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Bibliometric and Visual Analysis of Breast Surgery

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Abstract

In the past, various female breast diseases, especially breast cancer, often required a total mastectomy. With advances in medical treatment, developments in chemotherapy and radiotherapy, and changes in the concept of breast surgery, concerns about the anatomical appearance of patients' breasts and their prognosis have been incorporated into the treatment in addition to targeting the initial disease. In recent years, breast conserving surgery has not only performed well in preserving the anatomical appearance of patients' breasts, but has also demonstrated the same prognosis as conventional total mastectomy when combined with chemotherapy and radiotherapy. Additionally, breast conserving surgery has been consistently verified for its therapeutic efficacy and superiority, receiving successive recognition from relevant professionals as a safe and effective treatment for patients who meet the criteria, and it may even result in satisfactory curative efficacy. Therefore, this study attempts to guide the future direction of breast surgery by presenting new scientific evidence obtained through the integration of academic research and literature resources using technology.

This study employed the Web of Science Core Collection database, an online research-oriented academic resource integration platform, and made full use of the platform's information search, data access, management, and evaluation features to explore knowledge and information related to breast surgery as a whole. Additionally, bibliometric analysis was conducted by adopting the

modeling and clustering techniques of VOSviewer The data structure and relationship weights of the literature were visualized in a simulated vector space through clustering and mapping algorithms, presenting the trends of changes in the knowledge structure in an obvious, direct, and colorful way.

Keywords: bibliometric, breast surgery, visual analysis, VOSviewer.

Introduction

Breast surgery refers to various types of surgery targeting the therapeutic or medical treatment of female or male breast tissue. Breast surgery may be performed for aesthetic reasons, such as breast augmentation, or for medical reasons, such as mastitis or tumor.

For female patients with breast cancer, breast surgery is often included in the course of treatment for a number of reasons. For example, a doctor may arrange breast conserving surgery or a mastectomy to remove a breast tumor, a sentinel lymph node biopsy or an axillary lymph node dissection to examine metastasis of the axillary lymph nodes, and breast reconstruction surgery to preserve the anatomical appearance of the patient's breasts.

Over the past 30 years, not only have surgical treatments been constantly innovated and improved, they have also been advanced to minimally invasive surgeries. From a diagnostic point of view, mammography and ultrasound-guided biopsy both achieve diagnosis with minimal damage to patients; from a surgical treatment point of view, minimally invasive breast surgery reduces the size of the surgical wound, enhances the patient's post-operative recovery and satisfaction, and greatly lessens the post-operative pain and the occurrence of complications in comparison to traditional surgery.

Alan Pritchard proposed bibliometrics in 1969 to discover the structure and process of scientific progress and defined it as "the use of statistical and mathematical methods to present the characteristics and development trends of the discipline based on the internal structure of textual information through a process of data processing". A collaborative model of bibliometrics and scholarly communication is used to describe the characteristics and developmental process of a given discipline, to compile statistical data related to books and journals, to demonstrate historical progress, and to identify the uses of books and journals in research around the world (Tsai, 2003).

Therefore, this study utilized the advantages of the bibliometrics information system by consolidating the most authoritative literature in the Web of Science database through Internet links, and based on high-hierarchy search, quantitatively analyzed data obtained from the core databases into various types of graphs using VOSviewer, as well as analyzing and simulating the changes in temporal trends. Next, the visual graphs were used to identify the most forward-

looking studies and issues worth exploring in the academic field of breast surgery in order to probe the cooperative relationships and correlations between mainstream countries and research institutes in the research field, and to explore the changes in core authors and classic texts, issues of interest to leading journals, and cross-disciplinary collaborations over different periods.

Finally, the network data were visualized to show the key development trends, academic development trends, knowledge structures, and knowledge exchanges regarding breast surgery at the present stage in various countries and major research institutes around the world. The patterns and relationships of literature distribution and the performance of influence indexes were also explored, and these aspects served as probative evidence of the observed academic research capacity to attract other healthcare professionals for further discussion on the issue.

Graph visualization is the process of optimizing real-world spatial data through analysis, derivation, differentiation, and modelling into an entity–relation model with knowledge accumulation and inheritance, which is converted into visual images (graphs, charts, maps, tables, etc.) to present the research achievements, scientific literature, and academic viewpoints of various academic disciplines. The research area is rapidly evolving, with a great number of innovative techniques applied to patents, genetic research (Kim, 2001), and the quantitative analysis of other types of information (Card, Mackinlay & Shneiderman, 1999) to quantify the key topics in the literature and to explore the accuracy and reliability of research.

Method

Web of Science was founded by Garfield (1964), the citation analytics pioneer, as an information retrieval tool. It is also known as the Science Citation Index (SCI). As a result of extensive search and discovery by researchers around the world and the close cooperation of all research groups dedicated to bibliometrics, with the advancement of technology, the data formats that SCI can analyze have expanded from magnetic tape, magnetic disk, and CD-ROM to key technologies, which are accessible directly through the world wide web. The tool allows users to quickly obtain a variety of multimedia data such as graphics, text, video, and audio from all over the world using their web browser and hyperlinks, which has profoundly sped up the process of accessing and processing citation data (Cawkell & Garfield, 2001).

VOSviewer is a Java-based bibliometric analysis tool that was developed by the Leiden University Centre for Science and Technology Studies (CWTS) in 2007 based on the concept of science mapping (Eck & Waltman, 2007). The tool embeds interactive visualization features in the network data analytic function and utilizes descriptive statistics to view the temporal and spatial characteristics of literature (Hallinger & Bryant, 2013), such as size, geographic distribution, topic distribution, and dynamic analysis of knowledge (time series analysis).

This study employed VOSviewer to conduct cluster analysis of highly cited literature, authors, and journals in the academic field of breast surgery and examined the characteristics of the research community, such as literature, authors, research topics, and research methods. By comparing the trends and statuses of different periods, as well as the citation relevance, interdisciplinary collaboration patterns, and the impacts of research results on various disciplines, the core themes and focal issues concerning researchers were explored to further detect the direction of academic development.

Furthermore, a knowledge graph was also adopted for quantitative and qualitative analyses of keywords from literature published in authoritative journals to determine the core developmental process and characteristics of the research. This process gave a more accurate understanding of the developmental progress of breast surgery, as well as the hotspots in academic research and the changes in trends over time, providing a reference on medical diagnosis and adjuvant therapy for healthcare professionals.

I.   Research data source

The data of this study were collected from the Science Citation Index Expanded (SCI-Expanded) and Social Sciences Citation Index (SSCI) in the Web of Science Core Collection database. The database covers the most influential literature for 178 scientific disciplines; the contents are strictly selected, reviewed by experts, and pass the formal indexes and a complete editing process to maintain the quality and authority of the data. The Advanced Search was applied to search for journals with the periodical index of "breast surgery", and the results included all bibliographic data, author, abstracts and records (number of publications, number of citations by others, h-index, number of self-citations, etc.). Using a global source of research information enhanced the effectiveness and efficiency of this research, thereby meeting the data requirements for multivariate data analysis.

II.   Data Retrieval Scope

In this study, "breast surgery" was set as the scope of search. In the Web of Science Core Collection database, "1990 to August 2023" was set as the data retrieval period, "article" as the literature type, and the formatting options of authors and references were selected, resulting in a total of 11,091 articles. All retrieved data including authors, titles, abstracts, and references were downloaded under the file name download*.txt, which was converted and saved.

III.   Content analyzed in this study

VOSviewer Version 1.6.18 software was used for the visual analysis of breast surgery literature. By using the system's various functional and optional processes, different analytical functions were selected to analyze the most frequently cited literature in a time series analysis in order to

present the optimal network analysis results. The scope of research is shown in Figure 1.

Figure 1. Research Scope
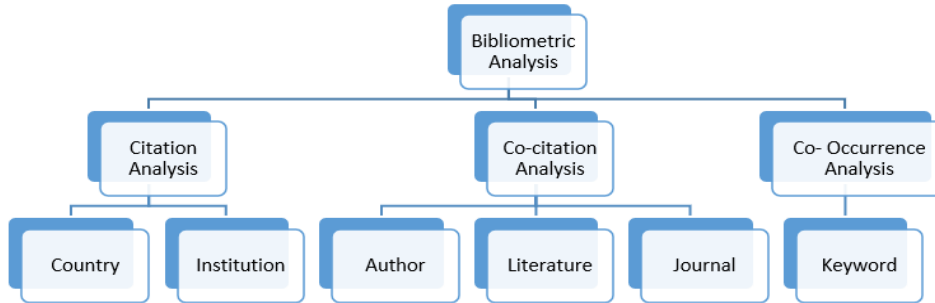
Results

1. Cluster analysis by countries

The distribution of citation weights is indicated by the color (warm > cool) and the size of the circle labels. As shown in Figure 2, collaborations among countries in the area of breast surgery research were mainly categorized into six clusters. Cluster 1 (red) contains eight countries with a relatively close cooperative relationship including Ireland, Mexico, Norway, Brazil, Canada, and the United States. Cluster 2 (green) contains eight countries with a relatively close cooperative relationship including England, the Netherlands, Greece, Russia, and Australia. Cluster 3 (blue) contains seven countries with an excellent cooperative relationship including Denmark, New Zealand, India, and Finland. Cluster 4 (yellow) contains seven countries with a relatively close cooperative relationship including Austria, Belgium, Germany, and Spain. Cluster 5 (purple) contains six countries with a relatively close cooperative relationship including Japan, China, Korea, and Taiwan. Cluster 6 (turquoise) contains France and Italy, which have a relatively close cooperative relationship. The results of the VosViewer software analysis of the ratio of quantity and citation impact of publications by country are displayed in Table 1.

Figure 2. Breast Surgery – Cluster Analysis by Countries – Network Visualization
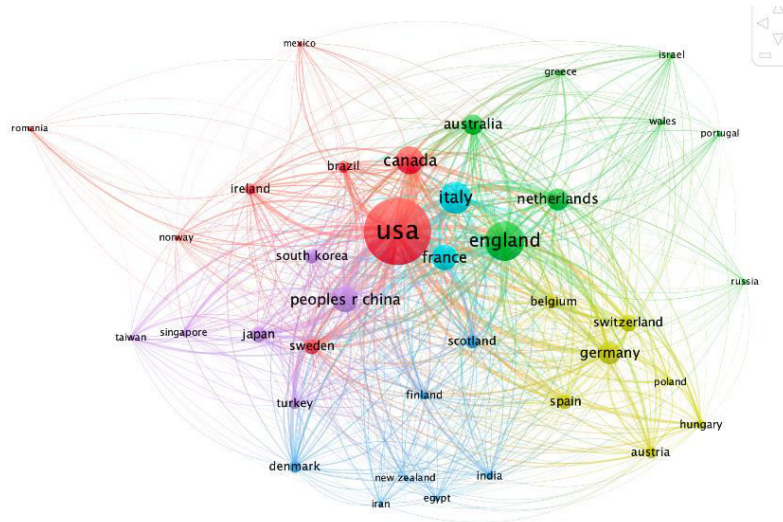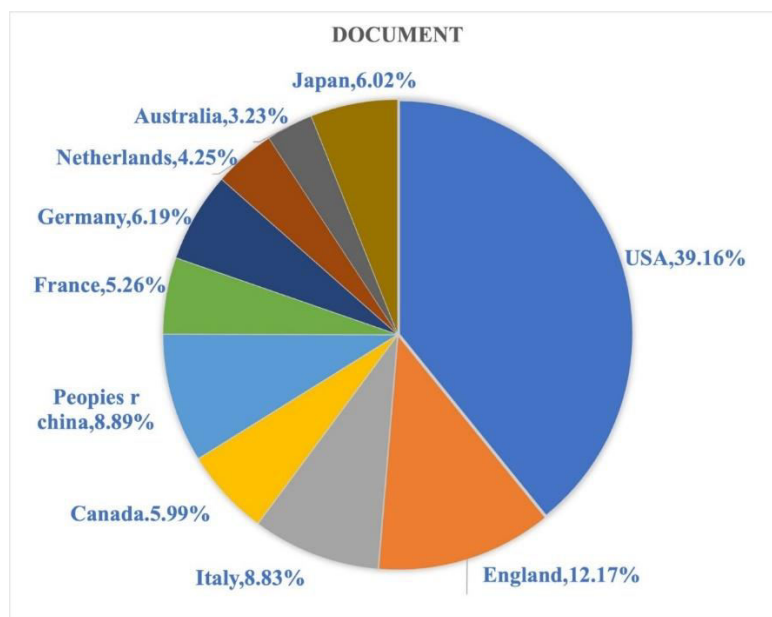
Table 1. Breast Surgery – Quantity and Citation Impact of Publications by Country

2. Cluster analysis by research institutes

Figure 3 illustrates the current state of knowledge production on breast surgery and its academic distribution, revealing that research institutes are divided into four major clusters. The results of

the VOSviewer software analysis display the quantity and citation impact of publications from each research institute (Table 2), of which the Memorial Sloan Kettering Cancer Center demonstrated the strongest total link strength, followed in order by Harvard University, the University of Texas MD Anderson Cancer Center, and the University of Michigan.

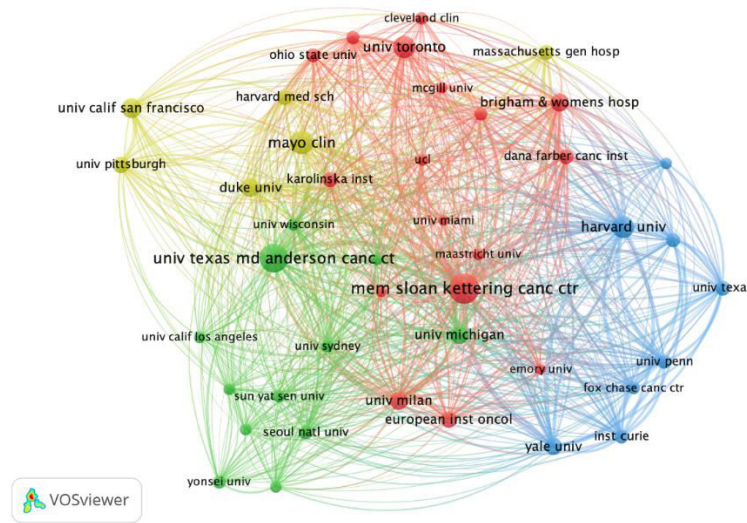**Figure 3.** Breast Surgery – Cluster Analysis by Research Institute

Table 2. Breast Surgery – Quantity and Citation Impact of Publications by Research Institute
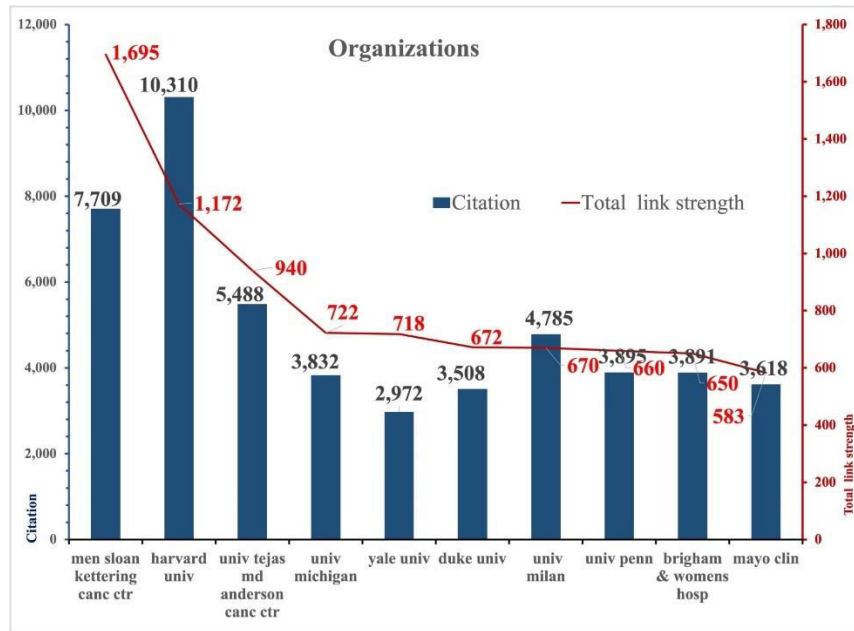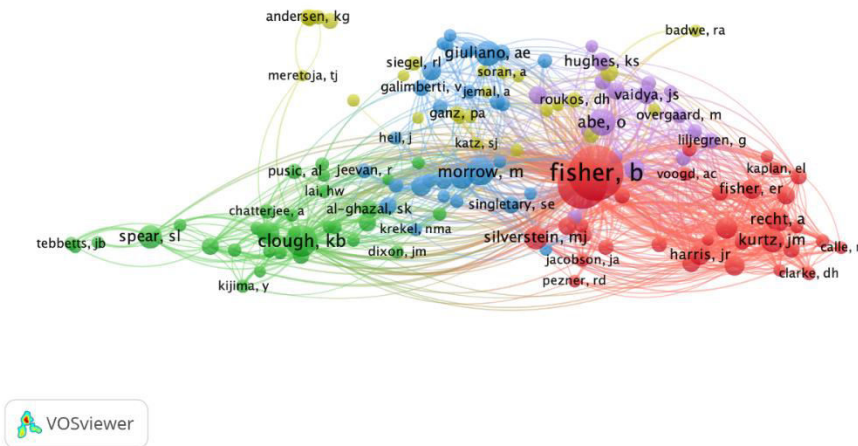

Figure 4. Cluster Analysis of Author Co-citation Frequency – Network Visualization

3. Author Co-citation Relationships

Author co-citation relationships were divided into five clusters (Figure 4). The author co-citation density map (Figure 5) generated by VOSviewer represents the strength of authors' collaborative relationships and the excellence of their academic performance. The distribution of collaborations moves from the yellow area (high weight) to the blue area (low weight). Authors in areas presenting a distinct yellow shade, such as B Fisher, U Veronesi, and KB Clough, are core authors in the academic field of breast surgery.

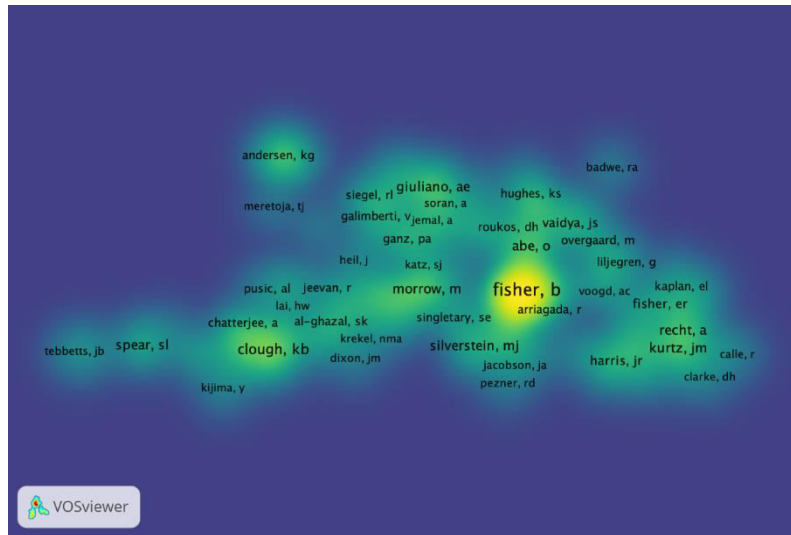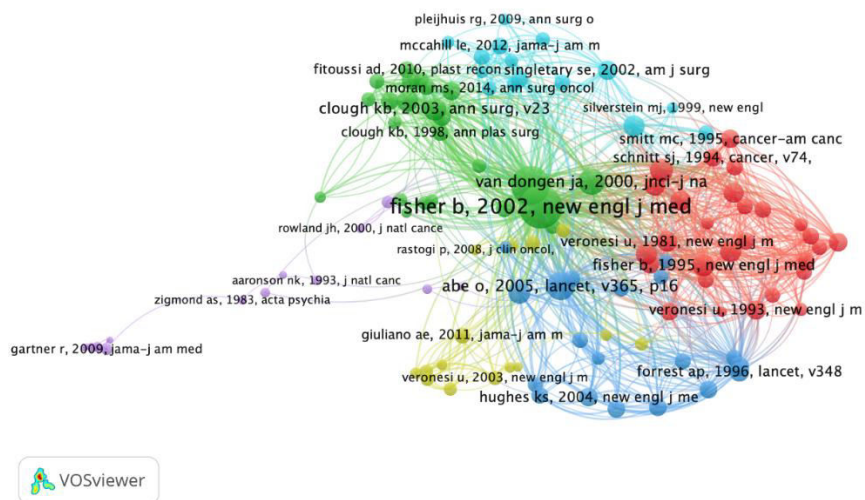**Figure 5.** Cluster Analysis by Author Co-citation Frequency – Density Visualization

Figure 6. Cluster Analysis by Co-citation Strength of Breast Surgery Literature

4. Co-citation strength by articles

Literature was divided into 6 clusters (Figure 6). Table 3 lists the co-citation relationship of breast surgery literature in order of link strength, e.g., B Fisher (2002), with 818 citations and a link strength of 4032; U Veronesi (2002), with 605 citations and a link strength of 3228; O Abe (2005), with 362 citations and a link strength of 1570; and Van dongen ja (2000), with 188 citations and a link strength of 1337.

Table 3. Co-citation Strength of Breast Surgery Literature

Co-citation Reference		
Reference	**Citation**	**Total link strength**
Fisher b, 2002, new engl j med, DOI: 10.1056/NEJMoa022152	818	4,032
Veronesi u, 2002, new engl j med, DOI: 10.1056/NEJMoa020989	605	3,228
Abe o, 2005, lancet, v365, p1687, DOI: https://doi.org/10.1016/S0140-6736(05)66544-0	362	1,570
Van dongen ja, 2000, jnci-j natl cancer i, v92, doi.org/10.1093/jnci/92.14.1143	188	1,337
Clough kb, 2003, ann surg, v237, p26, doi: 10.1097/00000658-200301000-00005	165	1,048
Jacobson ja, 1995, new engl j med, v332, p907-911,DOI: 10.1056/NEJM199504063321402	133	1,024
Fisher b, 1995, new engl j med, v333,p1456-1461, DOI: 10.1056/NEJM199511303332203	164	936
early breast canc trialists collab, 2011, lancet, doi.org/10.1016/S0140-6736(11)61629-2	232	915
Fisher b, 1989, new engl j med, v320, p822, DOI: 10.1056/NEJM198903303201302	200	908
Fisher b, 1985, new engl j med, v312, p674-681, DOI: 10.1056/NEJM198503143121102	227	1895

5. Co-citation strength by journal

Journals were divided into 5 clusters (Figure 7). Table 4 lists the co-citation relationship of breast surgery journal in order of link strength.

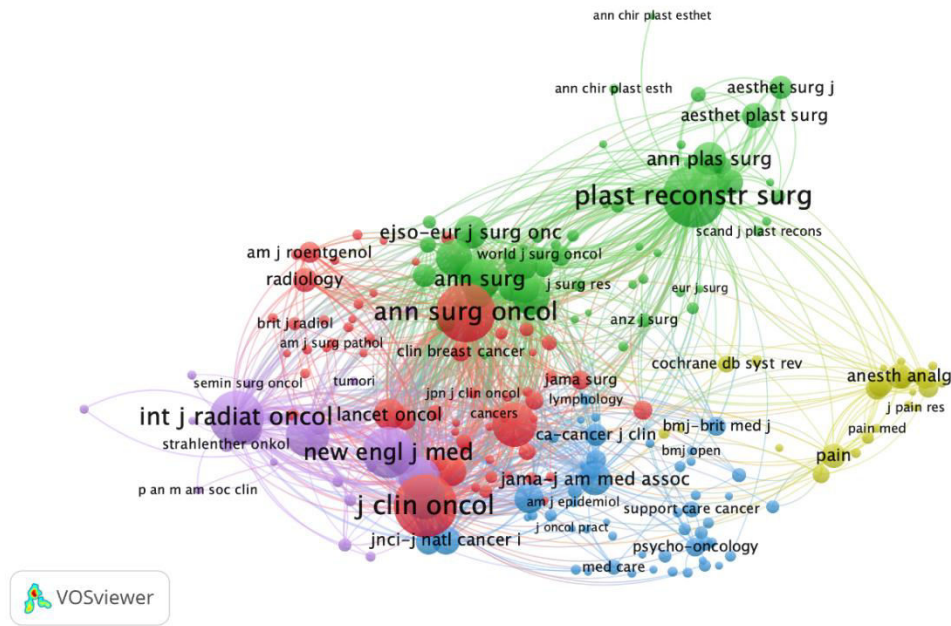**Figure 7**. Cluster Analysis by Co-citation Strength of Breast Surgery Journal
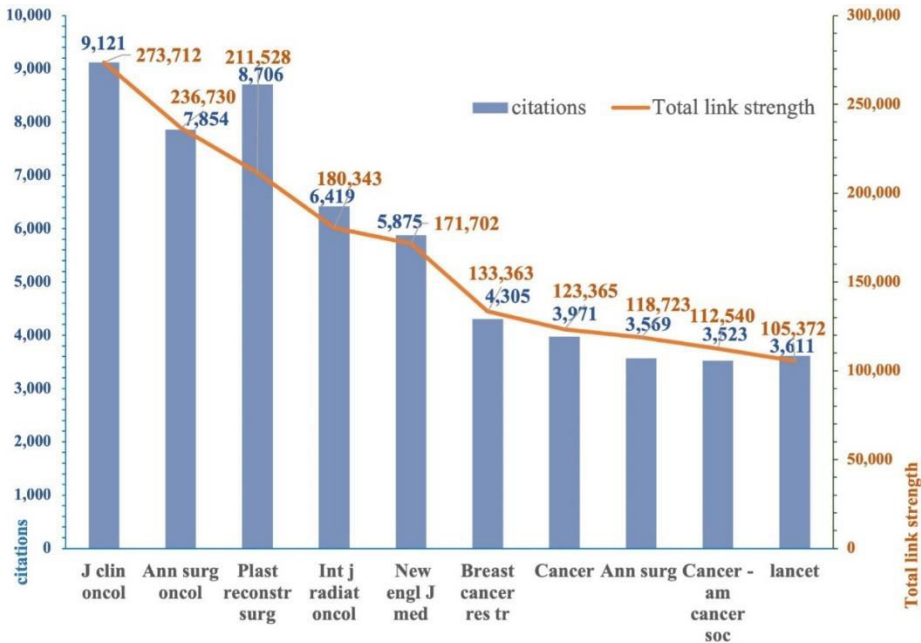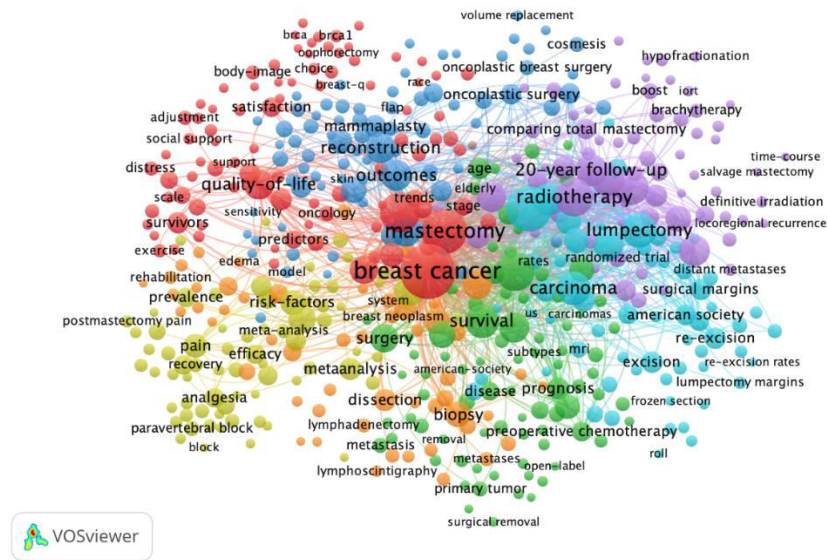
**Table 4.** Co-citation Strength by Breast Surgery Journal

6. Co-occurrence analysis of keywords

Keywords were divided into 8 clusters, as shown in Figure 8.

Figure 8. Co-occurrence of Breast Surgery Keywords – Network Visualization

The time series analysis of breast surgery bibliometric keywords (Figure 9) shows the distribution of research hotspots as well as the publication time, which corresponds to the color of the clusters. The size of each circle represents the weight of the keyword, whereas the color indicates the average influence time. The closer the nodes are to each other, the stronger the relationship, with indicators ranging from dark blue to red.

Figure 9. Time Series Analysis of Breast Surgery Keywords – Overlay Visualization
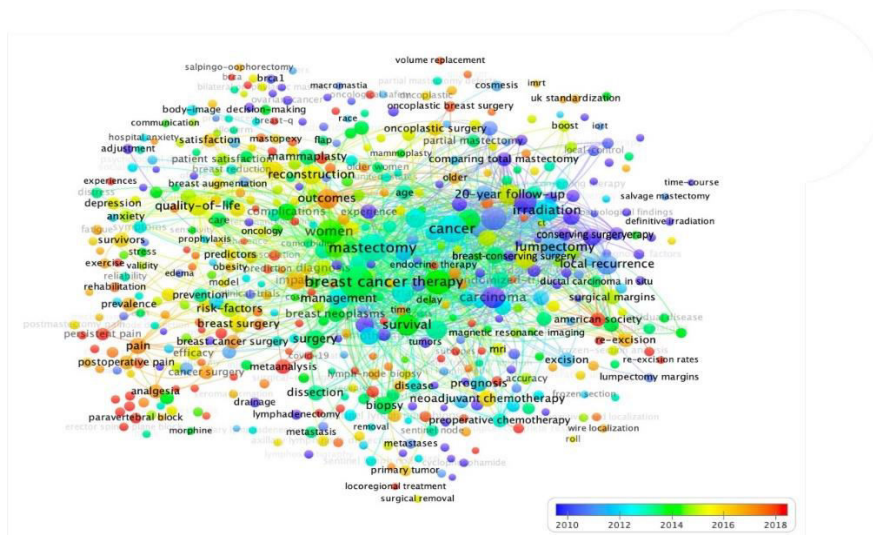
Keywords are the essence of literature content, and the link strength of keywords reveals the prioritized research topics and urgent developmental issues in different countries across different time periods. Based on the co-occurrence frequency distribution of keywords, this study identified research areas and analyzed research hotspot distribution, which is illustrated in Table 5.

Table 5. Co-occurrence Frequency of Breast Surgery Keywords
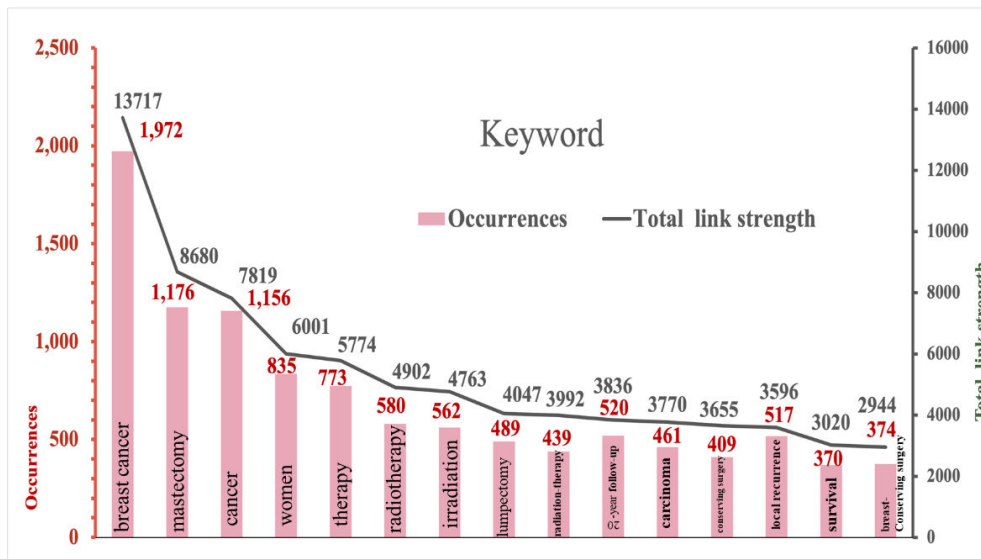
Discussion and Conclusion

Most academic studies and clinical applications of breast surgery are case reports or focus on clinical practicalities and applications of surgery, chemotherapy, and radiotherapy. Articles presenting relevant research topics in the bibliometric method by using knowledge graphs are rare. The resulting lack of effective comparative references may lead to biased results.

In this study, researchers retrieved data from breast surgery journals in the Web of Science database, adopted the modeling and clustering techniques of VOSviewer (Van Eck & Waltman, 2010), and integrated and analyzed the data with clustering algorithms and graphical presentation. This goal of this research was to identify the most influential works in the academic field of breast surgery as well as the key turning points in the evolution of the literature, thereby clarifying the overall developmental progress of the field through the use of graphs, and eventually analyzing the trends and overviews of different periods.

Regarding citation analysis by country and research institute, based on the distribution of 11,091 relevant published papers on breast surgery, Western countries had the highest publication capacity. The United States accounted for 39.16% of the global publications, England 12.17%, Italy 8.83%, and Canada 5.99%. In Asia, China exhibited the best performance with 8.89% of global publications, followed by Japan with 6.02%.
The citation analyses by country and research institute revealed that the relationships among countries and research institutes were strongly positively correlated with regions and language systems.

Moreover, the researchers analyzed author co-citation relationships. Author co-citation analysis

is a microcosm of a social partnership, i.e., direct or indirect participation in one or multiple collaborations with research institutes. The similarity and strength of correlations between clusters were observed from the most scientific viewpoint as an assessment of the performance of each academic achievement and social role (Mulyawati & Ramadhan, 2021). The author co-citation analysis revealed that the three authors with the strongest co-citation relationships were B Fisher, U Veronesi, and KB Clough, and their most frequently cited articles concerned the comparison between breast conserving surgery and conventional total mastectomy.

The co-citation frequency analyses by literature and journals reflected the extent of concerns regarding the literature from other researchers as well as the levels of impact on other academic fields (Durieux & Gevenois, 2010). Higher numbers of citations indicate that the knowledge or technology generated by the literature is valued and respected by successive generations of researchers.

The co-citation analysis by literature indicated that all three articles with the highest co-citation strength were about the comparison between breast conserving surgery and conventional total mastectomy.

Regarding the co-occurrence analysis of keywords, the results indicated that the early stages of breast surgery research focused on the discussion on radiotherapy, conservative surgery, and local recurrence; however, the discussion switched to cancer, mastectomy, and lumpectomy between 2012 and 2014. Additionally, after 2016, meta-analysis, outcomes, 20-year follow-up, and breast conserving surgery were more frequently discussed.

The results of the breast surgery bibliometric visual analysis support the following conclusions: First, among the networks of cooperative relationships by countries and research institutes, there is close cooperation between European and American countries and among Asian countries. Second, the dynamic structural change of co-citation—in both author co-citation analysis and literature co-citation analysis—revealed that the strongest links involved comparisons between breast conserving surgery and conventional total mastectomy with regard to breast surgery. Third, the co-occurrence analysis of keywords suggested that that focus in the early stage was on surgery, radiotherapy, and the prevention of local recurrence, but the focus shifted to the possibility of replacing conventional total mastectomy with breast conserving surgery between 2010 and 2014. Moreover, after the standards for breast conserving surgery were established in 2016, the widely discussed topics shifted to the 20-year follow-up analysis and patient prognosis. In the future, experts and scholars in the related fields are advised to break the regional and linguistic barriers and refer to the literature of relevant experts when analyzing breast surgery. Furthermore, they should focus on issues other than breast conserving surgery and analyze different types of radiotherapy and chemotherapy, as well as surgical techniques, complications, and prognosis, which may be the focus of future research in the field of breast surgery.

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