comprehensive search strategy with predefined inclusion and exclusion criteria was applied to identify original articles related to penile fracture. Data extraction and analysis were performed using Microsoft Excel and BibExcel. Visual mapping and network analyses, including co-authorship, co-occurrence of keywords, and bibliographic coupling, were conducted using VOSviewer.

Results: A total of 255 original research articles were identified, authored by 1,064 researchers from 36 countries and published across 93 journals. The United States, Türkiye, and Egypt were the most productive countries, while the *Journal of Urology*, *Urology*, and the *Journal of Sexual Medicine* emerged as the most influential journals. Leading authors included Favorito LA, Koifman L, and Barros R. Keyword co-occurrence analysis revealed strong associations between “penile fracture,” “erectile dysfunction,” and “trauma,” while emerging trends highlighted diagnostic modalities such as ultrasonography and MRI. Bibliographic coupling identified a limited number of pivotal publications shaping the knowledge base.

Conclusion: This study provides the first comprehensive bibliometric evaluation of penile fracture research, highlighting global publication trends, influential contributors, and evolving research themes. The findings underscore the need for increased international collaboration and methodologically robust prospective studies to strengthen the evidence base. By identifying research gaps and emerging priorities, this study not only strengthens the scientific evidence base but may also inform future guideline development and optimize clinical management strategies for this rare but significant urological emergency.

Keywords: Bibliometrics, wounds and injuries, urology, emergency service, hospital, internationality

INTRODUCTION

Penile fracture is a rare but clinically significant urological emergency, characterized by the abrupt and typically traumatic rupture of the tunica albuginea of the erect penis.¹ It most commonly occurs during sexual intercourse due to sudden bending or direct impact, and presents with the classic clinical triad of an audible “snap” sound, acute pain, rapid detumescence, and subsequent hematoma and swelling. Without prompt and appropriate surgical intervention, long-term complications such as erectile dysfunction, penile curvature, and fibrotic plaque formation may develop. Therefore, accurate recognition and timely management of penile fracture are critical for optimizing patient outcomes.^{2,3}

Although the diagnosis of penile fracture is most often established based on patient history and physical examination, imaging modalities such as ultrasonography and magnetic resonance imaging (MRI) are increasingly utilized in the differential diagnosis and in guiding surgical planning.^{4,5} Surgical repair remains the gold standard treatment, with early intervention strongly recommended. Nevertheless, the literature on penile fracture cases and their management is relatively limited compared to other urological traumas, consisting predominantly of case series, retrospective cohort studies, and only rarely prospective investigations.^{6,7}

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In recent years, the growing number of scientific publications has heightened the importance of bibliometric analyses, which aim to reveal trends, productivity levels, and citation impacts within a given field.⁸ Bibliometrics enables the quantitative evaluation of publication distribution, citation patterns, collaboration networks, and research trends within a specific domain, thereby allowing for the examination of both the structural and dynamic aspects of scientific productivity.⁹ This approach provides researchers with the opportunity to systematically map existing knowledge, identify research gaps, and determine priority areas for future investigations.

A comprehensive bibliometric analysis assessing the global scientific output and citation performance of studies on penile fracture, along with author and institutional collaborations, the most frequently investigated topics, and the conceptual development within the literature, would contribute to a more holistic understanding of the current knowledge base. Furthermore, such an analysis could provide valuable data to guide future research directions for both clinicians and investigators.

The aim of this study is to analyze the bibliometric characteristics of publications on penile fracture indexed in the Web of Science (WoS) Core Collection database, in order to identify scientific production trends, citation impacts, and international collaboration networks related to the topic.

METHODS

Ethics

Since this study is a bibliometric study, ethics committee approval is not required.

Search Strategy and Data Collection

The WoS platform (<https://www.webofscience.com/>) provides subscription-based access to multiple databases that offer comprehensive citation data across diverse academic disciplines. For this study, the WoS Core Collection database was used to perform a bibliometric analysis. The study period was set from 1980 to 2024.

A sophisticated 'topic' (TS) search parameter was applied within the WoS Core Collection to ensure retrieval of all relevant publications. The search strategy was defined as: TS=("penile fracture*" OR "penis fracture*" OR "penile rupture*" OR "fracture of the penis" OR "fracture of penis" OR "corpus cavernosum rupture" OR "rupture of corpus cavernosum" OR "rupture of the corpus cavernosum")

All bibliographic records that met the inclusion criteria were retrieved on August 3, 2025, and subsequently exported for detailed bibliometric analysis.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Articles published in journals indexed in the Science Citation Index Expanded (SCIE) within the WoS database.
- Publications available only in English.

- Original research articles (including both open-access and subscription-based publications).
- Articles retrieved using the specified search terms related to penile fracture.

Exclusion criteria: Publication types other than original research articles, including but not limited to case reports, case series, narrative reviews, systematic reviews, and meta-analyses, were excluded. Case reports and case series were specifically excluded because they usually provide limited bibliographic metadata and have relatively low citation potential. Although clinically valuable especially in rare conditions such as penile fracture their descriptive nature may disproportionately influence citation metrics and bias the interpretation of research impact.

Data Analysis Tools

For effective data extraction, analysis, and visualization, Microsoft Excel (version 2016) was used for tabulation and management of bibliometric datasets.¹⁰ Bibliometric data were processed using BibExcel (version 2016-02-20) to identify the most productive authors, countries, and journals.¹¹

For each category, the following metrics were calculated:

- Number of articles
- Total citation count
- h-index
- Citation sum within the h-core

For the most productive journals, the average number of citations per article was also calculated to provide a normalized measure of impact.

Although the initial selection criterion was to identify the top 10 entries in each category, all authors or countries with identical h-index values were included to ensure fair comparison.

For example, in the author ranking table, 13 authors were listed instead of 10 because several authors shared the same h-index score, thus qualifying for inclusion under the fairness criterion.

Bibliometric performance was assessed using the h-index, total citation counts, and total link strength (TLS). These indicators were selected because they are widely used in bibliometric research, facilitate comparability with prior studies, and allow for standardized evaluation of publication productivity and impact. Although normalized indicators such as the Field-Weighted Citation Impact (FWCI) could provide a more nuanced assessment of scientific influence by accounting for disciplinary differences in citation practices, FWCI is not directly available within the WoS Core Collection and therefore could not be included in this analysis.

Visual Mapping and Network Analysis

Visual maps were generated using VOSviewer (version 1.6.20).¹² The following bibliometric analysis types were employed:

- Co-authorship analysis
- Co-occurrence analysis
- Bibliographic coupling

For all analyses, the full counting method was applied. To normalize the strength of connections between items, the association strength normalization method was used.

The random start parameter was set to 1000, allowing the algorithm to begin from multiple different initial positions and thereby optimize the layout arrangement. The maximum iterations parameter was set to 1000, enabling the algorithm to perform up to 1000 iterations to find the most optimal configuration.

These settings were chosen to enhance the consistency of the analysis results and to help the algorithm avoid local minima, thus increasing the likelihood of approaching a global optimum.

In the network and overlay visualizations, the nodes represent items (e.g., authors, keywords, journals), while the links denote connections between these nodes.

Co-authorship Analysis

In the co-authorship analysis, collaborative relationships between authors were evaluated. In the network visualization, each node is color-coded according to the cluster it belongs to; these colors reflect the relational proximity between the corresponding items. Each node represents a single author.

The importance of a node is depicted by its size and label. Only significant items are labeled in the visualization to maintain clarity. The links between nodes represent collaborative relationships between authors. The length of a link is inversely proportional to the strength of the connection (i.e., shorter links indicate stronger collaboration). Thicker lines indicate higher levels of collaborative strength between authors.

For network construction, the following inclusion thresholds were applied:

- Minimum number of documents per author: 2
- Minimum citation count per author: 10

Disconnected items meeting these criteria were also included in the visualization to provide a comprehensive overview. The weighting of nodes was based on TLS, with larger nodes indicating higher overall collaborative strength.

Co-occurrence Analysis of Keywords

The co-occurrence analysis illustrated the interrelationships between keywords. This method is employed to identify the conceptual structure of a research topic by examining how frequently specific keywords appear together in publications. In this study, co-occurrence analysis was performed based on the author-provided keywords from the included articles.

The analysis was conducted using overlay and network visualization techniques:

Overlay visualization: In this visualization, colors reflect the temporal distribution of keyword usage. Keywords used in more recent studies are shown in yellow, whereas those predominantly found in earlier publications appear in purple. This allows for the identification of emerging and declining research trends.

Network visualization: This visualization highlights the relationships between the most frequently used keywords and their co-occurring terms. Each keyword is represented as a node, and the connecting lines represent the frequency of co-occurrence in the same publications.

Weighting and inclusion criteria:

- Nodes were weighted by occurrence frequency, with larger nodes indicating higher total occurrences in the dataset.
- The average publication year (APY) was selected as the scoring parameter for overlay visualization.
- A minimum threshold of 2 occurrences was applied for inclusion, ensuring that only keywords with notable recurrence and field-specific relevance were displayed.

This approach enables a clearer identification of core concepts within the field, as well as the detection of shifts in research focus over time.

Bibliographic Coupling Analysis

To identify the structural relationships within the literature, the connections between studies sharing similar citation patterns, and the core research clusters in the field, a bibliographic coupling analysis was conducted.

Methodology:

- A minimum citation threshold of 0 was applied, ensuring that all documents indexed in the dataset were eligible for inclusion regardless of their citation count.
- Citation counts were used as the weighting parameter to evaluate the strength of connections between documents.

Visualization:

- The network visualization map was generated to illustrate the bibliographic coupling results.
- **Nodes (documents):** Each node represents a single document; the size of the node reflects the total citation count of that document.
- **Proximity:** The physical closeness between nodes indicates the strength of their bibliographic coupling (i.e., how many references they share).
- **Colors:** Different colors represent clusters of publications with similar citation behavior, signifying distinct thematic or methodological research groups within the penile fracture literature.

This analysis allows the identification of not only the most influential works but also the thematic connections between

studies, facilitating a deeper understanding of the field's conceptual and methodological structure.

Data Cleaning

Prior to conducting the bibliometric analyses, a comprehensive data cleaning process was implemented to ensure accuracy and consistency. The raw dataset obtained from the WoS database was manually reviewed to standardize variations in author names, country names, and journal titles, correcting spelling inconsistencies, abbreviations, and formatting discrepancies. Using BibExcel, duplicate records referring to the same authors or countries were merged to ensure accurate attribution of productivity and citation metrics. Additionally, a thesaurus file was applied in VOSviewer to consolidate alternative spellings of author names, preventing fragmentation in co-authorship and keyword networks. These steps enhanced the validity of bibliometric metrics and improved the clarity and reliability of the visual mapping outputs.

RESULTS

Applying the predefined search strategy in the WoS database for penile fracture-related studies initially yielded 754 records. After applying the inclusion and exclusion criteria, 255 original research articles were identified (**Figure 1**). These publications involved contributions from 1,064 authors representing 36 countries and were published across 93 different journals.

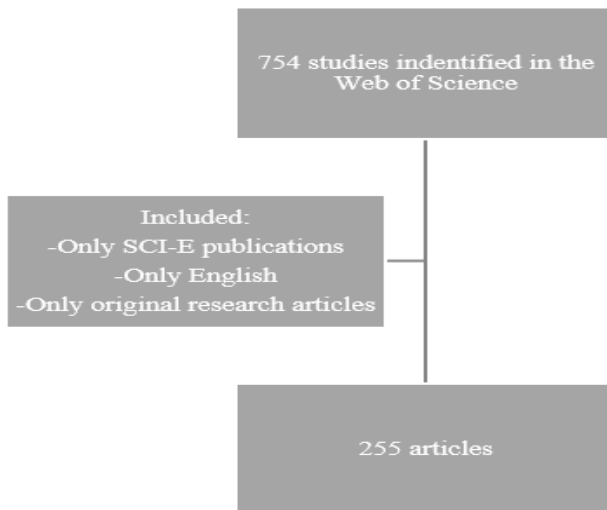


Figure 1. Flow diagram of the inclusion process

Countries with the highest citation sum within the h-core (CSh) were as follows: the USA (71 articles, 1,798 CSh), Egypt (14 articles, 518 CSh), Turkiye (40 articles, 504 CSh), Iran (8 articles, 462 CSh), and the UK (13 articles, 235 CSh) (**Table 1**).

When considering both citation impact and productivity, the journals with the highest h-index were as follows: Journal of Urology (23 articles, h-index 10), Urology (22 articles, h-index 16), Journal of Sexual Medicine (13 articles, h-index 12), International Journal of Impotence Research (16 articles, h-index 10), and BJU International (11 articles, h-index 10) (**Table 2**).

The authors with the highest number of articles and h-index were Favorito LA (8 articles, h-index 8), Koifman L (8 articles,

Table 1. The most productive and effective countries on the subject of penile fracture

No	Countries	All articles	Citation sum within h-core	All citations	h-index
1	USA	71	1798	2311	27
2	Turkiye	40	504	628	15
3	Egypt	14	518	520	13
4	UK	13	235	246	9
5	Brazil	11	207	221	6
6	Germany	7	166	172	5
7	Iran	8	462	468	5
8	Italy	7	161	168	5
9	Peoples R China	4	23	23	4
10	Saudi Arabia	5	62	62	4
11	Tunisia	6	141	141	4
12	India	5	53	59	3
13	Nigeria	4	47	49	3
14	Trinidad Tobago	3	53	53	3

h-index 7), and Barros R (8 articles, h-index 7) (**Table 3**). The authors with the highest citation sum within the h-core (CSh) were Morey AF (5 articles, 461 CSh), McAninch JW (5 articles, 378 CSh), Santucci RA (2 articles, 371 CSh), Zargooshi J (4 articles, 353 CSh), and Breyer BN (2 articles, 339 CSh).

To illustrate international collaboration, a network map was generated and is presented in **Figure 2**. Among the 1,064 authors, those with a minimum of two publications and at least 10 citations (a total of 67 authors) were included in the co-authorship analysis, with TLS selected as the weighting parameter. Some nodes were unconnected; the largest connected cluster contained eight nodes. However, to reflect the overall network structure, all items meeting the inclusion criteria were visualized. The analysis revealed a total of 24 clusters, 78 links, and a cumulative TLS of 179. Authors with the highest TLS were Barros R (8 articles, 26 TLS), Favorito LA (8 articles, 26 TLS), Koifman L (8 articles, 26 TLS), El-Assmy A (5 articles, 15 TLS), El-Tholoth HS (5 articles, 15 TLS), Ibrahim EHI (5 articles, 15 TLS), and Mohsen T (5 articles, 15 TLS).

In **Figure 3**, a network map was generated to illustrate the connections between the most frequently used keyword, "penile fracture," and other terms. The analysis identified a total of 73 keywords, organized into 12 clusters, with 298 links and a cumulative TLS of 545. "Penile fracture" was the only keyword connected to all other clusters, serving as the central linking term. The five most frequently occurring keywords were: penile fracture (78 occurrences, 136 TLS), penis (57 occurrences, 144 TLS), fracture (18 occurrences, 49 TLS), erectile dysfunction (18 occurrences, 35 TLS), and trauma (15 occurrences, 43 TLS). The keyword pairs with the highest link strength (LS) were: penis-fracture (17 LS), penile fracture-erectile dysfunction (14 LS), penis-wounds and injuries (13 LS), penile fracture-penis (9 LS), penile fracture-tunica albuginea (9 LS), penis-fractures (8 LS), penis-surgery (8 LS), and penis-rupture (8 LS).

In the keyword analysis, the term “penile fracture” demonstrated strong associations with “erectile dysfunction” and “trauma”, indicating that research in this field has predominantly focused on clinical outcomes and etiological factors. The notable increase since 2019 in diagnostic modality-related keywords such as “ultrasound” and “MRI” reflects the growing importance of non-invasive imaging techniques in the diagnosis of penile fracture.^{23,24} This trend aligns with current clinical guidelines emphasizing the critical role of accurate and rapid diagnosis in guiding timely surgical intervention.²⁵ Over time, the research landscape on penile fracture has undergone notable shifts. Early publications largely consisted of case reports and small series focusing on clinical presentation and surgical repair. Since the early 2000s, diagnostic imaging modalities such as ultrasonography and cavernosography received increasing attention. In the past decade, studies have highlighted the role of MRI in diagnosis, evaluated long-term outcomes of different surgical approaches, and explored complications such as erectile dysfunction and penile curvature. Emerging research directions include comparative imaging studies, functional outcome analyses, and the development of multicenter registries to standardize data collection. Collectively, these evolving trends reflect a gradual transition from descriptive to more methodologically robust and outcome-oriented research.

The bibliographic coupling analysis revealed that the knowledge base in this field is clustered around a limited number of highly influential publications. Landmark studies such as Morey and Zargooshi stand out as pivotal reference points in the literature, contributing both to advancements in surgical techniques and to the accumulation of epidemiological data.^{26,27} However, the current body of research is largely comprised of retrospective and observational studies. This underscores a critical need for well-designed, prospective, multicenter, and randomized controlled trials to enhance the level of evidence and strengthen the generalizability of clinical recommendations. In addition, future investigations should prioritize field-specific directions. First, comparative evaluations of diagnostic modalities, particularly MRI versus ultrasonography, are needed to better define their roles in the early and accurate diagnosis of penile fracture. Second, long-term outcome studies assessing different surgical repair techniques should be undertaken, focusing on erectile function, penile curvature, and patient-reported outcomes. Third, the development of multicenter registries would facilitate large-scale data sharing, reduce fragmentation across the literature, and enhance methodological robustness. Collectively, these priorities may advance not only the scientific evidence base but also inform the evolution of clinical guidelines in this rare but clinically significant emergency.

Strengths and Limitations

One of the key strengths of this study is its broad temporal coverage, encompassing a wide range of years, which allows for an in-depth evaluation of long-term research trends. The analysis exclusively included original research articles indexed in the SCIE, thereby ensuring the inclusion of high-quality, peer-reviewed publications. Furthermore, advanced software tools were utilized for data cleaning and visualization,

enhancing both the precision and the interpretability of the bibliometric findings.

However, certain limitations must be acknowledged. First, this study relied exclusively on the WoS Core Collection. While WoS provides standardized citation data and high-quality coverage, this restriction may have resulted in the omission of relevant studies indexed in other databases such as Scopus or PubMed. Consequently, some regional or non-English language publications may not have been captured. Future bibliometric analyses using multi-database approaches could help provide a more comprehensive and inclusive assessment of penile fracture research. Second, restricting the analysis to English-language publications may have introduced a language bias, underrepresenting studies from non-English-speaking countries, particularly in the Middle East and Asia, where penile fracture has been relatively more frequently reported. As a result, the global research landscape presented here may not fully capture contributions from these regions. Future bibliometric studies should consider including non-English publications to minimize this bias and provide a more accurate representation of worldwide research activity.

Another limitation, our study did not incorporate normalized citation metrics such as the FWCI, which could provide a more refined evaluation of scientific influence across disciplines. This omission reflects the constraints of the WoS database. Future bibliometric studies may benefit from integrating FWCI or similar advanced indicators through multi-database approaches.

CONCLUSION

As a result, this study provides the first comprehensive bibliometric mapping of penile fracture research, offering unique insights into global publication patterns, influential contributors, and emerging research themes. These findings highlight critical knowledge gaps and point to concrete priorities for future research, including comparative evaluations of imaging modalities, long-term outcome studies of surgical repair, and the establishment of multicenter registries. By addressing these priorities, future investigations may not only strengthen the scientific evidence base but also inform guideline development and optimize clinical management of this rare yet significant urological emergency.

ETHICAL DECLARATIONS

Ethics Committee Approval

Since this study is a bibliometric study, ethics committee approval is not required.

Informed Consent

Since this study is a bibliometric study, written informed consent is not required.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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