Global Trends in Innovation and Productivity in Microsurgery for Plastic Surgery: A Bibliometric Analysis

Tendencias Globales de Innovación y Productividad en Microcirugía para la Cirugía Plástica: Un Análisis Bibliométrico

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Abstract
Introduction: Microsurgery in plastic surgery has experienced significant growth since 1976, particularly in fields such as breast reconstruction and the management of surgical flaps. However, inequalities persist in scientific output and global access to this technology.
Objective: This bibliometric study analyzed global trends in productivity, innovation, collaboration and gaps in microsurgery applied to plastic surgery.
Method: A bibliometric analysis was conducted on publications indexed in Scopus, utilizing terms related to microsurgery and plastic surgery. Scientific mapping techniques and bibliometric analyses were applied to evaluate global output, international collaborations, and research themes.
Results: A total of 282 documents were identified, with the United States leading in scientific production and impact (h-index of 24). Microsurgery emerged as the most prolific journal, while Plastic and Reconstructive Surgery stood out for its impact. Key thematic areas included breast reconstruction and surgical flaps. Since 2012, a notable increase in scientific output has been observed. International collaboration networks are predominantly composed of countries with high or upper-middle incomes.
Conclusions: This analysis provides a comprehensive overview of global trends in microsurgery applied to plastic surgery, highlighting the central role of international collaborations and emerging thematic areas. The findings carry significant implications for evidence-based decision-making and the design of policies that promote equity in research and specialized surgical care.

Keywords: Plastic Surgery, Plastic Surgery Procedures, Microsurgery, Biomedical Research, Bibliometrics

Resumen
Introducción: La microcirugía aplicada a la cirugía plástica ha experimentado un crecimiento significativo desde 1976, especialmente en ámbitos como la reconstrucción mamaria y el manejo de colgajos quirúrgicos. Sin embargo, persisten desigualdades en la producción científica y el acceso global a esta tecnología.
Objetivo: Este estudio bibliométrico analizó las tendencias globales de productividad, innovación, colaboración y brechas en microcirugía aplicada a cirugía plástica.
Metodología: Se realizó un análisis bibliométrico de publicaciones indexadas en Scopus, utilizando términos relacionados con microcirugía y cirugía plástica. Se aplicaron técnicas de mapeo científico y análisis cienciométricos para evaluar la producción global, colaboraciones internacionales y temáticas de investigación.
Resultados: Se identificaron 282 documentos, con Estados Unidos liderando la producción científica e impacto (índice h de 24). Microsurgery fue la revista más prolífica, mientras que Plastic and Reconstructive Surgery destacó por su impacto. Las áreas temáticas principales incluyeron reconstrucción mamaria y colgajos quirúrgicos. Desde 2012, se ha observado un aumento notable en la producción científica. Las redes de colaboración internacional son predominantemente a expensas de países de altos y altos y medianos ingresos.
Conclusiones: Este análisis proporciona una visión integral de las tendencias globales en microcirugía aplicada a la cirugía plástica, destacando el papel central de las colaboraciones internacionales y las áreas temáticas emergentes. Los hallazgos tienen implicaciones relevantes para la toma de decisiones basada en evidencia y el diseño de políticas que promuevan la equidad en investigación y atención quirúrgica especializada.

Palabras clave: Cirugía Plástica, Procedimientos de Cirugía Plástica, Microcirugía, Investigación Biomédica, Bibliometría.

I. INTRODUCTION

Microsurgery, as applied to plastic surgery, has undergone significant evolution since its initial clinical applications in the 1970s [1]. This approach, which integrates precise surgical techniques with advanced technology, has enabled the development of complex procedures such as breast reconstruction, the management of surgical flaps, and the repair of specialized tissues [2]. Its impact on medical practice has not only improved clinical outcomes but has also expanded therapeutic options for patients with complex reconstructive and aesthetic needs [3]. However, substantial challenges continue to restrict its global reach and effectiveness.

One of the primary current challenges lies in disparities in access to microsurgical procedures. These inequities are particularly pronounced in resource-limited countries, where the lack of specialized training, technological infrastructure, and access to state-of-the-art equipment hinders the implementation of these techniques [4]. Moreover, microsurgery demands a high level of interdisciplinary coordination and international collaboration, which is often unfeasible in settings with economic or structural constraints [5]. These barriers, compounded by the insufficient integration of the latest scientific evidence into clinical practice, underscore the urgent need for research aimed at understanding and addressing these limitations [6].

Despite the growing interest in microsurgery, significant gaps persist in the evidence base. Systematic analyses characterizing global trends in the field, identifying collaboration patterns, and evaluating the quality and impact of scientific publications remain scarce [7]. These deficiencies complicate the implementation of evidence-based strategies designed to promote equitable access to microsurgery and enhance its impact on health outcomes.

In this context, bibliometric analysis emerges as a powerful tool to address these gaps [8]. This approach enables the mapping of research landscapes, the identification of emerging trends, the assessment of international collaborations, and the measurement of the impact of scientific publications on advancing knowledge. Furthermore, it provides a foundation for the development of informed scientific and public health policies aimed at strengthening microsurgical capacities and reducing existing inequities. Thus, the objective of the present study was to explore global trends and the evolution of scientific output in microsurgery as applied to plastic surgery.

II. METHODS

A bibliometric analysis was conducted using Scopus, a database recognized as one of the largest platforms for peer-reviewed scientific literature. The selection of this database for studies of this nature has been supported and widely applied in previous research [9, 10].

To collect the data, a semi-structured search was designed and executed, incorporating health sciences descriptors, MeSH terms, and their synonyms, considering both English and Spanish. After pilot testing to assess the precision of the search strategies, the following formula was applied: TITLE-ABS (Microdissection) OR TITLE-AB (Microsurgery) OR TITLE-ABS (Micromanipulation) AND TITLE-ABS-KEY(“Plastic Surgery Procedures”) OR TITLE-ABS-KEY(“Plastic Surgery Procedure”) OR TITLE-ABS-KEY(“Plastic Surgical Procedures”) OR TITLE-ABS-KEY(“Plastic Surgical Procedure”) OR TITLE-ABS-KEY(“Esthetic Surgical Procedures”) OR TITLE-ABS-KEY(“Esthetic Surgical Procedures”) OR TITLE-ABS-KEY(“Cosmetic Reconstructive Surgery”) OR TITLE-ABS-KEY(“Cosmetic Reconstructive Surgeries”) OR TITLE-ABS-KEY(Abdominoplasty) OR TITLE-ABS-KEY(“Body Contouring”) OR TITLE-ABS-KEY(“Guided Tissue Regeneration”) OR TITLE-ABS-KEY(Mammaplasty) OR TITLE-ABS-KEY(Rhinoplasty) OR TITLE-ABS-KEY(“Sex Reassignment Surgery”) OR TITLE-ABS-KEY(“Tissue Expansion”).

The results were exported in .CSV format for manual review, which included removing duplicates and verifying compliance with inclusion criteria. Selected documents were required to meet the following conditions: (A) explicitly identifying the analysis, study, or synthesis of evidence related to microsurgery in plastic surgery as a primary or secondary objective, and (B) providing access to the full text. The search was conducted on November 1, 2024.

For the characterization and visualization of the results, corresponding to scientific mapping, topic and co-occurrence networks were generated, and scientometrics metrics were

calculated. These activities were performed using the Bibliometrix package in R (version 4.3.1) [11]. Additionally, frequency and percentage calculations were performed using Microsoft Excel 2016.

Ethical Statements

Ethical committee approval was not required for this study, as it did not involve research on humans, biological models, or the use of medical records.

III. RESULTS

Following the application of inclusion and exclusion criteria, 282 scientific documents were selected. The first publication in the dataset was recorded in 1976. The scientific output predominantly consisted of original articles (77.31%; n = 218), followed by review articles (13.83%; n = 39). International collaboration was observed in 12.77% of the documents (Table 1). From the time of the initial publication, the output demonstrated limited activity, with slow but steady growth beginning in 2012 (Figure 1). In contrast, citation frequency displayed fluctuations, with a declining trend in more recent years (Figure 1).

Regarding country-level contributions, the United States emerged as the most productive and impactful nation, with 107 documents and an h-index of 24, followed by Germany (31 documents; h-index of 10) and the United Kingdom (23 documents; h-index of 9). In terms of institutional affiliations, Harvard Medical School (USA) and Beth Israel Deaconess Medical Center (USA) historically stood out, each contributing 11 documents with an h-index of 5.

The journal Microsurgery (n = 43) published the highest number of articles on the topic (Figure 2-A). This journal also accumulated the greatest citation frequency (n = 826) (Figure 2-B) and demonstrated significant impact based on h- and g-indices. However, Plastic and Reconstructive Surgery exhibited the highest m-index to date (Figure 2-C). Since 2013, Microsurgery has been the preferred outlet for authors publishing on microsurgery in plastic surgery (Figure 2-D).

TABLE 1. GENERAL CHARACTERISTICS OF GLOBAL RESEARCH ON MICROSURGERY IN PLASTIC SURGERY (N = 282).

	n	%
Authors		
Authorship	1243	
Documents with single authorship (n = 1,243)	21	1,69
Article type		
Original article	218	77,31
Review	39	13,83
Editorial	2	0,71
Letter	7	2,48
Book chapter	3	1,06
Note	2	0,71
Short survey	3	1,06
Conference paper	8	2,84
Collaboration		
Articles with single authorship	22	-
Average number of co-authors per article International co-authorship	5,15 -	12,77
Average article age (years)	8	-
Average citations per document	14,17	-
Keywords	519	-
Scientific Sources	105	-

In the context of scientific collaborations, Harvard Medical School has established itself as one of the most prominent institutions globally, serving as a key reference center. It is followed by the Mayo Clinic and Stanford University (Figure 3-A). At the country level, the United States has led in collaboration volume, particularly with nations such as Germany, the

United Kingdom, and Asian countries, including China. Five distinct collaboration clusters demonstrate significant interaction frequencies (Figure 3-B).

Regarding thematic patterns and research trends, an analysis of the most frequently used keywords revealed a strong association between microsurgery and topics such as "breast reconstruction," "mammaplasty," and "surgical flaps," which were the most common keywords (Figure 4-A). From approximately 1976, research was largely exploratory, timely, and nonspecific (Figure 4-B). By the year 2000, a clearer focus had emerged on transplants, flaps, and breast tumors, which became some of the most studied topics. In recent years, there has been a noteworthy trend toward investigating medical and surgical curricula, with potential inclusion of microsurgery training (Figure 4-C).

A thematic map revealed various research niches, characterized by differentiation across age groups, surgical techniques, surgical specialties, and research subjects (Figure 4-D).

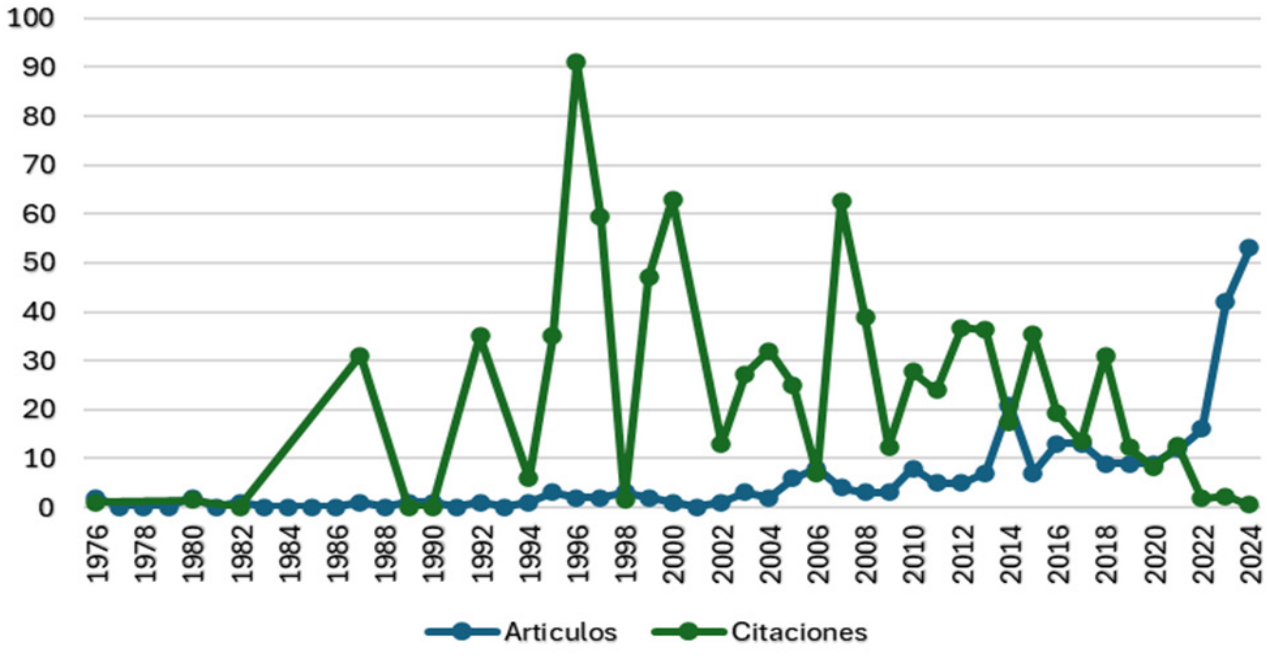

Figure 1. Trends in global research on microsurgery in plastic surgery. Blue: Annual publication frequency. Green: Average citations per article per year.

IV. DISCUSSION

The findings of this bibliometric analysis provide a comprehensive overview of global trends and patterns in research on microsurgery in plastic surgery. A total of 282 documents were identified, showing sustained growth since the first publication in 1976, with a more pronounced increase starting in 2012. This trend reflects the growing relevance of microsurgery as a critical tool in complex reconstructive procedures, driven by technological advancements and the rising demand for personalized surgical solutions [12].

One of the most notable findings is the leadership of the United States in scientific output and impact, with over 100 publications and the highest measured influence. This dominance can be attributed to factors such as substantial investment in research and development, access to advanced technology [13], and the presence of prestigious academic institutions like Harvard Medical School and the Mayo Clinic, which have played a pivotal role in generating knowledge. International collaboration, at 12.77%, highlights the importance of global partnerships in addressing the complex challenges associated with microsurgery.

The sustained growth in microsurgery research since 2012 may be linked to advancements in technologies such as 3D printing, robotics, and biomaterials, which have expanded clinical possibilities and stimulated further investigation [14]. Additionally, the increasing demand for reconstructive procedures following oncological surgeries, trauma, and congenital deformities has attracted significant interest from both researchers and clinicians [15]. The influence of science and technology policies in countries like the United States and Germany, which emphasize translational research and innovation, should also be considered [16].

In contrast, the low research output in low-income countries highlights structural and financial barriers that restrict participation in high-complexity investigations [17]. These inequalities are further reflected in the limited collaborations with developing countries, underscoring the need for global initiatives to promote inclusivity and equity in research [18].

This analysis addresses critical gaps by providing a detailed mapping of collaboration networks, emerging research topics, and citation patterns. For instance, identifying key thematic areas such as breast reconstruction, surgical flaps, and transplants highlights focal points for future research efforts. Additionally, the keyword analysis uncovers recent trends toward integrating microsurgery into medical and surgical curricula, which could significantly influence the training of the next generation of surgeons.

However, substantial challenges remain, including the lack of standardization in methodologies and definitions within microsurgery research. Furthermore, the declining citation trend underscores the need for strategies to enhance the visibility and impact of recent studies.

The findings of this study hold both theoretical and practical implications. From a theoretical standpoint, the bibliometric analysis provides a robust foundation for understanding the evolution of knowledge in microsurgery and identifying gaps that warrant attention. Practically, the results can support evidence-based decision-making, guiding clinicians, researchers, and policymakers in designing training programs, allocating resources, and fostering international collaborations [19, 20].

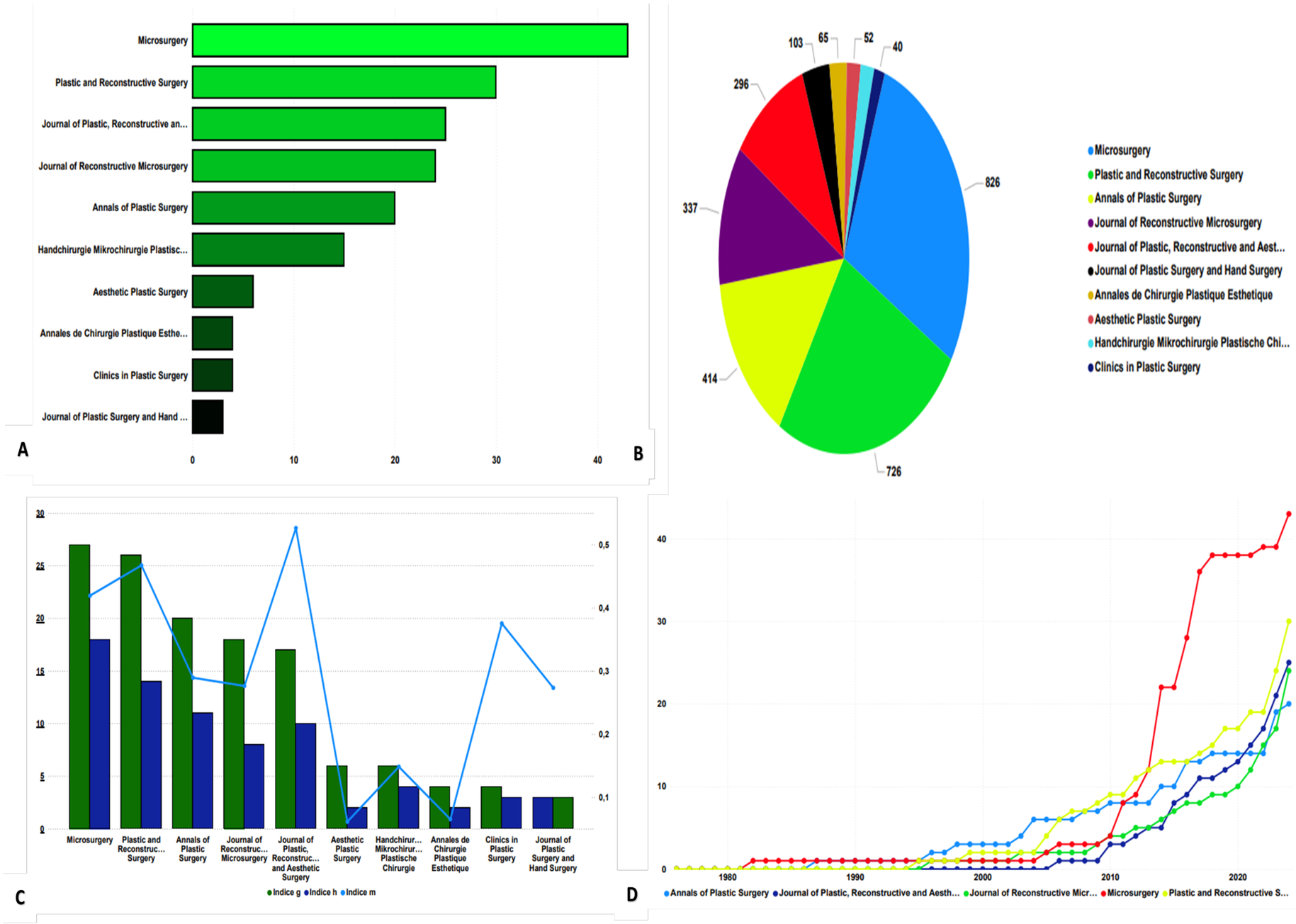

Figure 2. Citations and scientific impact of journals with the highest volume of publications on microsurgery in plastic surgery. A. Cumulative frequency of published documents. B. Total citations received. C. h-index, g-index, and m-index by journal. D. Cumulative publication volume over time for the top five journals with the highest number of documents.

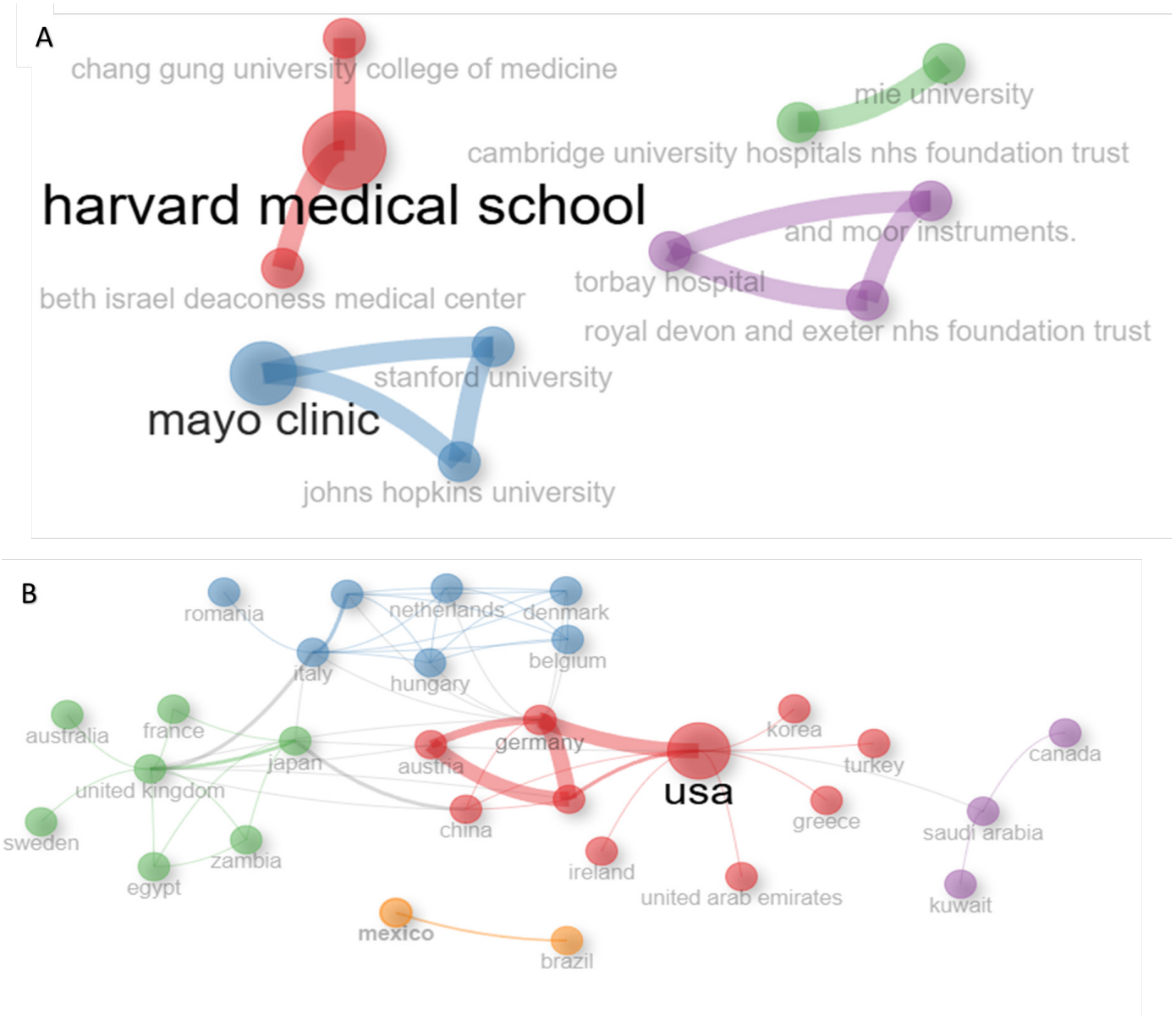

Figure 3. International scientific collaboration networks in global research on microsurgery in plastic surgery. A. Institutional collaboration. B. Country-level collaboration.

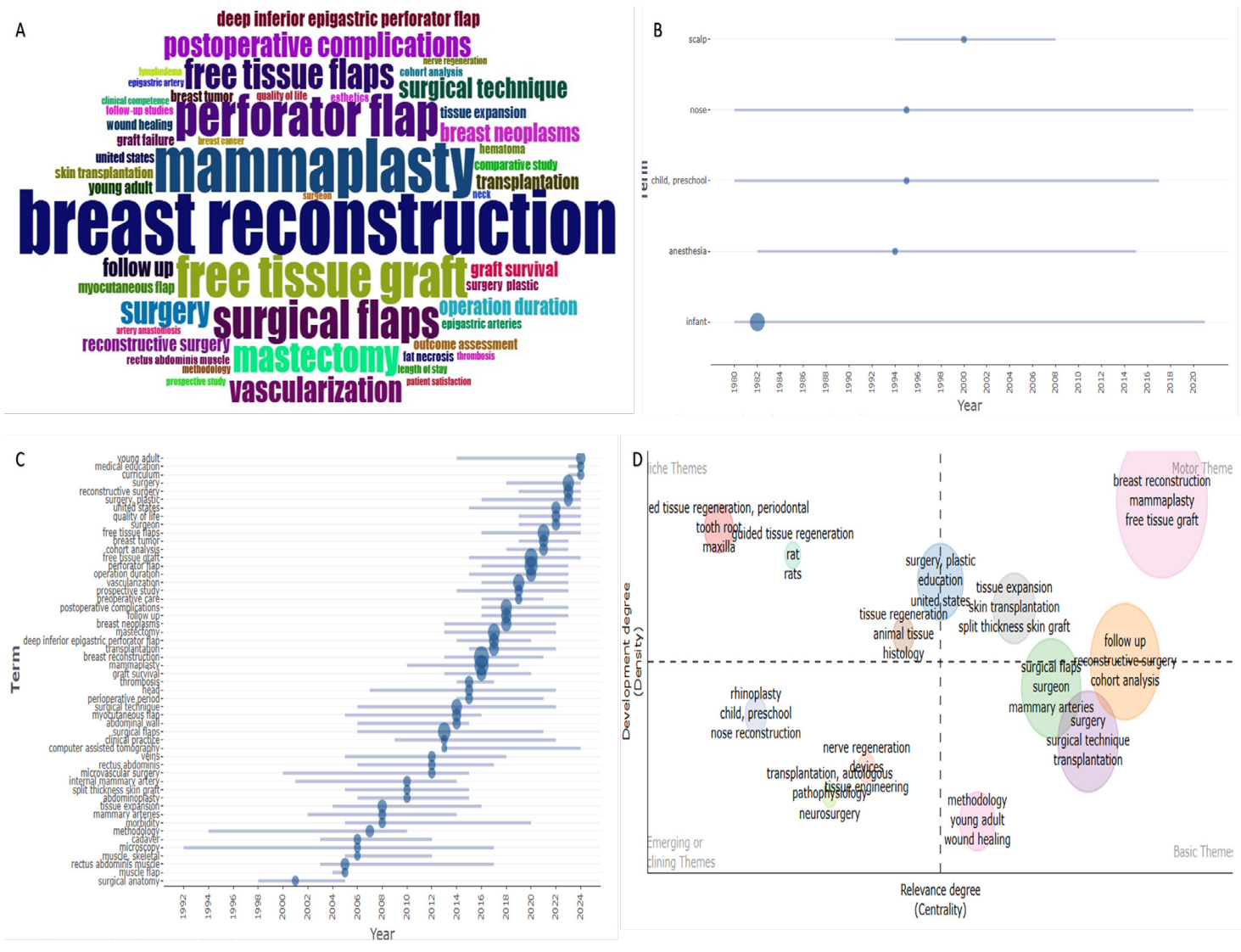

Figure 4. Research patterns and topic evolution in global studies on microsurgery in plastic surgery. A. Word cloud of the most frequently used bigram keywords. B. Most frequently studied topics from 1982 to 2000. C. Most frequently studied topics since 2000. D. Thematic map of the most relevant research niches.

In the context of public policy, this study highlights the need for initiatives that promote equity in access to research and advanced technologies. These include implementing funding programs for researchers in low- and middle-income countries and establishing global networks to facilitate the exchange of knowledge and resources. From a meta-scientific perspective, the findings provide valuable insights for identifying gaps, opportunities, and scientific pluralism, enabling the design of future studies aligned with health research needs. Such efforts could help bridge theoretical and practical knowledge gaps in microsurgery applied to plastic surgery [21, 22, 23, 24]. Additionally, understanding this conceptual landscape supports the evolution of programs and technologies aimed at training future professionals [25].

Among the limitations of this study, the exclusive use of Scopus as the data source stands out, potentially excluding relevant research indexed in other databases. Furthermore, focusing on articles published in English may underrepresent scientific output in other languages. Future studies could address these limitations by incorporating multiple databases and conducting multilingual analyses.

V. CONCLUSIONS

This bibliometric study identified key patterns in global research on microsurgery in plastic surgery, highlighting the United States as the leading contributor in scientific output and impact. International collaborations and the establishment of specialized journals, such as Microsurgery and Plastic and Reconstructive Surgery, have played a pivotal role in advancing the field. Emerging trends were observed in areas such as breast reconstruction, surgical flaps, and transplants.

Despite these advancements, significant inequalities in research persist, particularly in low- and middle-income countries, emphasizing the need for global strategies to address these gaps. Additionally, the recent stagnation in citation rates presents a challenge to maintaining the field's relevance and impact.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

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