Insights into research trends on recurrent laryngeal nerve damage in thyroid surgery (1974–2024): a bibliometric review

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Background: Insufficient iodine intake is a global health issue, causing goiter in about 2.2 billion people, with a prevalence of 15.8%. Thyroid surgeries, although necessary, can lead to serious complications like recurrent laryngeal nerve (RLN) injury. This study aims to identify leading countries, institutions, and keywords related to thyroid surgery and RLN injury to guide future research and clinical practice.

Methods: A search in the Scopus database on May 7, 2024, resulted in 1,440 publications from 346 sources, analyzed using the Bibliometrix R-package.

Results: The analysis shows an upward trend in publications. The USA leads with 730 publications, followed by China (n=660) and Italy (n=388). Kaohsiung Medical University Hospital has the highest publication count (n=103), followed by Harvard Medical School (n=60). China provided the most research grants (n=100), followed by the USA (n=46). Extensive collaborations are noted, especially between the USA, China, Italy, and Korea. The *World Journal of Surgery* published the most articles (n=67), while the *International Journal of Surgery* had the highest impact factor (15.3). Prominent authors include Dionigi G with 49 articles and Wu CW. with forty. The keywords "thyroidectomy" and "recurrent laryngeal nerve" were frequently used from 1974 to 2024.

Conclusions: This bibliometric analysis underscores the increasing global research focus on RLN injury in thyroidectomy, highlighting the need for enhanced surgical techniques, international collaboration, and standardized practices to improve patient outcomes.

Keywords: Thyroidectomy; recurrent laryngeal nerve injuries (RLN injuries); thyroid diseases/surgery; bibliometrics; postoperative complications

Introduction

Iodine deficiency poses a significant global public health challenge, given its indispensable role as a micronutrient essential for synthesizing thyroid hormones, thyroxine (T4), and triiodothyronine (T3) (1). These hormones are

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critical for regulating growth and metabolism throughout life. Insufficient iodine intake is a leading cause of goiter worldwide, affecting approximately 2.2 billion people (2,3). The global prevalence of goiter in the general population stands at 15.8% (4,5), with women being approximately four times more likely to develop goiter than men (6). Notably, benign thyroid diseases have been associated with an increased risk of thyroid cancer, particularly in conditions such as hyperthyroidism, hypothyroidism, and goiter (7).

The treatment of goiter typically involves medical therapy and surgical intervention, including partial or complete thyroidectomy. However, thyroid surgeries, while essential, can lead to serious complications, one of which is recurrent laryngeal nerve (RLN) injury. The incidence of RLN injuries during thyroid surgeries is reported to be 3% to 8% (8-10). RLN injury can result in vocal fold movement disorders, manifesting with symptoms such as hoarseness, diplophonia, dysphagia, and dyspnea (11). Male patients have been found to have a fivefold higher risk of transient dysphonia compared to females (12).

Various methodologies are employed to preserve the integrity of the thyroid gland during surgical procedures; however, intraoperative nerve visualization is considered the optimal standard for preventing RLN injury (13). Additionally, the use of loupes magnification and microsurgical techniques has been shown to enhance the precision of RLN identification during thyroid surgery, potentially reducing the incidence of nerve injury (14). The utilization of intraoperative neuromonitoring (IONM) during thyroidectomy shows promise in reducing the risk of postoperative bilateral vocal cord paralysis (VCP). Moreover, studies have indicated that both the operative time and hospitalization duration were shorter in the optical magnification group than in the IONM group (12).

In addition to the existing literature, bibliometric studies have been conducted on childhood thyroid cancer (15), the management of thyroid cancer (16), and the evolution in the field of thyroid disease (17). However, we did not find any studies specifically addressing RLN injury resulting from thyroidectomy. Furthermore, the existing studies were conducted using the Web of Science database and utilizing software such as VOS Viewer and CiteSpace, whereas this study was conducted using RStudio.

This bibliometric analysis sheds light on the complication associated with RLN injury following thyroidectomy, thereby contributing to the optimization of surgical methods and patient care in thyroid surgery. The aim of present study is identifying the most productive countries, author institutions, and keywords related to this issue, we intend to provide comprehensive data that can guide future research and clinical practice in the field of thyroid surgery. We present this article in accordance with the BIBLIO reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-2025-198/rc).

Methods

Search strategy

The search was conducted in the Scopus database on May 07, 2024 (*Figure 1*). Scopus was selected as the primary database due to its extensive coverage of peer-reviewed biomedical and surgical literature, standardized metadata, and compatibility with the Bibliometrix R-package for bibliometric analysis. Its ability to export data in BibTeX format ensured consistency in processing the 1,440 retrieved publications. While PubMed and Web of Science are valuable, Scopus was prioritized for its broader journal inclusion and robust metadata, which are critical for comprehensive bibliometric evaluations. A combination of keywords "recurrent laryngeal nerve", "thyroidectomy", and their synonyms was utilized using Boolean operators (AND, OR). Additionally, various terms for study types were employed in the search to limit it to original articles. A detailed query of the keywords used is provided in *Table 1*.
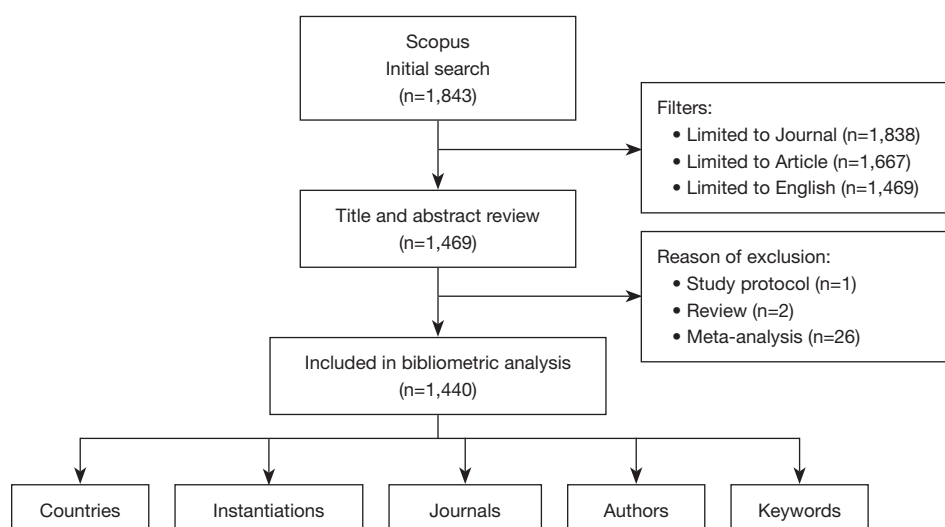

Highlight box

Key findings

- The USA (n=730), China (n=660), and Italy (n=388) lead in research output on recurrent laryngeal nerve (RLN) injury in thyroid surgery. Kaohsiung Medical University Hospital (n=103) and Harvard Medical School (n=60) are the top contributing institutions. China provided the most research grants (n=100), followed by the USA (n=46). The *World Journal of Surgery* published the most articles (n=67), while the *International Journal of Surgery* had the highest impact factor (15.3). Top authors: Dionigi G (49 articles) and Wu CW (40 articles). Most frequent keywords: "thyroidectomy" and "recurrent laryngeal nerve" (1974–2024).

What is known and what is new?

- RLN injury is a serious complication of thyroid surgery, impacting voice and respiratory function.
- This bibliometric analysis reveals global research trends, collaboration networks, and funding patterns, highlighting gaps and future directions.

What is the implication, and what should change now?

- Despite growing research, RLN injury remains a critical issue, requiring better surgical techniques, intraoperative monitoring, and standardized reporting.

Figure 1 Article selection for bibliometric insights into research trends on recurrent laryngeal nerve damage in thyroid surgery.

Table 1 Query for the Scopus for bibliometric insights into research trends on recurrent laryngeal nerve damage in thyroid surgery

Code	Queries
#1	TITLE-ABS-KEY("Recurrent Laryngeal Nerve") OR TITLE-ABS-KEY("Laryngeal Nerve, Recurrent") OR TITLE-ABS-KEY("Laryngeal Nerves, Recurrent") OR TITLE-ABS-KEY("Nerve, Recurrent Laryngeal") OR TITLE-ABS-KEY("Nerves, Recurrent Laryngeal") OR TITLE-ABS-KEY("Recurrent Laryngeal Nerves") OR TITLE-ABS-KEY("Laryngeal Nerve, Inferior") OR TITLE-ABS-KEY("Inferior Laryngeal Nerve") OR TITLE-ABS-KEY("Inferior Laryngeal Nerves") OR TITLE-ABS-KEY("Laryngeal Nerves, Inferior") OR TITLE-ABS-KEY("Nerve, Inferior Laryngeal") OR TITLE-ABS-KEY("Nerves, Inferior Laryngeal")
#2	TITLE-ABS-KEY("Thyroidectomy") OR TITLE-ABS-KEY("Thyroidectomies")
#3	TITLE-ABS-KEY("Clinical Trial") OR TITLE-ABS-KEY("Intervention Study") OR TITLE-ABS-KEY("Cross Sectional Studies") OR TITLE-ABS-KEY("Cross-Sectional Study") OR TITLE-ABS-KEY("Studies, Cross-Sectional") OR TITLE-ABS-KEY("Study, Cross-Sectional") OR TITLE-ABS-KEY("Cross Sectional Analysis") OR TITLE-ABS-KEY("Analyses, Cross Sectional") OR TITLE-ABS-KEY("Cross Sectional Analyses") OR TITLE-ABS-KEY("Disease Frequency Surveys") OR TITLE-ABS-KEY("Cross-Sectional Survey") OR TITLE-ABS-KEY("Cross Sectional Survey") OR TITLE-ABS-KEY("Cross-Sectional Surveys") OR TITLE-ABS-KEY("Survey, Cross-Sectional") OR TITLE-ABS-KEY("Surveys, Cross-Sectional") OR TITLE-ABS-KEY("Surveys, Disease Frequency") OR TITLE-ABS-KEY("Disease Frequency Survey") OR TITLE-ABS-KEY("Survey, Disease Frequency") OR TITLE-ABS-KEY("Analysis, Cross-Sectional") OR TITLE-ABS-KEY("Analyses, Cross-Sectional") OR TITLE-ABS-KEY("Analysis, Cross Sectional") OR TITLE-ABS-KEY("Cross-Sectional Analyses") OR TITLE-ABS-KEY("Cross-Sectional Analysis") OR TITLE-ABS-KEY("Prevalence Studies") OR TITLE-ABS-KEY("Prevalence Study") OR TITLE-ABS-KEY("Studies, Prevalence") OR TITLE-ABS-KEY("Study, Prevalence") OR TITLE-ABS-KEY("Retrospective Studies") OR TITLE-ABS-KEY("Studies, Retrospective") OR TITLE-ABS-KEY("Study, Retrospective") OR TITLE-ABS-KEY("Retrospective Study") OR TITLE-ABS-KEY("Prospective Studies") OR TITLE-ABS-KEY("Prospective Study") OR TITLE-ABS-KEY("Studies, Prospective") OR TITLE-ABS-KEY("Study, Prospective")
#4	LIMIT-TO (DOCTYPE, "ar")
#5	LIMIT-TO (SRCTYPE, "j")
#6	LIMIT-TO (LANGUAGE, "English")
#7	#1 AND #2 AND #3 AND #4 AND #5 AND #6

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The search results were exported from Scopus in Bib.tex (18).

Study selection and data extraction

The inclusion and exclusion criteria for the study were carefully defined to ensure the quality and relevance of the selected literature. Only original research articles were included to ensure that the analysis was grounded in primary research contributions. Editorials, reviews, conference papers, letters, and book chapters were excluded. To maintain consistency in data interpretation and analysis, only articles published in English were selected. The study considered publications from 1974 to 2024 in order to capture both historical and contemporary trends in research on RLN damage associated with thyroid surgery. Inclusion was limited to studies focusing on RLN injury, thyroidectomy, surgical complications, intraoperative nerve monitoring, and related clinical outcomes. The Scopus database was used for literature retrieval due to its comprehensive coverage of biomedical scientific literature.

Exclusion criteria were applied to refine the dataset further. Non-original research, including review articles, meta-analyses, case reports, and other non-research publications such as editorials and commentaries, were excluded to maintain focus on primary data and avoid redundancy. Articles published in languages other than English were also excluded to ensure uniformity in keyword analysis and interpretation. Additionally, studies that did not directly address RLN injury in the context of thyroid surgery—such as those focusing exclusively on thyroid cancer without reference to surgical complications—were omitted. Duplicate records or multiple versions of the same study were removed to prevent bias in bibliometric analysis.

The study selection process involved two independent authors (Y.Z., A.T. and B.S.Z.), who screened the titles and abstracts for eligibility. Any discrepancies in selection were resolved through discussion or consultation with a third author. Ultimately, the final dataset comprised 1,440 publications that met the predefined criteria. This rigorous selection process ensured that the resulting bibliometric analysis accurately reflected research trends and key contributions related to RLN injury during thyroid surgery.

Visualization and statistical tools

The data collection process began with a comprehensive search of the Scopus database using a predefined search strategy (*Table 1*). The retrieved records were exported in BibTeX format. Duplicate entries were identified and removed to maintain data integrity. Metadata including authors, affiliations, citations, and keywords were extracted and standardized, with efforts made to unify variations in institutional names for consistency across the dataset.

For bibliometric and scientometric analysis, the Bibliometrix R-package (version 4.3.2) was utilized. This allowed for a detailed quantitative evaluation of the dataset. Descriptive statistics were computed to assess total publications, average citations per document, authorship trends, collaboration indices, annual growth rate, and historical trends in publication output. Analysis at the country and institutional levels identified the leading contributors based on publication count and visualized collaboration networks through co-authorship matrices.

Journal analysis involved the identification of core journals using Bradford's Law, along with evaluation of journal impact via Journal Citation Reports (JCR) quartile rankings and impact factors. Author productivity was assessed by identifying the top authors in terms of publication count and citation impact, and examining the temporal trends in their output. Keyword co-occurrence analysis was conducted to explore the frequency and evolution of author keywords, as well as keyword trends over time.

Statistical analysis

For data synthesis and visualization, various schematic tools were employed. Network maps, such as chord diagrams, illustrated international collaborations. TreeMaps were used to visualize keyword frequency, while scatter plots depicted keyword trends. Bar graphs and line charts were used to summarize annual publication trends and institutional contributions. Visualization tools such as the R Graph Gallery and ggplot2 provided high-quality graphics, and specific Bibliometrix functions—such as biblioAnalysis() and couplingMap()—enabled advanced scientometric mapping.

Interpretation and validation of the results involved cross-verifying key metrics with Scopus data to ensure accuracy. Collaboration patterns and funding information were manually reviewed to confirm consistency. This structured and multi-layered methodological approach ensured a robust and transparent analysis of research trends in RLN injury associated with thyroid surgery.
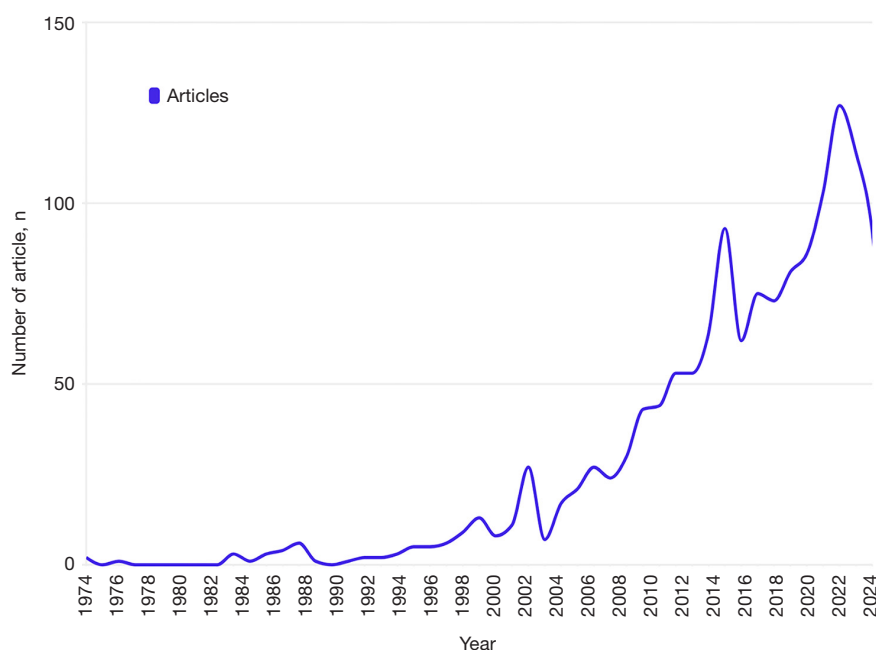
Figure 2 Annual publication trends on recurrent laryngeal nerve injury in thyroid surgery (1974–2024). The figure shows the yearly number of published articles on recurrent laryngeal nerve injury associated with thyroid surgery from 1974 to 2024. A steady increase in publications is observed after 2000, reflecting the growing research interest and clinical importance of this topic.

Results

Summary of the papers

The current bibliometric analysis includes 1,440 publications from 346 sources, with an average number of citations per document of 25.84. The average document age of 9.23 years over the period from 1974 to 2024. Moreover, the analysis includes 5.997 authors, with an international collaboration rate of 11.39% and an average of 6.48 co-authors per document.

Annual analysis of publication

The annual analysis of scientific publications shows an upward trend, characterized by an annual growth rate of 6.19% over the past five decades (*Figure 2*). The period from the 1970s to the early 1980s is characterized by sparse scientific articles, with occasional minor contributions. The late 1990s and early 2000s mark a turning point, with a significant increase in research volume. Starting from the 2000s, publication activity is characterized by exponential growth, with a sharp rise in the number of articles published annually. The highest number of articles was published in 2021, totaling 127 articles per year. In 2022 and 2023,

there is a slight decrease to 114 and 92, respectively, but it remains at a high level.

The most productive country and institutions

Figure 3A illustrates the distribution of scientific production across countries during the specified period. The USA leads with 730 publications, followed by China with 660 and Italy with 388. *Figure 3B* presents the most productive institutions from various countries in America, Europe, and Asia. Notably, Kaohsiung Medical University Hospital has the highest publication count (n=103) in this field, followed by Harvard Medical School with 60 articles. These institutions are located in China and the USA, respectively. Furthermore, *Figure 3C* provides information on funding sources for researchers involved in thyroidectomy projects. China sponsored researchers in this field the most, with 100 grants, followed by the USA with 46 grants. Additionally, the USA extensively collaborates with other nations in this field, notably China, Italy, and South Korea, to a considerable degree, and with Thailand, Poland, and Turkey to a lesser extent. Furthermore, China demonstrates high activity in collaboration, particularly with Italy and South Korea (*Figure 3D*).
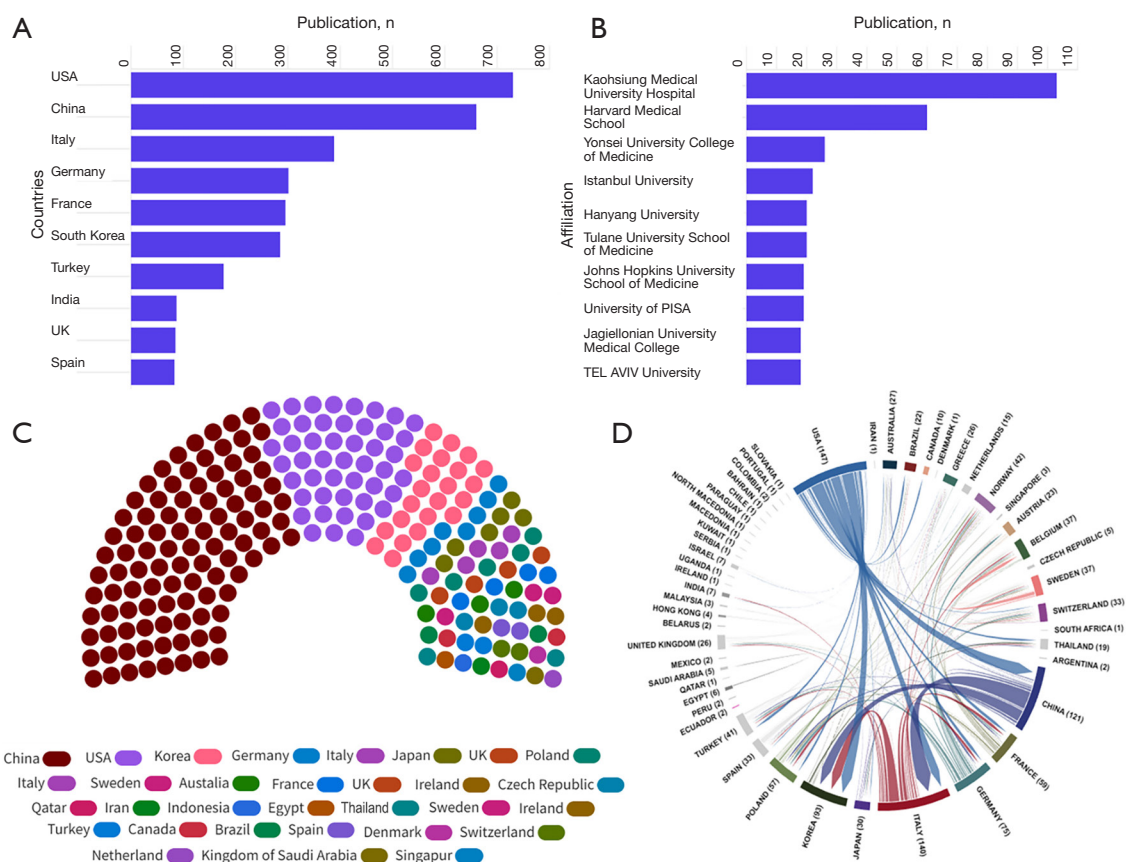
Figure 3 Global research output and collaboration in thyroidectomy from 1974 to 2024. (A) Annual number of publications in the most productive countries. (B) Most relevant affiliations contributing to thyroidectomy research. (C) A parliament chart illustrating the most active funding organizations supporting thyroidectomy-related research; each circle represents one organization, colored by country. (D) A chord diagram depicting international scientific collaboration among countries; the semicircle size is proportional to the number of publications, and line thickness indicates the intensity of collaboration.

Journals

Bradford's Law describes the distribution of scientific articles across journals. *Figure 4* shows the top ten journals that researchers consider being the primary for publication. The largest number of publications (n=67) were published in the *World Journal of Surgery*. *Laryngoscope* followed with 60 articles. In the list of most cited sources, the *International Journal of Surgery* has the highest impact factor with impact factor =15.3, followed by *Thyroid* with an impact factor of 6.6. Furthermore, the majority of journals (50%) are categorized as quartile first (Q1) in Science Citation Index Expanded (SCIE) by JCR (*Table 2*).

Contributions of authors

Among the top ten authors in the field of thyroidectomy, Dionigi G stands out with 49 articles, while Wu CW. closely follows with forty articles, demonstrating remarkable productivity in scientific publishing (*Figure 5A*). *Figure 5B* presents the dynamics of the scientific production of the mentioned authors over time. Barczyński M started their publication activity in 2002 and remaining active until now, indicative of sustained engagement and enduring interest. Wu CW published the highest number of articles (n=8) on this topic during 2021, with a total citation per year of 18.25. Tufano RP attained the highest total citation rates
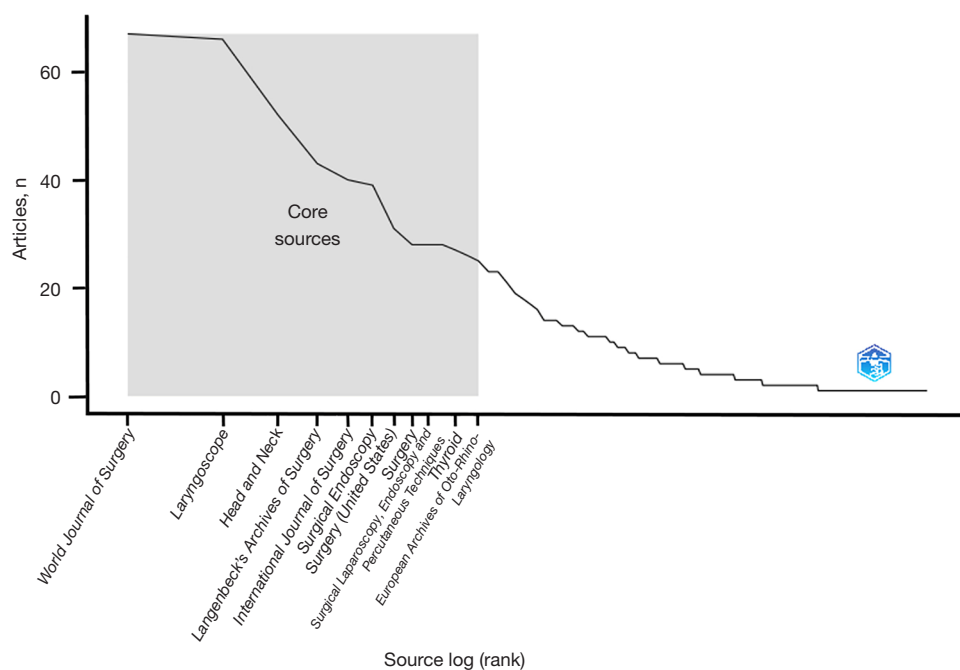
Figure 4 Core journal distribution according to Bradford's law (1974–2024) for bibliometric insights into research trends on recurrent laryngeal nerve damage in thyroid surgery.

Table 2 Most relevant journals, IF and JCR category for bibliometric insights into research trends on recurrent laryngeal nerve damage in thyroid surgery

Rank	Journal	Article, n	IF	JCR category (quartile)
1	*World Journal of Surgery*	67	2.6	Surgery: SCIE (Q2)
2	*Laryngoscope*	66	2.6	Medicine, research & experimental: SCIE (Q3). Otorhinolaryngology: SCIE (Q1)
3	*Head and Neck*	52	2.9	Otorhinolaryngology: SCIE (Q1). Surgery: SCIE (Q2)
4	*Langenbeck's Archives of Surgery*	43	2.3	Surgery: SCIE (Q2)
5	*International Journal of Surgery*	40	15.3	Surgery: SCIE (Q1)
6	*Surgical Endoscopy*	39	3.1	Surgery: SCIE (Q1)
7	*Surgery (United States)*	31	3.8	Surgery: SCIE (Q1)
8	*Surgery*	28	0.9	Surgery: SCIE (Q4)
9	*Surgical Laparoscopy, Endoscopy and Percutaneous Techniques*	28	1.0	Surgery: SCIE (Q4)
10	*Thyroid*	28	6.6	Endocrinology & metabolism: SCIE (Q1)

IF, impact factor; JCR, Journal Citation Reports; SCIE, Science Citation Index Expanded.

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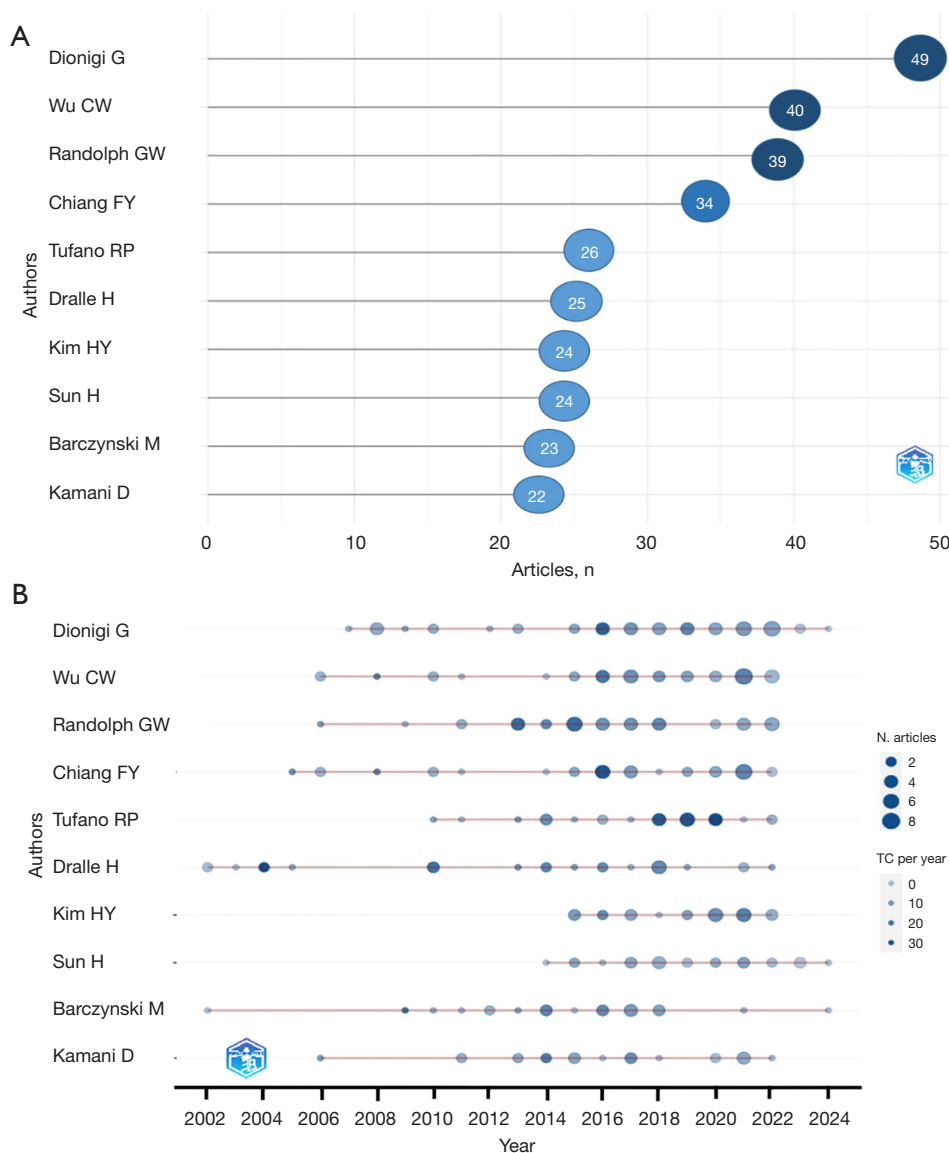Zhumabekov et al. RLN damage in thyroid surgery

Figure 5 Author productivity and influence in thyroidectomy research. (A) Most relevant authors by total number of publications. (B) Author productivity over time; each circle represents one article, with size indicating the number of publications and color intensity reflecting the citation count per year. TC, total citations.

per year, recording 28.57, 29.83, and 32.8 citations in 2018, 2019, and 2020, respectively.

Authors keywords

Ring the period spanning from 1974 to 2024 (*Figure 6A*), the author keywords "thyroidectomy" and "recurrent laryngeal nerve" emerged as the most frequently utilized,

reflecting the persistent clinical challenge of RLN injury. The increasing use of "intraoperative neuromonitoring" and "thyroid surgery" since the 2000s (*Figure 6B*) indicates a research trend toward technologies and techniques aimed at reducing RLN damage, such as IONM and optical magnification (12). By 2023, "thyroidectomy" reached 376 mentions per year, underscoring its centrality in RLN research.
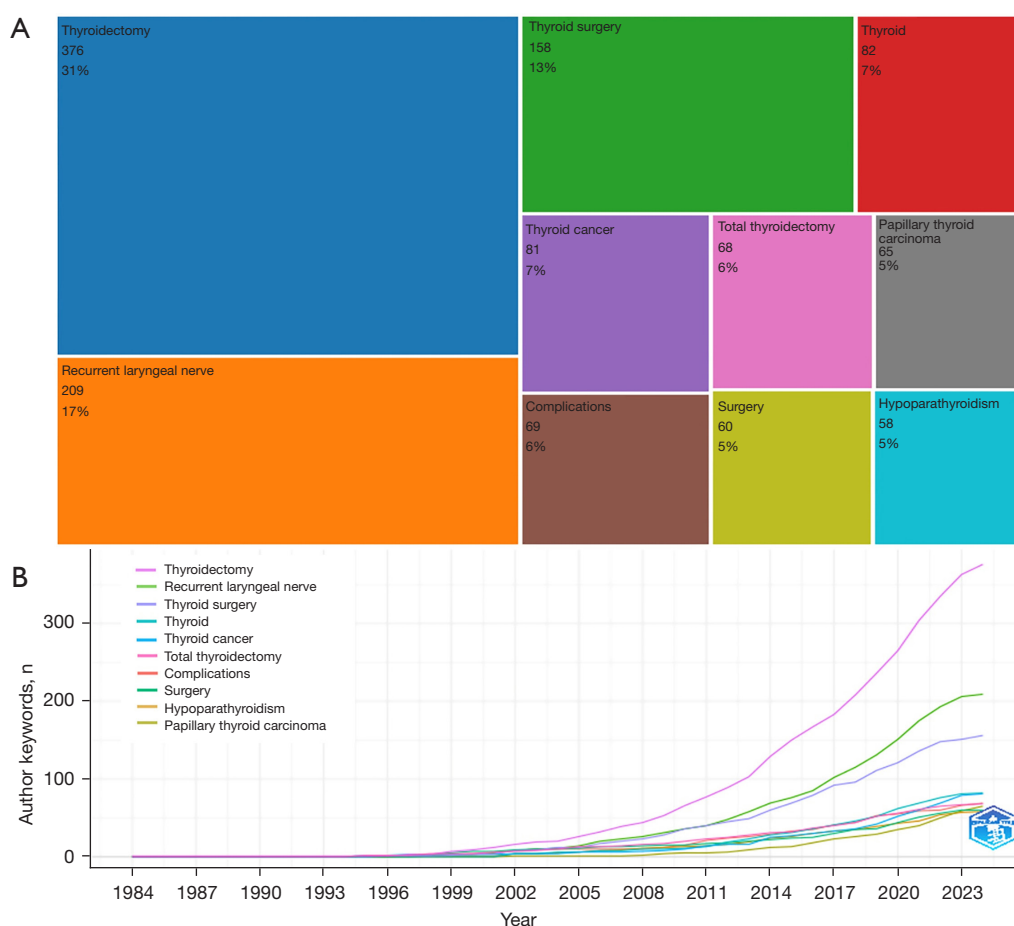
Figure 6 TreeMap (A) and scatter plot (B) illustrating the top ten author keywords between 1974 and 2024 for bibliometric insights into research trends on recurrent laryngeal nerve damage in thyroid surgery.

Discussion

This bibliometric analysis aims to illustrate the scope and characteristics of the scientific literature on thyroidectomy in surgery. The time frame for our analysis was determined based on the earliest articles available in the Scopus database, from 1974 to 2024. Some notable findings include publication metrics, trends in scientific output, countries and institutions contributions, collaboration patterns, journals, author productivity, and the most common author keywords used in this field.

The bibliometric metrics reported—publication counts, leading authors, institutions, and keyword trends—provide a comprehensive view of research trends in RLN damage during thyroid surgery. The exponential growth in publications since the 2000s reflects heightened awareness of RLN injury as a critical surgical complication, driven by advancements in IONM and minimally invasive techniques like video-assisted thyroidectomy (19). The prominence of institutions like Kaohsiung Medical University Hospital and Harvard Medical School underscores their role in pioneering these innovations. Keyword analysis reveals a sustained focus on "thyroidectomy" and "recurrent laryngeal nerve", indicating ongoing efforts to address vocal fold paralysis and other complications. These trends suggest a shift toward precision surgery and standardized practices, guiding future research toward optimizing RLN preservation and improving patient outcomes.

The analysis revealed a significant increase in the number of research articles in thyroidectomy in recent years. This upward trend indicates a growing recognition of the critical importance of understanding thyroidectomy and side outcome. The increasing volume of scientific research underscores the urgent need to address the challenges

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associated with RLN disorders due to traditional thyroid surgery. These challenges include the development of new methods for treating and permanent hypoparathyroidism or permanent RLN dysfunction (20,21). Much attention is also being paid to exploring innovative approaches to improving the surgical procedures, such as the minimally invasive video-assisted thyroidectomy (MIVAT). The overall complication rate for MIVAT lower than the overall complication rate in conventional thyroidectomy (19). Furthermore, there is robotic thyroidectomy, which has been shown to be lengthier in duration compared to endoscopic thyroidectomy, more costly, and associated with increased postoperative drainage, with no improvement in outcomes or complication rates (22).

This bibliometric analysis reveals several critical research trends in RLN damage during thyroid surgery. First, the exponential growth in publications since the 2000s, with a peak of 127 articles in 2021, reflects increasing global attention to RLN injury as a major surgical complication (*Figure 2*). This trend is driven by the adoption of IONM, which has become a standard technique to reduce RLN injury rates, as evidenced by its rising keyword frequency (*Figure 6B*) and studies demonstrating lower rates of bilateral VCP (12,13). Second, the shift toward minimally invasive techniques, such as MIVAT, is a prominent trend, with research indicating lower complication rates compared to conventional thyroidectomy (19). Third, international collaboration, particularly between the USA, China, and Italy (*Figure 3D*), has facilitated the development of standardized surgical protocols and advanced training programs. However, persistent challenges include the lack of universal guidelines for IONM use and the underrepresentation of research from low-income countries, which limits global applicability of findings (23). These trends highlight a move toward precision surgery and global collaboration but underscore the need for standardized practices and inclusive research to further reduce RLN injury rates.

The field of thyroidectomy is actively evolving and gaining interest both nationally and internationally. Beyond surgical research, interdisciplinary studies in nuclear medicine and cardiology contribute to RLN research by improving preoperative thyroid imaging and managing cardiovascular comorbidities that affect surgical outcomes. Although these publications may appear in journals with lower impact factors, their clinical impact underscores the need for a multidisciplinary approach to RLN injury prevention and management. The USA and China stand

out as the main leading countries in this area of research, with high levels of publications and funding. International scientific collaboration, particularly among the USA, China, and South Korea, with Italy, assumes a pivotal role in the advancement of science and technology within this domain. Furthermore, it is noteworthy to acknowledge the active engagement of funding organizations, particularly in China and USA, signifying a substantial interest in the advancement of this scientific discipline. Countries actively publishing in this field are those with high income levels. This indicates that developed economies, with significant financial and technological resources, have the ability to conduct research in this area. Our study revealed a lack of representation from low-income countries among the authors. This observation suggests that these regions face more apparent and substantial obstacles due to limited research funding, insufficient institutional support, and restricted educational opportunities in low-income environments (23). Language barriers and limited access to technical resources also hinder active participation in research endeavors.

Journals included in Core sources in the field of thyroidectomy comprise publications specializing in otorhinolaryngology, surgery, and endocrinology. Additionally, core sources feature journals with high impact factors, indicating their significant influence (24). The selection of such authoritative peer-reviewed publications is crucial to maintain trust in research findings, thereby ensuring the integrity of the presented data. This is particularly important as policymakers and healthcare providers heavily rely on high-quality evidence for decision-making (25).

Complications associated with thyroid surgery can only be assessed through analysis of clinical cases and subsequent follow-up data. For instance, Rosato *et al.* (26) conducted a study covering postoperative data from 14,934 patients who were observed for 5 years. All patients underwent total lobectomy, total thyroidectomy, or partial thyroidectomy with unilateral or bilateral remnants. Their study revealed a significant number of RLN injuries and the development of hypoparathyroidism following total thyroidectomy. The researchers advocate that visual nerve identification is the gold standard for RLN treatment in thyroid surgeries. Dralle *et al.* (13), in their study, compared various treatment methods for the RLN in 16,448 consecutive multi-institutional surgeries, identifying 29,998 nerves at risk of injury. Additionally, total thyroidectomy with lymph node dissection increased the frequency of background

hypoparathyroidism and temporary RLN damage (9,27). Therefore, challenges arising post-thyroidectomy, such as damage to the RLN and hypoparathyroidism, continue to be a significant focus of interest for researchers. While citation counts and journal impact factors highlight the academic influence of RLN research, the clinical relevance of these studies lies in their contribution to therapeutic decision-making. For instance, the widespread adoption of IONM, as reflected in keyword trends, has been associated with reduced rates of bilateral VCP (12,13). Similarly, research from leading institutions emphasizes minimally invasive techniques, which lower complication rates compared to conventional thyroidectomy (19). These advancements inform surgical protocols, enabling clinicians to prioritize RLN preservation and improve postoperative quality of life. Furthermore, identifying predictors of surgical difficulty, such as those proposed in a preoperative scoring system, may help surgeons anticipate and mitigate complications like RLN injury during thyroidectomy (28).

The author's keywords "thyroidectomy" and "recurrent laryngeal nerve" are frequently employed. This may serve as an indicator of common complications associated with thyroidectomy, including RLN palsy (29). The RLN plays a crucial role in innervating the vocal folds, and its injury can result in voice problems such as hoarseness or even vocal fold paralysis (30). These complications can significantly impact the patient's quality of life. Therefore, it is imperative for surgeons to possess a high level of skill and meticulously monitor the RLN during the operation.

Strengths and limitations of the study

This study presents several strengths that enhance the validity and comprehensiveness of its findings. First, the use of Scopus, a widely recognized and multidisciplinary database, ensured broad coverage of high-quality research on RLN injury in thyroid surgery. The robust bibliometric methodology, implemented through the Bibliometrix R-package, allowed for advanced quantitative analysis, including citation metrics, collaboration networks, and keyword trend evaluations. Tools such as Bradford's Law and impact factor assessments were employed to identify core journals and influential publications, adding further depth to the analysis.

The study's longitudinal scope—spanning 50 years from 1974 to 2024—enabled the identification of evolving research trends, technological innovations such as IONM, and shifts in surgical practices. Effective visualizations,

including chord diagrams, TreeMaps, and scatter plots, aided interpretation by clearly presenting collaboration patterns and keyword dynamics. The use of standardized bibliometric indicators such as JCR quartile rankings and citation counts facilitated objective comparisons. Clinically and academically, the study highlighted major contributing institutions like Kaohsiung Medical University Hospital and revealed funding patterns that can guide future research investments. Furthermore, the analysis identified important gaps in the literature, such as the underrepresentation of low-income countries, suggesting a need for greater global inclusivity in RLN research.

However, the study also has limitations. The reliance on Scopus may introduce database bias, as it excludes some regional and non-English language journals, potentially omitting relevant research from non-Western countries. Furthermore, the exclusive use of Scopus may have excluded publications indexed solely in PubMed or Web of Science, such as those in specialized medical or interdisciplinary journals. This limitation could affect the representation of studies from certain regions or emerging research areas, although Scopus's broad coverage mitigates this to some extent. The exclusion of conference abstracts and grey literature may result in overlooked emerging trends. Citation-based limitations also exist—older publications tend to accumulate more citations, which may undervalue recent high-impact work. Additionally, self-citations and institutional biases may artificially inflate certain metrics.

Moreover, the study's focus on surgical and otorhinolaryngology journals may underrepresent interdisciplinary publications in fields like nuclear medicine or cardiology, which could address thyroid imaging, comorbidities, or other factors influencing RLN outcomes. While these studies may appear in lower-impact journals, their clinical relevance to surgical planning and patient management is significant, suggesting a need for broader database inclusion in future analyses.

Additionally, the reliance on quantitative metrics like citation counts and journal impact factors may overemphasize academic productivity over clinical relevance, potentially distorting the research landscape in therapeutic contexts. While these metrics indicate influence, they do not directly assess the impact of research on surgical outcomes or patient care, warranting future studies that incorporate qualitative evaluations of clinical significance.

Keyword and metadata variability posed another challenge. Inconsistent terminology (e.g., "RLN injury" *vs.* "vocal cord paralysis") could affect the accuracy of co-

occurrence analyses, and manual efforts to resolve author and institutional name disambiguation (due to misspellings or affiliation changes) introduced the possibility of minor inaccuracies. The study's focus on quantitative metrics, while valuable for productivity assessments, does not directly translate to clinical impact; for instance, a high publication count may not reflect meaningful changes in surgical outcomes. Lastly, the observed decline in publications after 2021 (*Figure 2*) may not indicate an actual drop in research activity, but rather a data lag in Scopus indexing.

Despite these limitations, the study offers a detailed and reliable overview of bibliometric trends in RLN injury research, serving as a valuable resource for clinicians, researchers, and policy-makers.

Conclusions

This bibliometric analysis underscores the growing global focus on RLN injury in thyroidectomy, driven by key research trends such as the adoption of IONM, minimally invasive techniques, and international collaboration. The USA, China, and Italy lead in publications and funding, with institutions like Kaohsiung Medical University Hospital and Harvard Medical School at the forefront. Despite these advancements, challenges remain, including the need for standardized surgical protocols and greater research inclusion from low-income regions. Moving forward, prioritizing these trends and addressing gaps in global research will enhance RLN preservation and improve patient outcomes in thyroid surgery.

Acknowledgments

Footnote

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