



Research article

Mapping the lymph node metastasis landscape: A bibliometric Odyssey of papillary thyroid carcinoma publications (2012–2022)

Yu Mao ^{a,b}, Huatao Zhou ^c, Xiaoyong Wen ^{a,b}, Zeyu Li ^{a,b}, Mei Dai ^b, Shiwei Zhou ^{a,*}^a Department of Thyroid Surgery, Hunan Cancer Hospital & The Affiliated Cancer Hospital of Xiangya School of Medicine, Central South University, No. 238Tongzipo Road, Changsha, 410013, Hunan Province, China^b Department of Thyroid Surgery, the Second Xiangya Hospital, Central South University, Changsha, Hunan, 410011, China^c Department of Cardiovascular Surgery, the Second Xiangya Hospital, Central South University, Changsha, Hunan, 410011, China

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ABSTRACT

Objective: Lymph node metastasis in papillary thyroid carcinoma (PTC) has become an area of great interest in the study of thyroid diseases. The aim of this study was to elucidate the research trends and impact of lymph node metastasis of PTC in the study of thyroid diseases through a comprehensive bibliometric analysis.

Methods: We conducted an extensive bibliometric review of the literature on lymph node metastasis in PTC using the Web of Science Core Database (WOSCC), which included approximately 3292 publications from 2012 to 2022. Data analysis and visualization were performed, using advanced bibliometric tools including VOSviewer, CiteSpace, and bibliometrix R software packages.

Results: A total of 3292 publications from 81 one countries were identified. The analysis showed a pattern of growth in the number of publications per year from 2012 to 2022, with China having the highest number of papers. Outstanding contributions were made by China, Korea, USA, Italy and Japan, with Thyroid being the most important journal. The author who published the most papers was Jingqiang Zhu. The institutions that published the most papers were Shanghai Jiao Tong University and Yonsei University. The analysis found that prognosis, recurrence, and ultrasound were the keywords with the highest frequency of occurrence in addition to those related to the title of this article.

Conclusion: Our bibliometric analysis outlines the current state of research on lymph node metastasis in PTC, highlighting significant contributions, trends, and future research directions.

1. Introduction

Thyroid cancer (TC) is the most common type of endocrine cancer, making up around 3.8 % of all newly detected cancer cases [1, 2]. Papillary thyroid carcinoma (PTC) is the most common type of thyroid cancer, representing nearly 90 % of all cases, and it is characterized by favorable prognoses [3,4]. For middle-aged individuals with PTC, the overall 10-year survival rate typically ranges from 80 % to 95 %, reflecting its typically slow and benign clinical progression [5]. Nonetheless, the potential for lymph node metastasis in PTC remains a crucial factor affecting patient management and treatment outcomes [6], as several studies have indicated a link between lymph node metastasis and disease relapse [7–9], affecting approximately 30 %–80 % of individuals diagnosed with

* Corresponding author.

E-mail address: zhoushiwei@hnca.org.cn (S. Zhou).<https://doi.org/10.1016/j.heliyon.2024.e31398>

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Abbreviations

PTC	papillary thyroid carcinoma
WOSCC	Web of Science Core Database
TC	thyroid cancer
CCLN	central cervical lymph node
CEU	contrast-enhanced ultrasound
CND	central neck dissection
pCND	prophylactic central neck dissection
PTMC	papillary thyroid microcarcinoma
HT	hashimoto's thyroiditis
PI3K	phosphatidylinositol 3-kinase

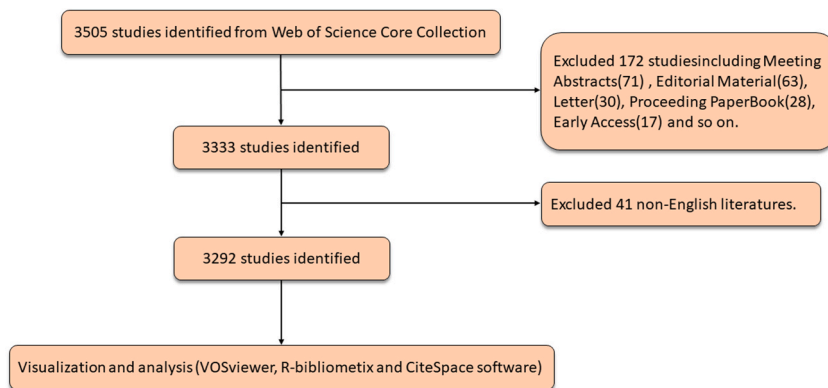


Fig. 1. Process for literature screening.

PTC.

Despite numerous research endeavors in lymph node metastasis in PTC, however, in past research, there have been few summaries from a bibliometric perspective or literature providing an overview of the publications on lymph node metastasis in PTC, including the trends in the field. This research uses relevant tools to evaluate the research base, frontiers, and priorities in lymph node metastasis in PTC, filling a gap in the direction of bibliometric analysis.

2. Materials and methods

2.1. Data collection

A database was established to retrieve relevant literature for bibliometric analysis, utilizing an advanced search strategy within the Web of Science (<https://access.clarivate.com>) Core Collection database. The Web of Science Core Collection was selected as the data source. Each document record included full record and cited reference. The strategy searched was (TS=(“papillary thyroid carcinoma” or “thyroid papillary carcinoma” or “thyroid carcinoma, papillary” or “papillary thyroid cancer” or “thyroid papillary cancer” or “thyroid cancer, papillary”) AND TS=(“lymph” or “lymph node” or “neck lymph node” or “lymph, nodes” or “neck, lymph nodes”)) and limited the search from January 1, 2012, to December 31, 2022. To limit search bias, we also included the following restrictions, including the type of literature being limited to literature and reviews only and the language of publication being limited to English language. Subsequently, 3292 retrieved documents constituted the final set of literature databases. The detailed retrieval flowchart is shown in Fig. 1.

2.2. Data analysis

This research chose to use VOSviewer(v1.6.19), CiteSpace(v6.2.R4), the “Bibliometrix” package of R (v4.3.1) and Microsoft Excel. Constructing bibliometric networks and visualizing them is the primary function of VOSviewer, a software application. It facilitates the creation and visualization of co-occurrence networks that highlight key terms extracted from a collection of scientific literature [10]. CiteSpace offers dynamic visualizations that elucidate the structural and temporal intricacies within scientific domains [11,12]. To ensure comprehensive research and result validation, this study combined multiple software tools for map cooperation networks (authors, institutions, and countries), keywords co-occurrence, documents co-citation clustering and coupling of literature sources.

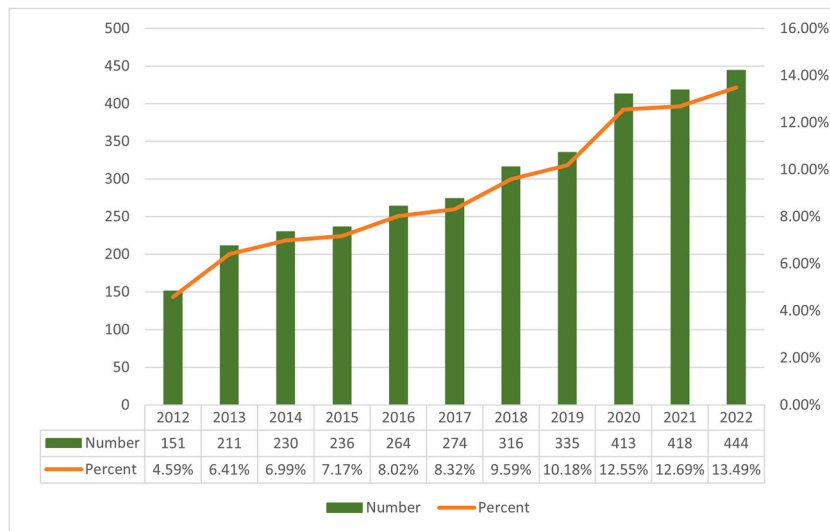


Fig. 2. Annual research output of lymph node metastasis in PTC.

Table 1

The top 10 countries/regions on research of lymph node metastasis in PTC.

Rank	Country	Publications	Proportion of publications(%)	Citations	Citations per publications(%)
1	China	1361	36.61	17174	24.16
2	South Korea	510	13.69	13470	14.54
3	USA	454	12.21	10334	18.95
4	Italy	203	5.46	5809	8.17
5	Japan	132	3.55	3646	5.13
6	Turkey	123	3.31	1061	1.49
7	Brazil	78	2.1	1952	1.73
8	Canada	55	1.48	1677	2.64
9	Australia	50	1.35	1876	2.75
10	Germany	47	1.26	1071	1.38

This research uses Bibliometrix to count the trend of publications and the number of publications in different countries. An open-source tool, the “bibliometrix” package in R (v4.3.1) enables the comprehensive analysis of science mapping [13].

3. Results

3.1. Trends in publication outputs

Our research identified a total of 3292 studies on lymph node metastasis in PTC between 2012 and 2022, including 3043 articles and 249 reviews. As shown in Fig. 2, when examining the publication growth annually, the number of lymph node metastasis in PTC documents continuously increased in 2012–2022. The year 2022 witnessed the highest number of publications, totaling 444 publications, which accounted for 13.49 % of the total. It is worth noting that the slowdown in the rise of publications starting in 2020 may be due to the COVID-19 pandemic.

3.2. Geographical and institutional distribution

These publications in the field of lymph node metastasis in PTC were disseminated from 81 countries or regions and 2434 institutions. China predominantly emerged as the leading publisher with 1361 publications, representing 36.61 % of the total, while South Korea followed with 510 publications at 13.69 %, trailed by the USA, Italy, and Japan, as indicated in Table 1. China, South Korea, and the United States combined contributed to 70.62 % of the total output. In Fig. 3A, a collaboration network comprising 81 countries or regions was built, all of which had at least 1 publication, uncovering strong international partnerships, notably the ones between China and the United States. In Fig. 3B, darker shades of blue indicate higher levels of research activity, while the lines across the map represent collaborative links between countries, showcasing a network of global partnerships.

An institutional co-occurrence map was generated from 2434 institutions, each required to meet a minimum inclusion criterion of 10 documents. As shown in Figs. 4 and 119 institutions met this threshold. Notably, this analysis highlights the dominance of the top 10 research institutions, with 6 located in China and 4 in South Korea. Leading this group are Shanghai Jiao Tong University and Yonsei

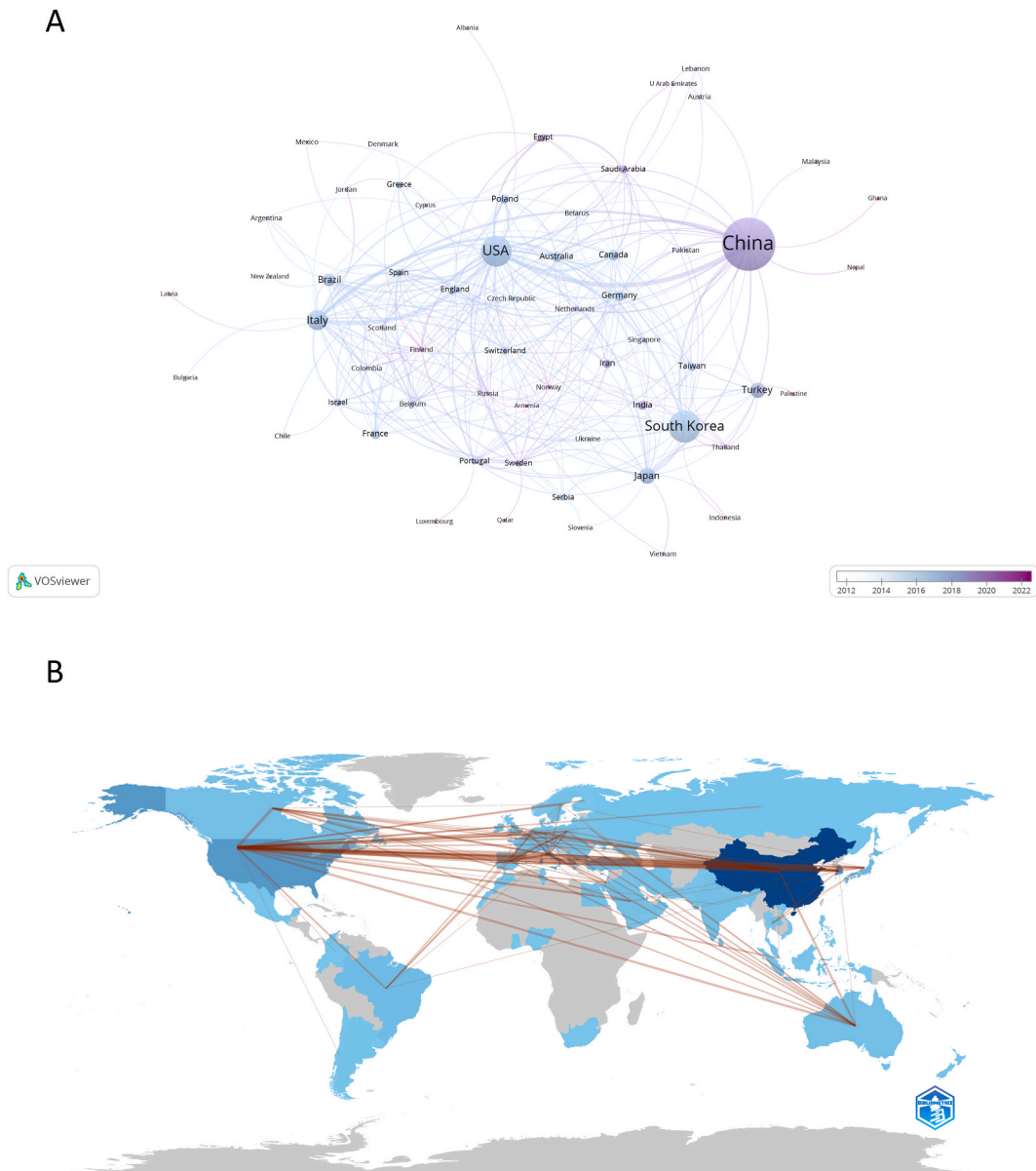


Fig. 3. Geographical and Institutional Distribution of lymph node metastasis in PTC. (A) Analysis of collaborative network visualization of countries/regions in VOSviewer according to average publication year, depicting countries/regions with document counts exceeding one. Nodes transition from white to purple to indicate more recent entries, with size reflecting publication frequency. (B) Global research landscape indicating countries/regions involved with collaborative links representing cross-national cooperation.

University, each with 83 publications, closely followed by Fudan University and Zhejiang University, each with 80 publications. In addition, Fig. 4 presents a graphical depiction of the ratio of publications from the last five years to the overall publications between 2012 and 2022. Different colors indicate different levels of research activity. A significant increase in studies was observed among the organizations in China, whereas the organizations in South Korea demonstrated a decrease in recent research activities.

4. Journals and co-cited journals

Thyroid research prominently features in 577 journals. We required an inclusion threshold of at least four documents. This criterion was satisfied by 183 journals. *Thyroid* takes the lead with 151 publications, accounting for 4.59 % of the total, followed by *Frontiers in Endocrinology* with 116 papers at 2.64 % and *World Journal of Surgery* with 74 papers at 2.67 %. Among the top 10 journals, *Thyroid* secures the leading position for the highest impact factor at 6.6, as indicated in Fig. 5A and Table 2, followed closely by *Journal of Clinical Endocrinology & Metabolism* at 5.8.

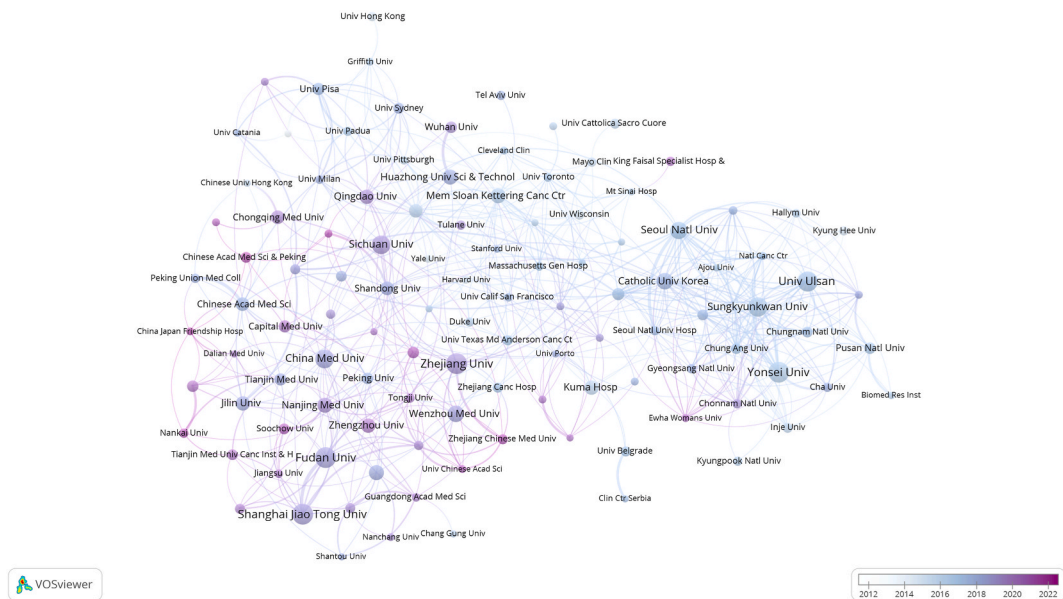


Fig. 4. Visualization of research institutions related to lymph node metastasis in PTC according to average publication year, depicting institutions with document counts exceeding ten. Nodes transition from white to purple to indicate more recent entries, with size reflecting publication frequency.

Through the evaluation of inter-article connections, co-citation analysis demonstrates the impact of a journal based on the frequency of its co-citations. Among 4826 co-cited journals, 11 journals surpassed 1000 citations. [Table 3](#) shows that *Thyroid* leads with 9723 citations, followed by *Journal of Clinical Endocrinology & Metabolism* with 5823 and *World Journal of Surgery* with 4544. Among the top 10, *Annals of Surgery* holds the highest IF at 10.1, with *Thyroid* following closely at 6.6. Based on the 2022 Journal Citation Reports, most of these highly co-cited journals were categorized as Q1. We conducted a bibliometric review of 4826 co-cited journals from a pool of 3292 papers, requiring a minimum of 45 documents for inclusion. Out of these, 308 co-cited journals qualified, as depicted in [Fig. 5B](#). This figure further illustrates the concentrated influence and interconnectedness within the academic sphere through the co-citation network map, assisting researchers in identifying pivotal journals for their scholarly contributions.

The overlay of dual-maps in [Fig. 6](#) reveals the interrelationships between the journals that cite and are cited. Two principal citation trajectories are discernible: the orange routes indicate that articles from Molecular/Biology/Genetics journals are predominantly cited by Molecular/Biology/Immunology journals; the green trajectory shows citations from Medicine/Medical/Clinical journals to studies in Molecular/Biology/Genetics and Health/Nursing/Medicine journals. The dynamic interactions shaping scholarly dialogue in these crucial research areas are vividly depicted through this mapping.

4.1. Authors and co-cited authors

From 2012 to 2022, the field of lymph node metastasis in PTC saw contributions from 27,020 authors. [Table 4](#) showcases the top ten most prolific ones, led by Zhu, Jingqiang with 35 papers. Ito, Yasuhiro, and Miyauchi, Akira both with 34 publications, closely trail him. Further scrutiny reveals geographical diversity among these leading authors: five are based in South Korea, three in China, and two in Japan. The collaborations among these researchers were mapped using VOSviewer software. Analyzing 13,923 authors across 3292 papers, we applied a minimum threshold of nine documents for inclusion. [Fig. 7A](#) shows that 232 authors met this criterion; each node in the figure represents an author. Thicker lines indicate stronger collaborations, and different colors indicate different publication years. The co-cited author network, depicted in [Fig. 7B](#), highlights the field's most frequently co-cited scholars. In examining 27,020 co-cited authors across 3292 papers, we established a 45-document threshold for inclusion, which resulted in 344 co-cited authors meeting this criterion. At the forefront is R. Michael Tuttle with 1514 citations, pursued by Yasuhiro Ito with 1430 citations, Akira Miyauchi with 1325 citations, Akihiro Miya with 1219 citations, and Kaoru Kobayashi with 1149 citations, all of which are outlined in [Table 4](#).

4.2. Co-cited references and reference with citation bursts

During the period from 2012 to 2022, 41,485 co-cited references have been gathered in the field of lymph node metastasis in PTC. As multiple publications frequently cite a set of manuscripts, it gives rise to co-citation networks and conceptual clusters. Listed in [Table 5](#), the groundbreaking work by Haugen, Bryan R [14], offers evidence-driven recommendations to guide clinical decision-making in the treatment of thyroid nodules and differentiated thyroid cancer. [Table 5](#) contains the top 10 co-cited references.

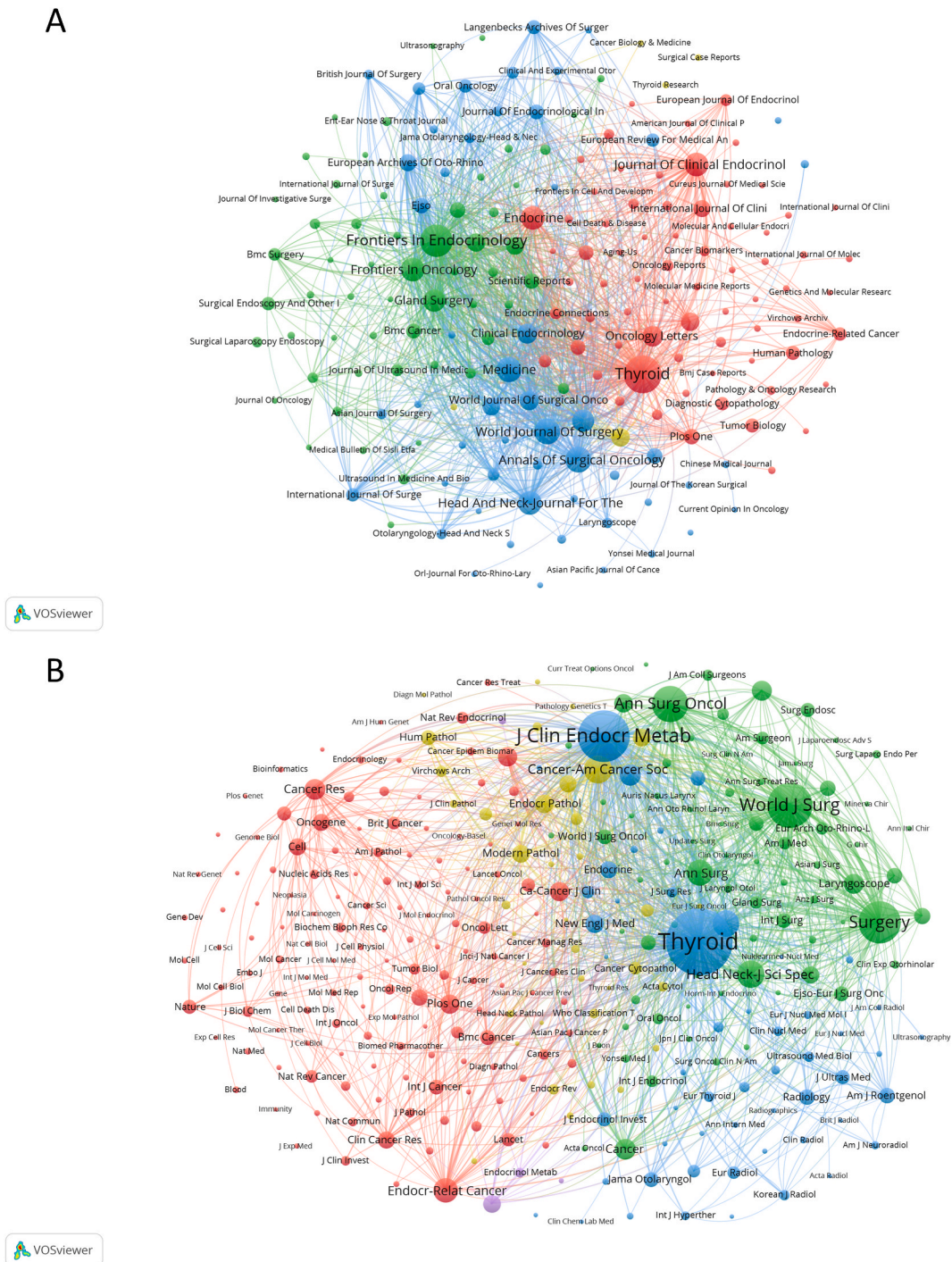


Fig. 5. Visualization of journal Analysis in lymph node metastasis in PTC. (A) Collaborative network visualization of journals in VOSviewer, highlighting journals with at least four documents. Node colors differentiate clusters, with size denoting publication frequency. (B) Analysis of collaborative network visualization of journals' citations in VOSviewer. Each circle represents a journal, the circle size indicates the number of co-citations in that journal, the larger the circle, the higher the number of co-citations, the lines between the circles indicate the connections between journals, and the connection networks of different colors indicate the collaborative clusters between different journals. Different colors represent different clusters.

Table 4
Top 10 authors and co-cited authors on research of lymph node metastasis in PTC.

Rank	Authors	Location	Count	Co-Cited Authors	Location	Citations
1	Zhu, Jingqiang	China	35	Tuttle, R. Michael	USA	1514
2	Ito, Yasuhiro	Japan	34	Ito, Yasuhiro	Japan	1430
3	Miyauchi, Akira	Japan	34	Miyauchi, Akira	Japan	1325
4	Shong, Young Kee	South Korea	32	Miya, Akihiro	Japan	1219
5	Kim, Tae Yong	South Korea	31	Kobayashi, Kaoru	Japan	1149
6	Zhang, Hao	China	31	Kihara, Minoru	Japan	993
7	Kim, Won Bae	South Korea	30	Shong, Young Kee	South Korea	742
8	Jeon, Min Ji	South Korea	28	Park, Young Joo	South Korea	734
9	Li, Zhihui	China	28	Jung, Chan Kwon	South Korea	731
10	Kim, Jee Soo	South Korea	27	Kim, Won Bae	South Korea	683

4.3. Hotspots and frontiers

Keywords concisely encapsulate the fundamental concepts of a paper, outlining the key areas of research interest. Using VOSviewer, we analyzed 3966 author keywords across 3292 documents, of which 137 met the minimum document criterion, requiring at least 10 documents per keyword.

Our analysis of 3292 papers involving 3966 keywords set a minimum inclusion threshold of 10 documents, with 137 keywords meeting this criterion. Fig. 10A presents a network visualization map that demonstrates the connections among these keyword co-occurrences. The sizes of the circles correspond to the frequency of occurrence of the keywords. In addition to keywords related to the title of this article, high-impact keywords include prognosis, recurrence, and ultrasound. Fig. 10B delineates 7 relevant clusters, from #0 (proliferation) to #6 (robotic thyroidectomy), as identified by CiteSpace. The analysis results, showing a modularity (Q) value of 0.3689 and a silhouette (S) value of 0.7031, both exceeding the benchmarks of 0.3 and 0.7097 respectively, confirm the robustness and significance of these clusters.

5. Discussion

This bibliometric study underscores the significant advances in the understanding of lymph node metastasis in PTC from 2012 to 2022, highlighting a concentrated burst of research activity primarily in Asia, with China, South Korea, and Japan leading in publication volumes. This regional emphasis might reflect localized epidemiological concerns or specific institutional investments in thyroid cancer research. The prominent output from institutions like Shanghai Jiao Tong University and Yonsei University not only indicates the depth of research conducted there but also their importance in the global lymph node metastasis in PTC research community.

Our analysis reveals a dynamic landscape of international collaborations, with notable interactions between leading research nations such as China, the United States, and South Korea. Such partnerships are crucial for advancing global understanding of PTC and developing unified approaches to treatment and management. The evolving research patterns also suggest a shift towards more collaborative and interdisciplinary studies, particularly given the complexity of lymph node metastasis mechanisms and treatment.

The role of high-impact journals and prolific authors, such as Prof. Ito Yasuhiro, highlights the influence of seminal works that continue to shape the field. Prof. Ito's contributions, for instance, challenge conventional treatment modalities and suggest potential shifts towards observation-based strategies for certain PTC cases. This could have significant implications for clinical practices worldwide, potentially leading to more personalized and less invasive management strategies.

Future research should build on these foundations, focusing on underexplored areas such as the molecular pathways of metastasis and the development of targeted therapies. There is also a need for more comprehensive guidelines that incorporate recent findings to enhance the management of PTC. Moreover, the rise of publications from China calls for further scrutiny into how research funding and policy developments in different regions are influencing study outcomes and priorities.

Seven of the most explosive keywords were identified in the keyword cluster shown in Fig. 10B. The core themes and evolving state of research in this field are captured through these factors. For the purposes of this analysis, keywords were grouped into 5 main categories for this study. The evolution of the keyword focus reflects the changing hotspots in scientific inquiry. We can summarize several promising future directions for the field of lymph node metastasis in PTC.

1. Diagnostic and Prognostic Biomarkers: This theme encompasses 'proliferation' and 'BRAF(V600E) mutation'. In TC, the dynamics of tumor cell proliferation and specific genetic mutations play pivotal roles in disease progression, diagnosis, and treatment strategies [16]. The concept of proliferation in thyroid cancer refers to the rate at which cancer cells multiply and expand. A higher rate of proliferation typically indicates a more aggressive tumor phenotype [17]. 'Proliferation' includes the study of the growth rate of tumor cells and their effect on lymph node metastasis, and further directions of research could focus on the effect of, for example, estrogen [18] or drugs on lymph node metastasis of thyroid cancer following tumor cell proliferation. Factors like genetic mutations, including oncogenes activation and tumor suppressor genes inactivation, contribute to this dysregulated proliferation [19]. 'BRAF(V600E) mutation', specifically, has been closely linked with lymph node metastasis in thyroid cancer [20–22]. This mutation leads to the continuous activation of the BRAF kinase, part of the MAPK/ERK signaling pathway, which is integral to cell division and differentiation [23,24]. In PTC, the presence of the BRAF(V600E) mutation is often correlated with a higher incidence of lymph node

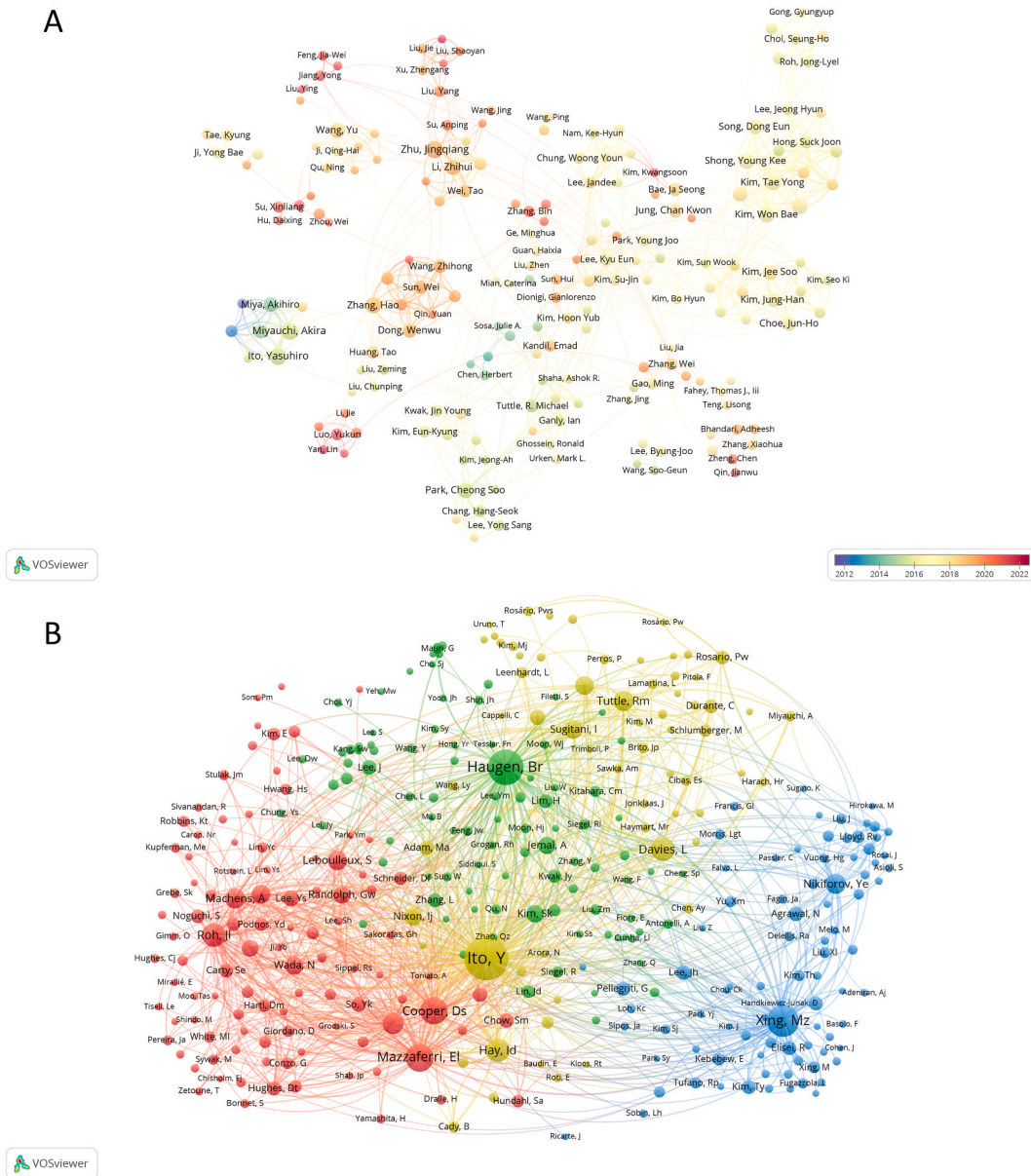


Fig. 7. Visualization of authors collaboration on research of lymph node metastasis in PTC. (A) VOSviewer's network visualization showcasing authors with over nine publications, with node colors identifying distinct clusters and size indicating publication counts. Nodes transition from purple to red to indicate more recent entries (B) Analysis of collaborative network visualization of authors' citations in VOSviewer. Each circle represents an author, the circle size indicates the number of co-citations of that author's published articles, the larger the circle, the higher the number of co-citations, the lines between the circles indicate the connections between authors, and the connection networks of different colors indicate the collaborative clusters between different authors. Different colors represent different clusters.

metastasis [14,25]. Additionally, the BRAF(V600E) mutation in thyroid cancer cells has been associated with certain histological features that are indicative of a more aggressive tumor phenotype, such as extrathyroidal extension and vascular invasion [26]. The presence of the BRAF (V600E) mutation also has implications for treatment. It can guide the use of targeted therapies, especially if the cancer is refractory to conventional therapies such as radioactive iodine [27,28]. By targeting specific pathways that activate this mutation, these therapies aim to inhibit the growth and spread of cancer cells, including metastasis to the lymph nodes, which could also be one of the future directions of research.

2.Diagnostic Imaging Techniques: 'Ultrasound' imaging plays a key role in clinical diagnosis and treatment strategies for thyroid nodules [29]. However, it is worth noting that despite the effectiveness of ultrasound in qualitative assessment of thyroid nodules and identification of lymph node location and morphology [14,30,31], there is no noninvasive method to accurately determine the presence of central cervical lymph node (CCLN) metastasis [32]. In recent years, efforts have been made by researchers to improve the

Top 25 References with the Strongest Citation Bursts

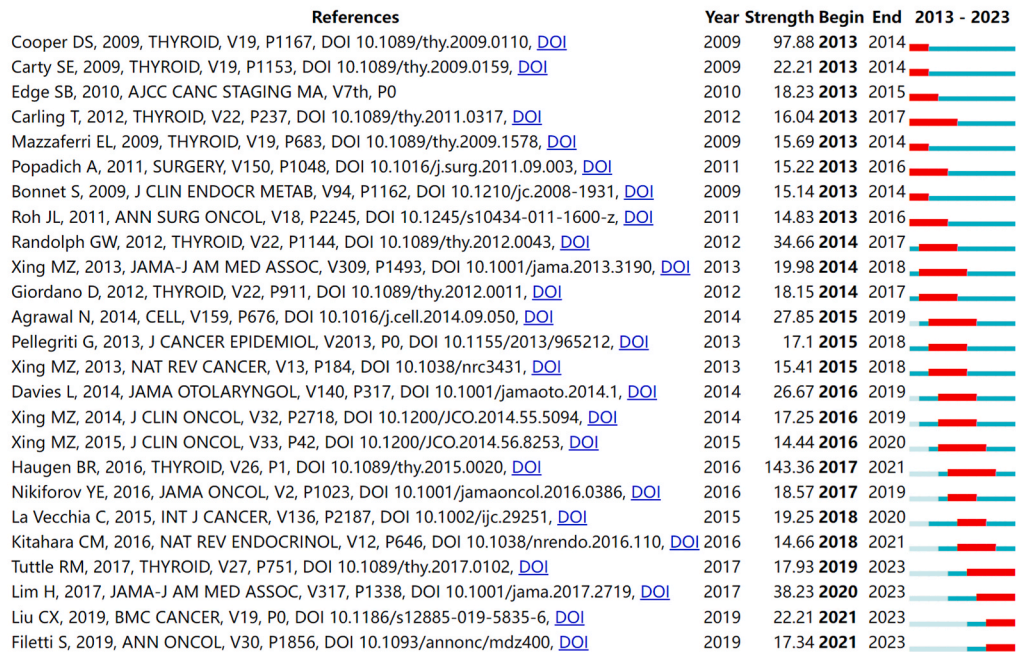


Fig. 9. The top twenty-five references with strong citation bursts of lymph node metastasis in PTC.

part of thyroid cancer surgery. Some studies have suggested that CND is necessary for patients with obvious lymph node metastases [14,35,36]. Some scholars have even proposed routine prophylactic central neck dissection (pCND) for all surgically referred patients with thyroid disease. In particular, there is controversy as to whether pCND should be performed in cN0 PTC patients [37,38]. On the one hand, it has been shown that CND may increase the risk of transient hypocalcemia [39,40], although this is transient. On the other hand, CND may increase the risk of laryngeal recurrent nerve injury [41], although most studies have suggested that this injury is primarily related to the thyroidectomy itself [42]. Notably, however, CND has been shown to significantly reduce the risk of recurrence of TC [43]. Detailed discussion and joint decision-making between physicians and patients needed regarding whether or not to perform prophylactic central neck dissection in patients with PTC, and central neck dissection has potential as a hot spot for future TC research. ‘Robotic thyroidectomy’ is an emerging surgical technique in the field of TC surgery. By introducing three-dimensional vision and a highly flexible robotic arm, the technique provides surgeons with a broader surgical field of view and more flexible instrumentation. This allows surgeons to more accurately localize and manipulate thyroid tissue, especially for small, deep structures such as lymph nodes, where robot-assisted surgery is significantly advantageous [44,45]. The high precision of the robotic system reduces interference from surrounding tissues and maximizes the protection of normal structures, thus improving the safety and effectiveness of surgery [46,47]. The introduction of this technology not only improves the surgeon’s experience, but also promises to reduce the risk of postoperative complications. Its precision, minimally invasiveness, and adaptability to cervical lymph node management make robotic thyroidectomy one of the high-profile options in modern TC treatment. However, more studies are needed to fully evaluate its long-term efficacy and potential complications to ensure its safety and feasibility in clinical practice.

4.Conservative vs. Interventional Approaches: The concept of ‘active surveillance’ has attracted a lot of attention in the field of TC [48], especially PTC [49]. The central idea is to adopt a conservative wait-and-see attitude after diagnosis, rather than immediately resorting to surgery or other aggressive treatments [50–52]. This strategy has emerged as a challenge to the traditional surgical approach to treatment, as it offers a more cautious and individualized option. One of the advantages of this approach is that it avoids surgery that may be unnecessary for some patients, especially for those with low-risk or papillary thyroid microcarcinoma (PTMC) [53, 54]. By closely monitoring the condition, physicians can more accurately assess the progression of the disease and intervene when necessary to avoid the risk of overtreatment the patient [55]. In addition, active surveillance helps to reduce the overall burden of treatment by minimizing potential complications associated with surgery and discomfort during recovery. Overall, active surveillance, as a conservative treatment strategy, occupies an important place in the study of papillary thyroid cancer. Nevertheless, the discussion on active surveillance of lymph node metastases, especially central lymph node metastases in patients with PTC, is still relatively limited. Current research has focused on predictive models [56,57], such as whether active surveillance or surgery is more appropriate for PTC patients with lymph node metastases. This research situation prompts us to reflect on whether active surveillance is really appropriate for these patients, and it is clear that more research is needed to explore and validate this. In addition, is there also a higher demand for accuracy and precision in preoperative ultrasound imaging for these patients? The answers to these questions may have

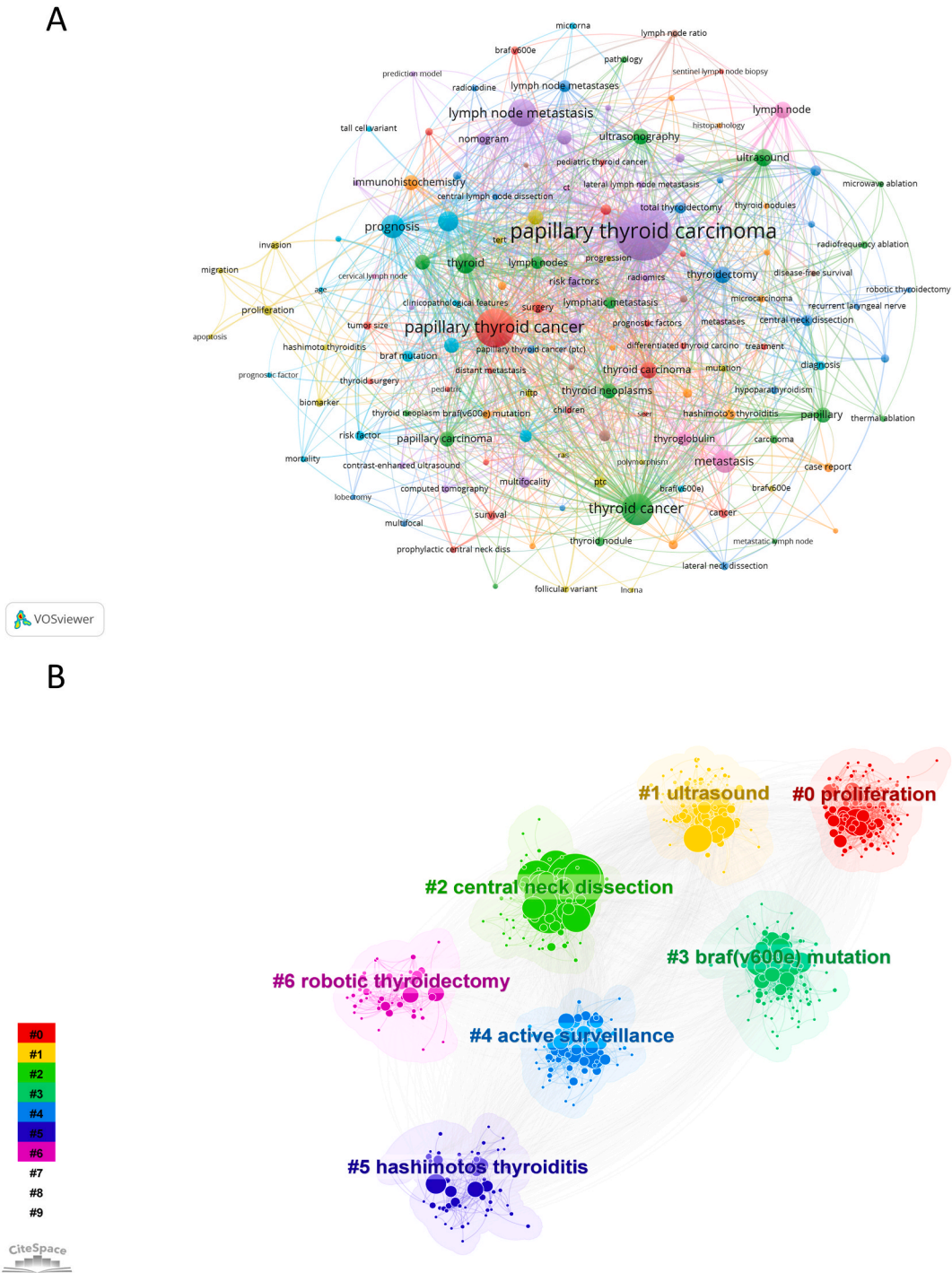


Fig. 10. Visualization of keywords on research of lymph node metastasis in PTC. (A) Node colors identifying distinct clusters and size indicating publication counts. (B) Clustering analysis of the keywords network based on CiteSpace in Thyroid Cancer Epigenetics Research.

some impact on treatment strategies and deserve further in-depth study.

5. Associated Autoimmune Conditions: 'Hashimoto's thyroiditis (HT)' is an autoimmune disease whose mechanism involves an attack on thyroid tissue by the immune system, leading to inflammation, antibody production, and hypothyroidism [58]. The researchers have found an association between HT and PTC, which has triggered an in-depth study of the potential link between the two diseases [59,60]. Several studies have shown that patients with PTC associated with HT have an increased risk of multifocal and bilateral TC [61,62], but the association with the risk of lymph node metastasis is controversial. The association between HT and PTC

not only prompts clinicians to pay close attention to the risk of PTC in patients with HT, but also provides a direction for future research to better understand the intricate link between autoimmune diseases and TC. In exploring this association, the researchers found that phosphatidylinositol 3-kinase (PI3K) may play some role in the relationship between HT and PTC [63], but whether it is associated with lymph node metastasis is not yet known. Obtaining this information could help clinicians make more accurate diagnostic and therapeutic decisions, which could potentially improve patient prognosis and survival in the future.

The study's limitations encompass several aspects. Firstly, all literature was sourced from the Web of Science core set only. Secondly, only English publications were considered, while other language types were not taken into account. Thirdly, the type of literature was limited to articles and reviews, which may lead to incomplete relevant data. For lymph node metastasis in PTC, central, lateral cervical, and distant lymph node metastasis were covered; however, this study did not differentiate them in detail, which may also lead to biased data. The most important point is that bibliometric studies should be updated to reflect the latest research trends and tendencies in order to keep the findings current and reliable. Since the study deadline was October 2023, literature from 2023 was not included in this study.

6. Conclusions

In summary, the number of research publications in the field of papillary thyroid cancer (PTC) lymph node metastasis is steadily increasing between 2012 and 2022, especially peaking in 2022. China, South Korea, and the United States have played a key role in the development of research in this field. The analysis not only highlights significant contributions but also identifies emerging trends and explores future research directions. This work contributes to an enhanced understanding of lymph node metastasis in PTC, serving as a valuable foundation for further studies in this field.

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Data availability statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

CRedit authorship contribution statement

Yu Mao: Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Huatao Zhou:** Resources, Investigation, Formal analysis. **Xiaoyong Wen:** Resources, Investigation, Data curation. **Zeyu Li:** Validation, Investigation, Data curation. **Mei Dai:** Resources, Data curation. **Shiwei Zhou:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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