ORIGINAL RESEARCH

Bibliometric and Visualization Analysis of Research Hotspots and Frontiers in Endoscopic Lumbar Discectomy

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Background: The increasing utilization of endoscopic lumbar discectomy (ELD) in spinal surgery has sparked widespread interest and research. This study utilizes bibliometric analysis to identify current research trends and advancements in this innovative surgical technique, with the goal of informing and improving surgical practices.

Methods: We retrieved relevant literature on ELD from the Science Citation Index Expanded (SCI-Expanded) within the Web of Science Core Collection (WoSCC) database as research samples. Various visualization tools, such as VOSviewer, CiteSpace, Scimago Graphica, Pajek, and online bibliometric platform, were employed to generate scientific knowledge maps for the purpose of visual presentation and data analysis.

Results: Over the past two decades, there has been significant progress in the research related to ELD, particularly since 2016. China has emerged as the most productive country, while South Korea and the United States have exerted greater academic influence. Tongji University has contributed the highest number of research output, while academic achievements published by Wooridul Spine Hospital are highly esteemed by scholars. Lee SH and Ruetten S are the most prolific author and the most highly cited author, respectively. *World Neurosurg* has published the highest number of publications, while *Spine* has become the most influential journal. Clinical Neurology and Surgery are the primary subject categories. Research in this field primarily revolves around improving ELD techniques, evaluating postoperative efficacy and prognosis prediction, studying complications and risk factors, as well as comparative research with other surgical techniques. Keywords such as risk factors, LDH, PETD, lumbar spinal stenosis, degeneration, recurrent herniation, laminectomy, local anesthesia, and foraminoplasty highlight the current research hotspots and future cutting-edge trends.

Conclusion: This study employed bibliometric analysis to elucidate the research hotspots and frontiers in ELD. The findings have significant implications for advancing research and development in this field.

Keywords: endoscopic lumbar discectomy, bibliometric, visualization analysis, VOSviewer, CiteSpace

Introduction

With the accelerating pace of modern life, changes in work environments, and the increasing aging population, the incidence of lumbar disc-related diseases such as lumbar disc herniation (LDH) has been on the rise.[1,2] In recent years, with the rapid development of endoscopic technology, endoscopic lumbar discectomy (ELD), as a minimally invasive surgical technique, has gradually attracted the attention of the medical community and has been widely applied in the treatment of lumbar disc-related diseases.[3–6] Compared to traditional open surgery, ELD offers advantages such as minimal trauma, faster recovery, and fewer postoperative complications, making it increasingly preferred by both patients and doctors as one of the treatment options.[7–9] However, the complexity of spinal anatomy and the intricate surgical

techniques involved in ELD present ongoing challenges in research.[10,11] Understanding the current hot topics and cutting-edge advancements in ELD research is of great importance for guiding clinical practice, promoting technological innovation, and improving treatment outcomes. Bibliometrics, as an effective research method, allows for systematic organization, evaluation, and analysis of a large body of relevant literature, uncovering research hotspots, areas of focus, and academic trends.[12–15]

Therefore, this study aims to conduct a comprehensive and systematic investigation and analysis of the research hotspots and cutting-edge advancements in ELD using bibliometric and visualization analysis methods. By collecting, organizing, and analyzing relevant literature, we will uncover the latest research trends in this field, and delve deeper into the advances in ELD operation techniques, clinical efficacy, and complications. Additionally, through visualizing research results in the form of charts and graphs, we aim to provide a more intuitive understanding of the distribution of relevant research in different regions and academic institutions, highlighting academic influence and collaborations. Furthermore, by analyzing research hotspots and frontiers, we can identify core issues and challenges crucial to the field, providing a deeper exploration direction for future research and practice. Ultimately, this study will also offer a comprehensive and systematic literature resource for scholars in related fields, promoting knowledge sharing and academic collaboration, driving advancements in ELD surgical techniques, and providing better treatment outcomes and quality of life for patients.

Materials and Methods
Data Source and Retrieval Strategy

This study searched for literature related to ELD from the Science Citation Index Expanded (SCI-Expanded) within the Web of Science Core Collection (WoSCC) database. To reduce the impact of database updates on data biases, literature retrieval and data extraction were completed on the same day. We constructed the search strategy using subject words and entry terms from Medical Subject Headings (MeSH). The search query was ((TS = (endoscop*)) AND TS = (lumbar)) AND TS = (diskectom* OR discectom*), with a restriction on article or review as document types, English as the language, and a time span from January 1, 2004, to September 30, 2023. After excluding irrelevant literature such as early access, letter, editorial material, proceeding paper, correction, and meeting abstract, a total of 1267 publications were included in the study.

Bibliometric Analysis

We exported the literature data from the WoSCC database in the form of plain text files and tab delimited files, and named them as download_xxx.txt. The tab delimited file was uploaded to the bibliometric online analysis platform for national/regional cooperation analysis. The plain text file literature data was first imported into CiteSpace 6.2.R4 software for data de-duplication. No duplicate literature was found, and we proceeded with the drawing of journal dual-map overlay, keyword clustering, keyword timeline, keyword burst, subject category co-occurrence, literature clustering, and literature burst maps. The plain text file literature data was then imported into VOSviewer 1.6.19 software for the drawing of cooperative, co-citation, and co-occurrence network knowledge maps. Finally, Pajek 5.18 and Scimago Graphica 1.0.36 software were used for layout adjustment and supplementary drawing of the maps.

Results and Discussion
Analysis of Annual Publications and Citations

This study included a total of 1267 papers related to ELD, published between 2004 and 2023. Among them, 1083 (85.48%) were research papers and 184 (14.52%) were review papers. The total citations (TC) for these papers were 22,008, with an average citation per publication (ACPP) of 17.37 and an H-index of 69. Figure 1 shows the trends in publications and citation frequency for the past 20 years, which indicate an overall upward trend in both areas, especially since 2016. However, due to the fact that the data for 2023 only covers a part of the year, there is a slight decrease in the number of publications and citation frequency. Specifically, the average annual publication and citation frequency between 2004 and 2006 were 9.3 and 8.7, respectively, while the average for 2020 to 2022 were 173 and 3438.3,
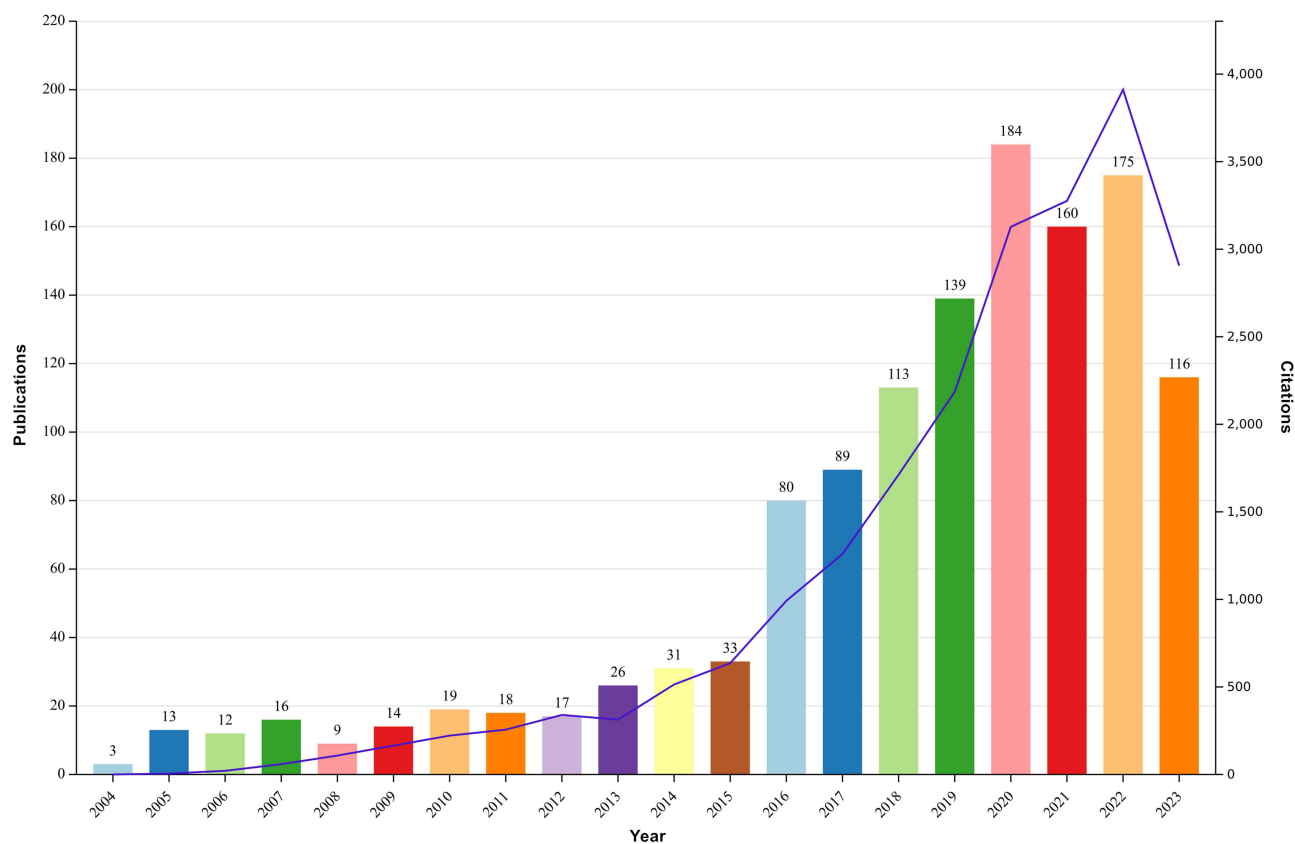
Figure 1 Trend chart of annual publications and citations related to ELD from 2004 to 2023.

respectively, representing an increase of 18.6 and 395.2 times, respectively. These data demonstrate that the field of ELD has attracted widespread attention from researchers in recent years, generating significant research interest and producing a considerable volume of research outcomes.
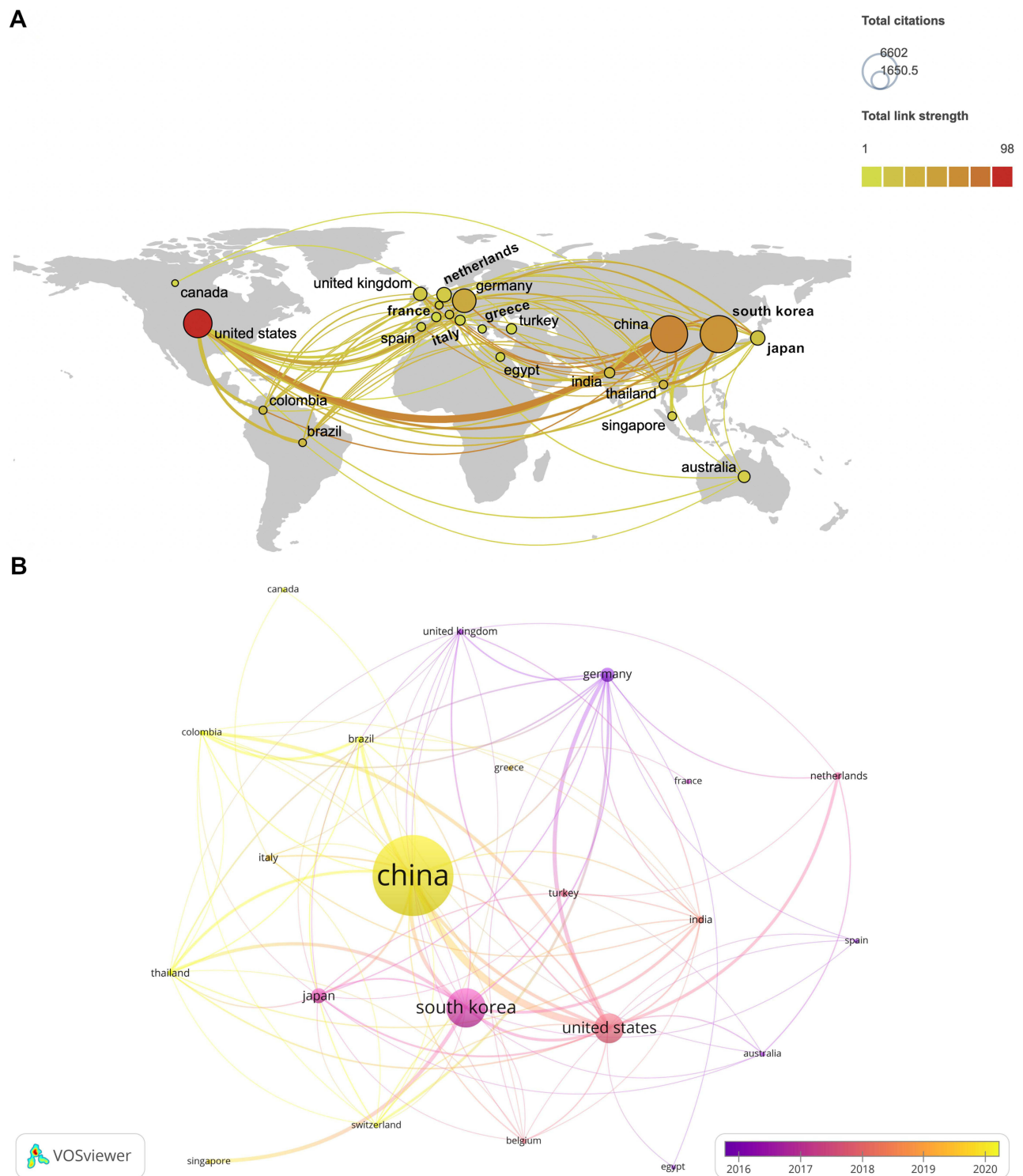
Analysis of Countries/Regions

A total of 51 countries/regions participated in the publication of these research papers. Among them, China (669, 52.80%) was the most productive country, followed by South Korea (241, 19.02%) and the United States (161, 12.71%). The combined publications of these three countries accounted for over 80% of the total, making them the leaders in this field. Figure 2A illustrates the trend of annual papers in the top 10 countries/regions. It can be seen that these countries have gone through two main stages of development in their research in this field. The first stage, from 2004 to 2015, was a period of slow development, as most countries were just beginning to enter this field of research and progress was relatively slow. South Korea made significant contributions during this period. The second stage, from 2016 to the present, witnessed a rapid development in research in this field, mainly due to China's contributions. China's rapid progress can be attributed to strong support from national policies and finances, making it the country with the highest annual publication volume. Figure 2B shows the collaboration between countries/regions, represented by the quantity and thickness of the lines, indicating the breadth and depth of collaboration.[16] It can be observed that China has relatively less collaboration with other countries/regions compared to the United States and South Korea. However, the United States has established close collaborations with China, Brazil, South Korea, the Netherlands, and Germany, among others.

The geographic distribution of countries/regions is depicted in Figure 3A, where the size of each node corresponds to the TC of publications from that country/region. The thickness of the lines between nodes reflects the degree of collaboration, while the color of the nodes indicates the total link strength (TLS) – a metric that measures the strength of a country/region's cooperative relationships with others.[17] It can be observed from the figure that South Korea has the

Figure 2 (**A**) Stacking area map of top 10 countries/regions in publications. (**B**) Pie chart of countries/regions cooperation.

Figure 3 (**A**) Geographical distribution map of countries/regions cooperation. (**B**) Time overlay map of cooperation between countries/regions.

highest TC (6602), followed by China (6509) and the United States (3810). The United States has the largest TLS (98), which means it has the most extensive partnerships. When combined with the data in Table 1, it can be seen that although China has the highest number of publications and ranks second in terms of TC, its ACPP (9.73) is relatively low. This reflects the comparatively lower quality of China's academic output, despite its large quantity. Therefore, Chinese scholars should focus on producing high-quality research results and strengthen international communication and

Table I Top 10 Countries/Regions in Publications

Rank	Countries/Regions	Counts (%)	TC	ACPP	H-index	TLS	BC
I	China	669(52.80%)	6509	9.73	36	67	0.16
2	South Korea	241(19.02%)	6602	27.39	45	59	0.47
3	United States	161(12.71%)	3810	23.66	34	98	0.33
4	Japan	61(4.81%)	814	13.34	15	25	0.18
5	Germany	57(4.50%)	2532	44.42	20	45	0.15
6	Turkey	25(1.97%)	310	12.40	10	2	0.26
7	India	23(1.82%)	324	14.09	9	27	0.01
8	Netherlands	22(1.74%)	844	38.36	14	14	0.05
9	Brazil	18(1.42%)	86	4.78	4	30	0.01
10	United Kingdom	18(1.42%)	676	37.56	11	17	0.12
II	Italy	18(1.42%)	285	15.83	9	9	0.01

Abbreviations: TC, total citations; ACPP, average citation per publication; TLS, total link strength; BC, betweenness centrality.

cooperation to increase their global impact in the field. In contrast, Germany has relatively lower papers but ranks first in ACPP (44.42), indicating a high level of research quality and recognition from scholars. Moreover, South Korea not only has the highest TC, but also holds the top position in H-index (45) and betweenness centrality (BC) (0.47). As H-index is one of the important indicators for measuring academic influence, and BC represents its crucial role as a bridge in the collaborative network,[18,19] indicating that South Korea not only has significant academic influence but also plays a critical role as a key connector in the cooperative network. Figure 3B depicts a collaboration network of countries/ regions with at least five publications, where the size of each node represents the number of publications, and the thickness of the lines indicates the strength of cooperation.[20,21] The color of each node reflects the average publication date, with yellow indicating a later publication date.[22] It can be observed that South Korea, the United States, Japan, and Germany made significant contributions in the early stage of research with earlier publication dates, while China, Brazil, Switzerland, Thailand, and Colombia gradually entered the research field in recent years and have been making remarkable progress, particularly in the case of China, which has taken a central position in the field in recent years.

Analysis of Institutions

A total of 1249 institutions collaborated in the publication of these 1267 documents, in which Tongji University (53, 4.18%) from China contributed the highest number of publications, followed by Wooridul Spine Hospital (51, 4.03%) and Catholic University of Korea (38, 3.00%) in South Korea. Detailed data presented in Table 2 shows that not only did Wooridul Spine Hospital have a high productivity, but it also ranked first in terms of TC (3030), ACPP (59.41), and H-index (31), indicating that the papers published by it have been highly regarded and extensively cited by numerous researchers, making it a core research institution with a leadership position in the field. However, although Tongji

Table 2 Top 10 Institutions in Publications

Rank	Institutions	Counts (%)	TC	ACPP	H-index	TLS	Location
I	Tongji University	53(4.18%)	674	12.72	15	19	China
2	Wooridul Spine Hospital	51(4.03%)	3030	59.41	31	20	South Korea
3	Catholic University of Korea	38(3.00%)	961	25.29	14	36	South Korea
4	Capital Medical University	37(2.92%)	164	4.43	8	13	China
5	Brown University	36(2.84%)	526	14.61	14	11	USA
6	Southern Medical University	26(2.05%)	162	6.23	7	11	China
7	Gachon University	26(2.05%)	465	17.88	13	18	South Korea
8	Leon Wiltse Memorial Hospital	24(1.89%)	808	33.67	14	18	South Korea
9	Shanghai Jiao Tong University	22(1.74%)	119	5.41	6	16	China
10	Seoul National University	21(1.66%)	425	20.24	11	27	South Korea

University published the highest number of academic papers, its TC (674) and ACPP (12.72) are relatively low, indicating that its research results have not been widely promoted and cited. Therefore, the institution should focus on improving its research strength and publishing high-quality academic results to increase its reputation and academic prestige in the field. Notably, 40% of these institutions are from China, while 50% are located in South Korea, which is consistent with the national/regional rankings of publications. Figure 4A shows the collaboration relationship between institutions, where Wooridul Spine Hospital has the most TC, and Changhua Christian Hospital in Taiwan, China, has the highest TLS (42), indicating that the institution has extensive collaborative relationships, particularly with Kaohsiung Medical University, also located in Taiwan, China. Figure 4B shows the average publication time of institutions that have published no less than 10 papers, indicating that high-productivity institutions such as Tongji University, Wooridul Spine Hospital, Catholic University of Korea, Brown University, Southern Medical University, Leon Wiltse Memorial Hospital, and Seoul National University made significant contributions to the establishment of important knowledge bases in the early research stages of the field. With the continued involvement of institutions such as Capital Medical University, Shanghai Jiao Tong University, Changhua Christian Hospital, Kaohsiung Medical University, Shandong University, and Qingdao University, this research field has entered a new era of development, which will drive high-quality and rapid development in this field.

Analysis of Authors

A total of 4578 authors contributed to the publication of the research papers, with Lee SH (52, 4.10%) from Wooridul Spine Hospital in South Korea being the most prolific author, followed by Ahn Y (43, 3.39%) from Gachon University in South Korea and Kim JS (41, 3.24%) from Catholic University of Korea. Table 3 presents detailed information on the top 10 authors ranked by publication output, indicating that Lee SH, not only being the most productive author, also holds the highest TC (2767), ACPP (53.21), and H-index (29) in the field, thus indicating his status as a highly influential core author whose research achievements have been widely cited, promoting the high-quality development of this field. It is worth noting that 50% of these highly productive authors are from South Korea and 40% are from China, which is also consistent with the national/regional ranking of publications. Figure 5A shows the collaboration relationships among authors, in which Lee SH and Ahn Y are the authors with the most TC, while He Shisheng from Tongji University in China has the highest TLS (83), reflecting his extensive collaborative relationships, especially with Gu Xin, Fan Guoxin, Zhang Hailong, Guan Xiaofei, Gu Guangfei, and Wang Chuanfeng. Figure 5B displays the average publication time of authors with no less than 10 publications, indicating that high productivity authors such as Lee SH, Ahn Y, Kim JS, Kim HS, He Shisheng, Zhou Yue, Fan Guoxin, and Gu Xin contributed significantly to the early research in the field, laying a solid theoretical foundation and possessing high academic influence. The addition of authors such as Chen CM, Lewandrowski KU, Park HJ, Hofstetter CP, Kotheeranurak V, Lin Guangxun, Wu Panghung, Zhu Bin, and Li Jian has injected new research energy into this field, thereby contributing vitality to the better and faster development of this field.

Figure 6A illustrates the co-citation relationships among highly cited authors with a minimum citation count of 60. The size and color of the nodes represent the magnitude of their citation counts and their respective clusters, respectively.[23] The links between nodes and their thickness indicate the co-citation relationships and the strength of those relationships, respectively.[24] By combining the detailed data listed in Table 4, it can be inferred that Ruetten S (1099) from Saint Anna Hospital in Germany is the most highly cited author, followed by Ahn Y (943) and Kambin P (700). This indicates their significant academic influence and the high scholarly value of their published research findings. Notably, Ruetten S also enjoys the highest TLS (14,300) and BC (0.32) scores among the authors, indicating that he serves as an important hub in the field and has established extensive co-citation relationships, particularly with Ahn Y, Kambin P, Yeung AT, Choi KC, Choi G, Kim HS, Lee SH, Hoogland T, and Mayer HM. Furthermore, it is observed that these highly cited authors mainly come from South Korea, Germany, and the United States, while China, which has the highest number of publications, does not have any highly cited authors. This suggests that the research output of Chinese scholars may not have received broad recognition and citation, indicating a lack of international academic influence. This serves as a reminder that a focus on the quality of academic achievements is crucial in conducting scholarly research. Only by publishing high-quality research can one enhance their academic reputation and contribute to the healthy and stable development of the field. In Figure 6B, the importance of authors in the field is
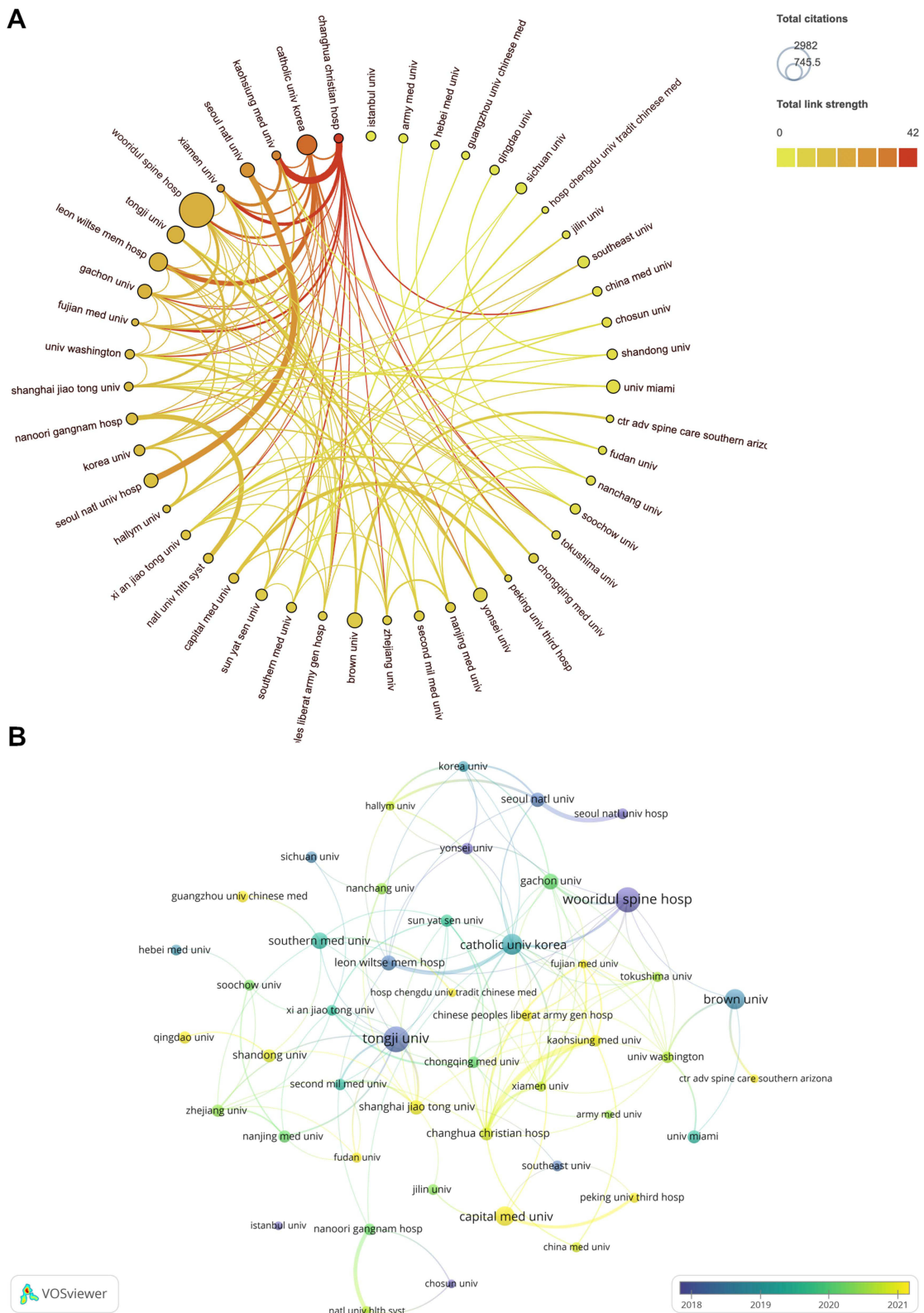
Figure 4 (**A**) Knowledge map of institutional cooperation network. (**B**) Time overlay chart of institutional cooperation.

Table 3 Top 10 Authors in Publications

| Rank	Author	Counts (%)	TC	ACPP	H-index	TLS	Location
1	Lee SH	52(4.10%)	2767	53.21	29	46	South Korea
2	Ahn Y	43(3.39%)	2104	48.93	24	32	South Korea
3	Kim JS	41(3.24%)	1197	29.20	17	69	South Korea
4	Kim HS	38(3.00%)	717	18.87	17	53	South Korea
5	Telfeian AE	34(2.68%)	509	14.97	14	59	USA
6	He Shisheng	31(2.45%)	423	13.65	13	83	China
7	Jang IT	25(1.97%)	458	18.32	12	48	South Korea
8	Zhou Yue	25(1.97%)	651	26.04	17	37	China
9	Fan Guoxin	24(1.89%)	327	13.63	12	71	China
10	Gu Xin	24(1.89%)	312	13.00	11	61	China

visualized through varying levels of density. A higher density indicates greater academic influence.[25] Thus, it is evident from the figure that Ruetten S, Ahn Y, and Kambin P possess significant scholarly prestige in the field, with their research findings holding high academic value and being frequently cited by numerous scholars, thereby establishing the foundation of research in the field.

Analysis of Journals

The relevant literature included in this study was published in a total of 185 journals. Among them, *World Neurosurg* (174, 13.73%) had the highest number of published papers, followed by *Pain Physician* (79, 6.24%) and *Medicine* (58, 4.58%). Detailed information regarding the top 10 journals in terms of publication output is presented in Table 5. From the data in the table, it can be observed that the average H-index and impact factor (IF) of these journals were 88.09 and 2.37, respectively. Furthermore, 54.5% of the journals belonged to Q1 or Q2 categories, indicating that the majority of research achievements in this field were published in journals with a moderate level of influence. This, to some extent, reflects the potential for significant improvement in the research quality within this field. Moreover, although *Spine* ranked sixth in terms of publication output, it ranked first in terms of TC (3029), ACPP (79.71), and H-index (254). This highlights the fact that *Spine* is a highly influential core journal and is widely recognized as a high-quality authoritative journal in the field of orthopedics. Additionally, it is worth noting that most of these highly productive journals originated from the United States or Europe, indicating the significant contributions made by journals from these regions in the dissemination of knowledge within this field.

Figure 7 displays the co-citation relationships among the highly cited journals with at least 100 citations. Based on the detailed data presented in Table 6, *Spine* (6210) was identified as the most highly cited journal, followed by *Eur Spine J* (2153) and *World Neurosurg* (1867). This indicates that these highly cited journals have high academic influence, and their published academic achievements have been recognized and widely cited by scholars. Furthermore, *Spine* also ranked highest in TLS (144,405) and H-index (254), indicating its strong co-citation relationships with other journals, particularly with *Eur Spine J, World Neurosurg, Pain Physician, Neurosurgery, J Neurosurg-Spine, Spine J, J Neurosurg, Clin Orthop Relat Res*, and *J Spinal Disord Tech*. It is noteworthy that all 10 of these highly cited journals are from the United States, indicating their positive reputation in the field and their outstanding contribution to the dissemination of academic knowledge. Figure 8 presents a dual-map visualization of the co-citation networks, with citing journals on the left and cited journals on the right, and the colored lines representing citation pathways.[26–28] The figure reveals three main citation paths, indicating that papers published in neurology/sports/ophthalmology journals typically cite articles from health/nursing/medicine, sports/rehabilitation/sport, and psychology/education/social journals. Based on the afore-mentioned journal analysis, scholars can derive some valuable insights. When consulting relevant literature in a particular field, it is advisable to prioritize articles published in highly cited journals. Additionally, when seeking an appropriate journal for manuscript submission, high-productivity journals should be prioritized. By following these recommendations, scholars can enhance the targeted nature of their manuscript submissions, facilitating the rapid acceptance and publication of their academic achievements.
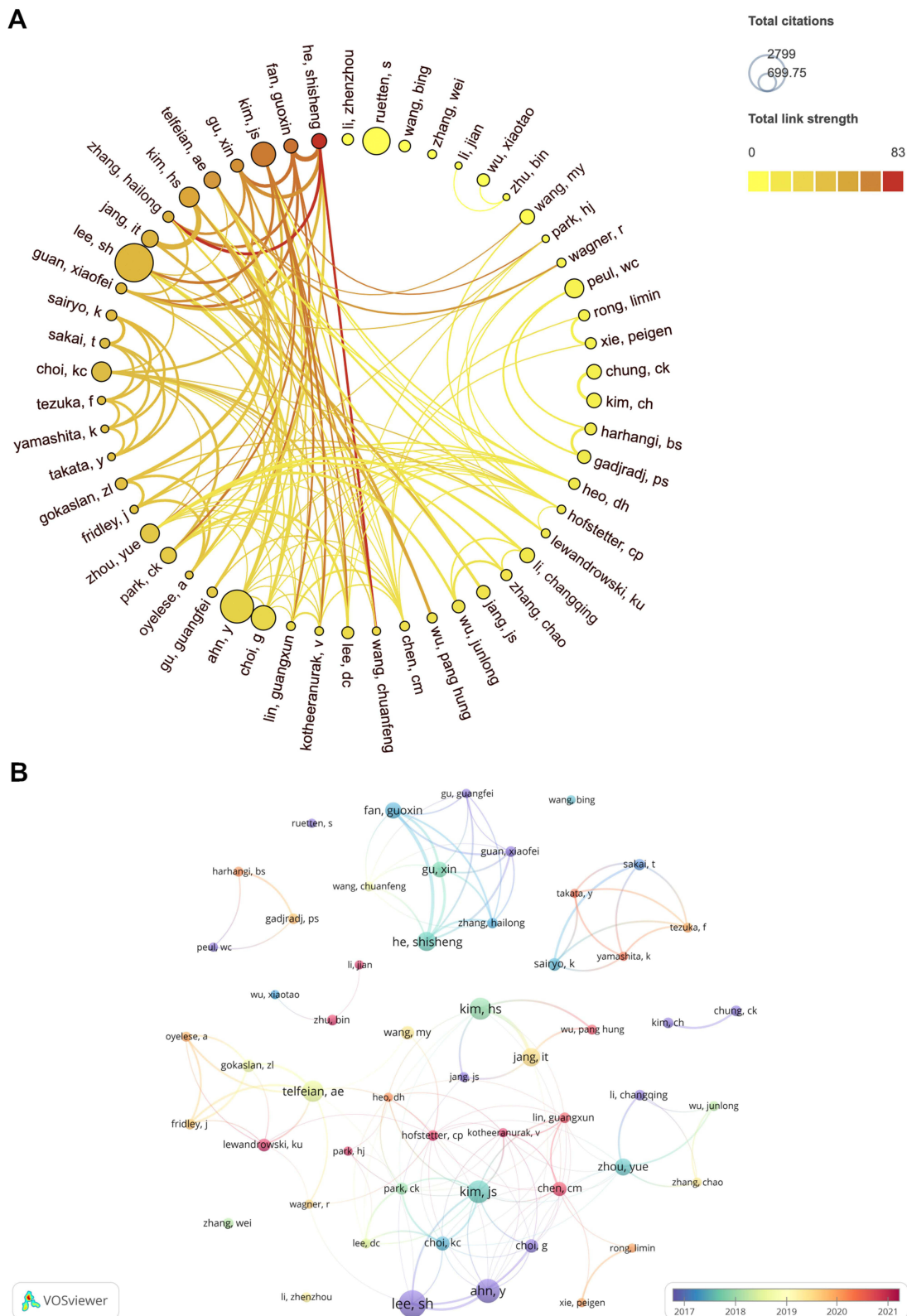
Figure 5 (A) Knowledge map of author collaboration network. (**B**) Time overlay chart of author collaboration.
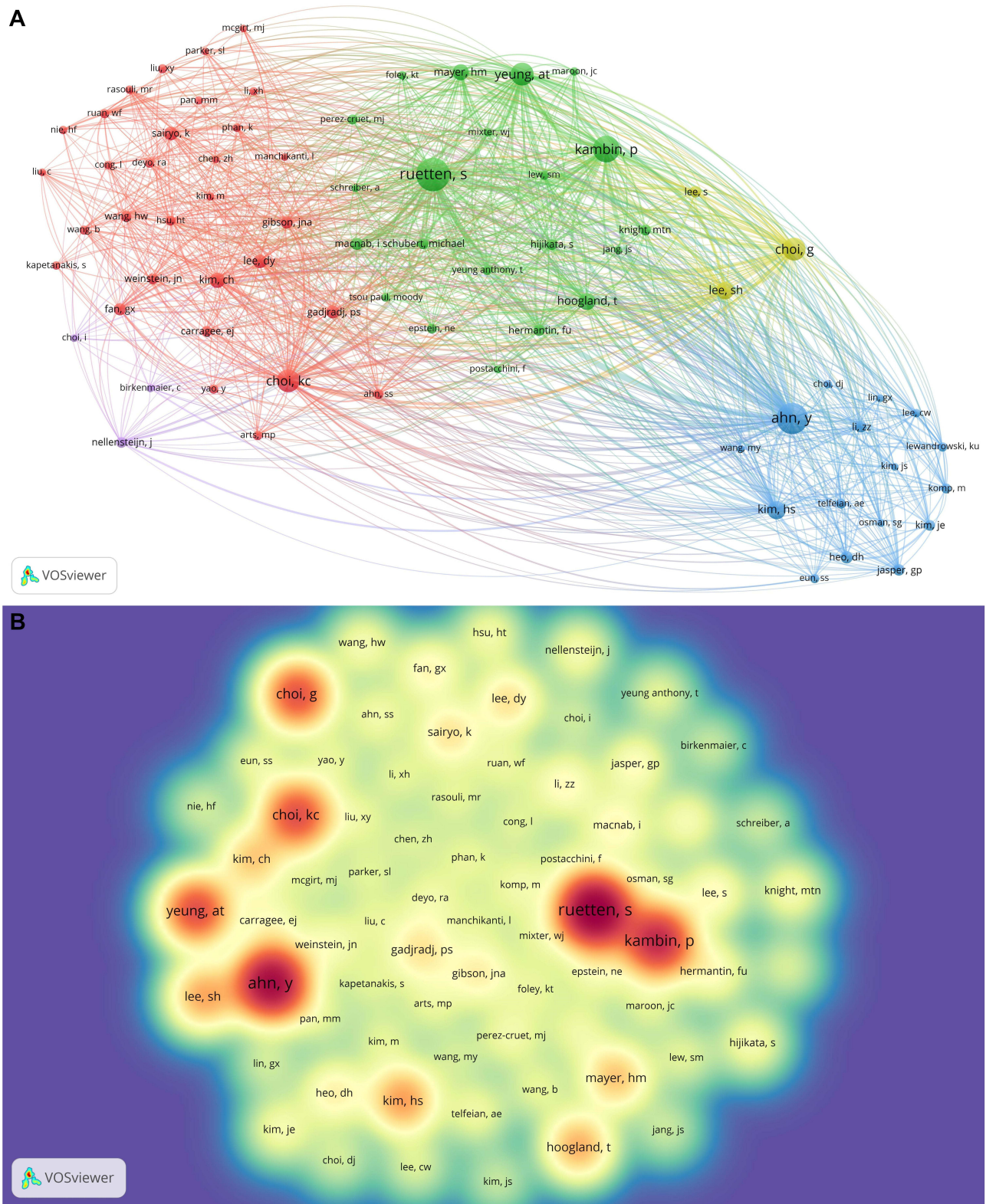
Figure 6 (**A**) Author co-citation network knowledge map. (**B**) Author co-citation density map.

Table 4 Top 10 Cited Authors by Citation Frequency

Rank	Co-Cited Author	Citations	TLS	BC	Location
1	Ruetten S	1099	14,300	0.32	Germany
2	Ahn Y	943	12,084	0.22	South Korea
3	Kambin P	700	9511	0.08	USA
4	Yeung AT	525	6876	0.07	USA
5	Choi KC	517	6115	0.10	South Korea
6	Choi G	506	6580	0.06	South Korea
7	Kim HS	316	4361	0.01	South Korea
8	Lee SH	298	4254	0.03	South Korea
9	Hoogland T	283	4024	0.02	Germany
10	Mayer HM	243	3712	0.19	Germany

Table 5 Top 10 Journals in Publications

Rank	Journal	Counts (%)	TC	ACPP	H-Index	IF (2022)	Quartile in Category
1	World Neurosurg (United States)	174(13.73%)	2196	12.62	95	2.0	Q3
2	Pain Physician (United States)	79(6.24%)	1752	22.18	99	3.7	Q2
3	Medicine (United States)	58(4.58%)	358	6.17	148	1.6	Q3
4	Eur Spine J (United States)	54(4.26%)	1564	28.96	136	2.8	Q2
5	Front Surg (Switzerland)	40(3.16%)	56	1.4	25	1.8	Q3
6	Spine (United States)	38(3.00%)	3029	79.71	254	3.0	Q2
7	J Orthop Surg Res (England)	37(2.92%)	359	9.70	48	2.6	Q2
8	Neurospine (South Korea)	36(2.84%)	490	13.61	12	3.2	Q1
9	J Neurol Surg Part A (United States)	35(2.76%)	275	7.86	33	1.0	Q4
10	BMC Musculoskel Dis (England)	33(2.60%)	182	5.52	96	2.3	Q2
11	Orthop Surg (China)	33(2.60%)	157	4.76	23	2.1	Q3

Analysis of Subject Categories

Figure 9 displays the co-occurrence relationships between subject categories with a minimum frequency of 2 occurrences. The size of the nodes in the graph corresponds to their frequency of occurrence, while the lines connecting the nodes represent their co-occurrence relationships. Nodes with a purple outer ring indicate the BC of no less than 0.1, with larger BC values indicating greater importance of the node within the network.[29] Table 7 presents the top 10 subject categories ranked by frequency of occurrence and BC. From the information depicted in the graph and table, it is evident that Clinical Neurology (725) has the highest frequency of occurrence, followed by Surgery (520) and Orthopedics (322). These three categories align with the main focus of the present study. Furthermore, the subject category with the highest BC is Radiology Nuclear Medicine Medical Imaging (0.76), followed by Surgery (0.71) and Mathematical Computational Biology (0.64). This signifies their crucial role as bridging disciplines within the field, facilitating connections between different subject areas. It is worth mentioning Surgery specifically, as it not only has a high frequency of occurrence but also exhibits high BC. This suggests that research in this domain primarily revolves around Surgery as a central theme, constantly integrating with other disciplines to promote diversified advancements in the field. Therefore, in future studies, it is necessary to enhance the interrelatedness and collaboration among various subject areas within this field, broaden the depth and breadth of research, and facilitate breakthroughs in high-quality research through interdisciplinary approaches, ultimately serving the betterment of human health.
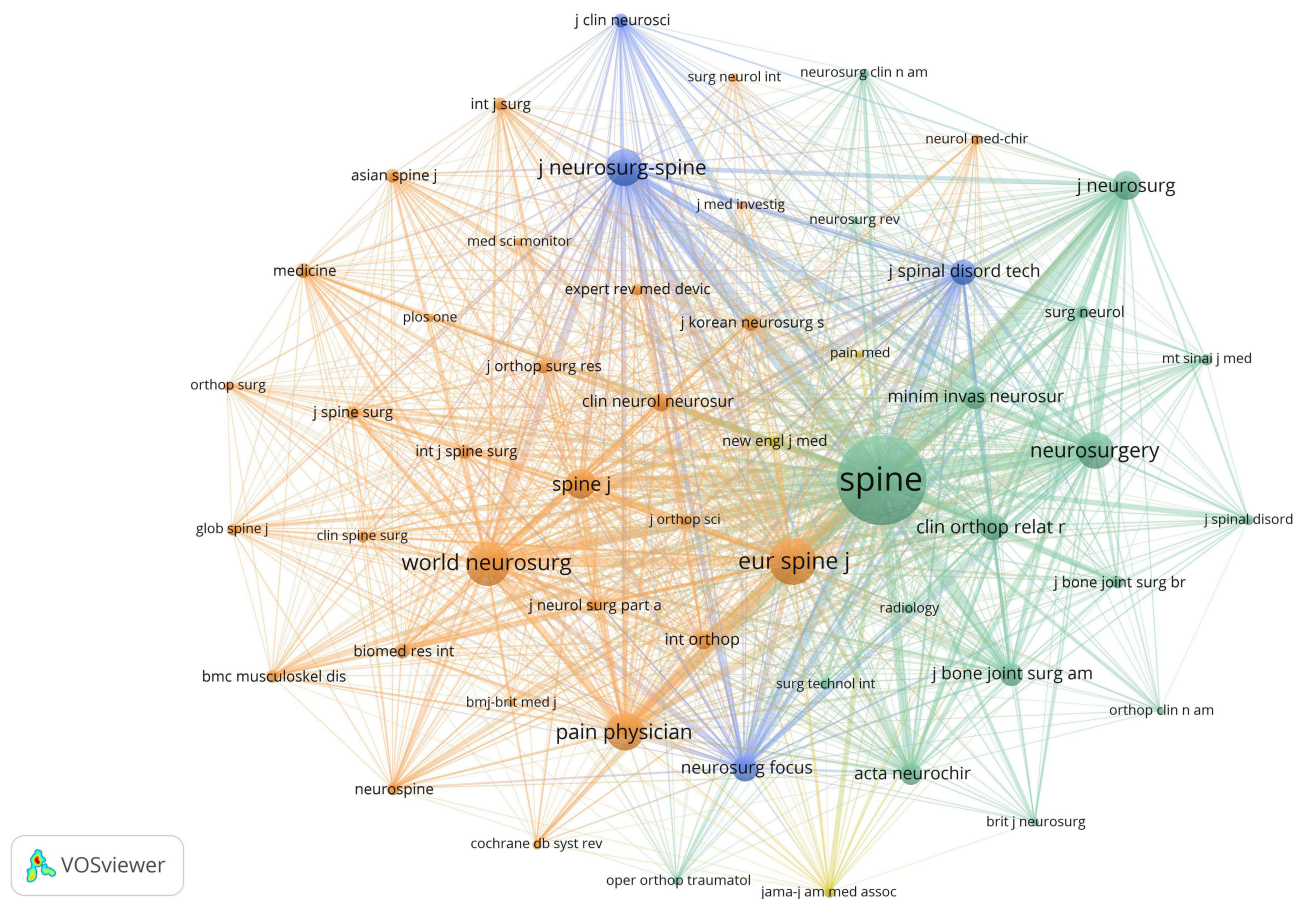
Figure 7 Journal co-citation network knowledge map.

Analysis of Highly Cited References

Highly cited literature not only indicates high-quality research outcomes but also reflects the knowledge foundation in a specific research field to some extent.[30] Figure 10 shows the co-citation relationships among the literature with a citation frequency of no less than 50, while Table 8 provides the list of the top 10 highly cited papers. Among them, the most highly cited paper is a study by Yeung et al,[31] published in *Spine* in 2002. The study investigated the outcome of posterior lateral ELD in 307 patients with LDH and found that 90.7% of the participants were satisfied with the surgical outcomes. This suggests that the clinical efficacy of posterior lateral ELD is comparable to

Table 6 Top 10 Cited Journals in Citation Frequency

Rank	Co-Cited Journal	Citations	TLS	H-index	IF (2022)	Quartile in Category
1	Spine (United States)	6210	144,405	254	3.0	Q2
2	Eur Spine J (United States)	2153	59,536	136	2.8	Q2
3	World Neurosurg (United States)	1867	49,581	95	2.0	Q3
4	Pain Physician (United States)	1511	36,674	99	3.7	Q2
5	Neurosurgery (United States)	1448	45,979	34	4.8	Q1
6	J Neurosurg-Spine (United States)	1399	42,479	100	2.8	Q2
7	Spine J (United States)	1041	29,164	108	4.5	Q1
8	J Neurosurg (United States)	943	31,593	210	4.1	Q1
9	Clin Orthop Relat R (United States)	820	22,948	204	4.2	Q1
10	J Spinal Disord Tech (United States)	770	23,985	85	N.A.	N.A.

Figure 8 Journal dual-map overlay.

Figure 9 Category co-occurrence network knowledge map.

traditional open transcanal microdiscectomy for treating LDH. In 2006, Ruetten et al[32] published a prospective study in *Minim Invas Neurosur*, investigating the technical feasibility of full-endoscopic interlaminar access. The 2-year follow-up of 331 patients with LDH revealed that 82% of the patients experienced the disappearance of leg pain symptoms, while 13% occasionally experienced pain. The decompression effect was found to be equivalent to conventional surgery. The recurrence rate was only 2.4%, and no severe surgical complications were observed. The following year, Ruetten et al[33] published another study in *J Neurosurg-Spine*, discussing the potential of using newly developed optical devices and instruments for full-endoscopic transforaminal and interlaminar discectomy of LDH.

Table 7 Top 10 Subject Categories in Frequency of Occurrence and Betweenness Centrality

Rank	Subject Categories	Frequency	Rank	Subject Categories	BC
1	Clinical Neurology	725	1	Radiology Nuclear Medicine Medical Imaging	0.76
2	Surgery	520	2	Surgery	0.71
3	Orthopedics	322	3	Mathematical Computational Biology	0.64
4	Medicine General Internal	112	4	Biology	0.63
5	Anesthesiology	90	5	Neuroimaging	0.61
6	Medicine Research Experimental	90	6	Cell Biology	0.55
7	Rheumatology	34	7	Biochemistry Molecular Biology	0.51
8	Biotechnology Applied Microbiology	32	8	Biotechnology Applied Microbiology	0.43
9	Neurosciences	27	9	Medicine Research Experimental	0.36
10	Neuroimaging	20	10	Anesthesiology	0.29

The results indicated the feasibility of this technique, highlighting its advantages as a truly minimally invasive surgery. One year later, in 2008, Ruetten et al[34] conducted another study published in *Spine*, evaluating the surgical outcomes of full-endoscopic interlaminar and transforaminal techniques compared to conventional microsurgical techniques. The 2-year follow-up of 178 patients with LDH who underwent full-endoscopic or microsurgical discectomy demonstrated similar clinical results for both treatment methods. However, full-endoscopic techniques presented advantages in terms of lower back pain, rehabilitation, complications, and trauma. In the same year, Choi et al[35] published a study in *Spine*, assessing the clinical efficacy of percutaneous endoscopic transforaminal lumbar
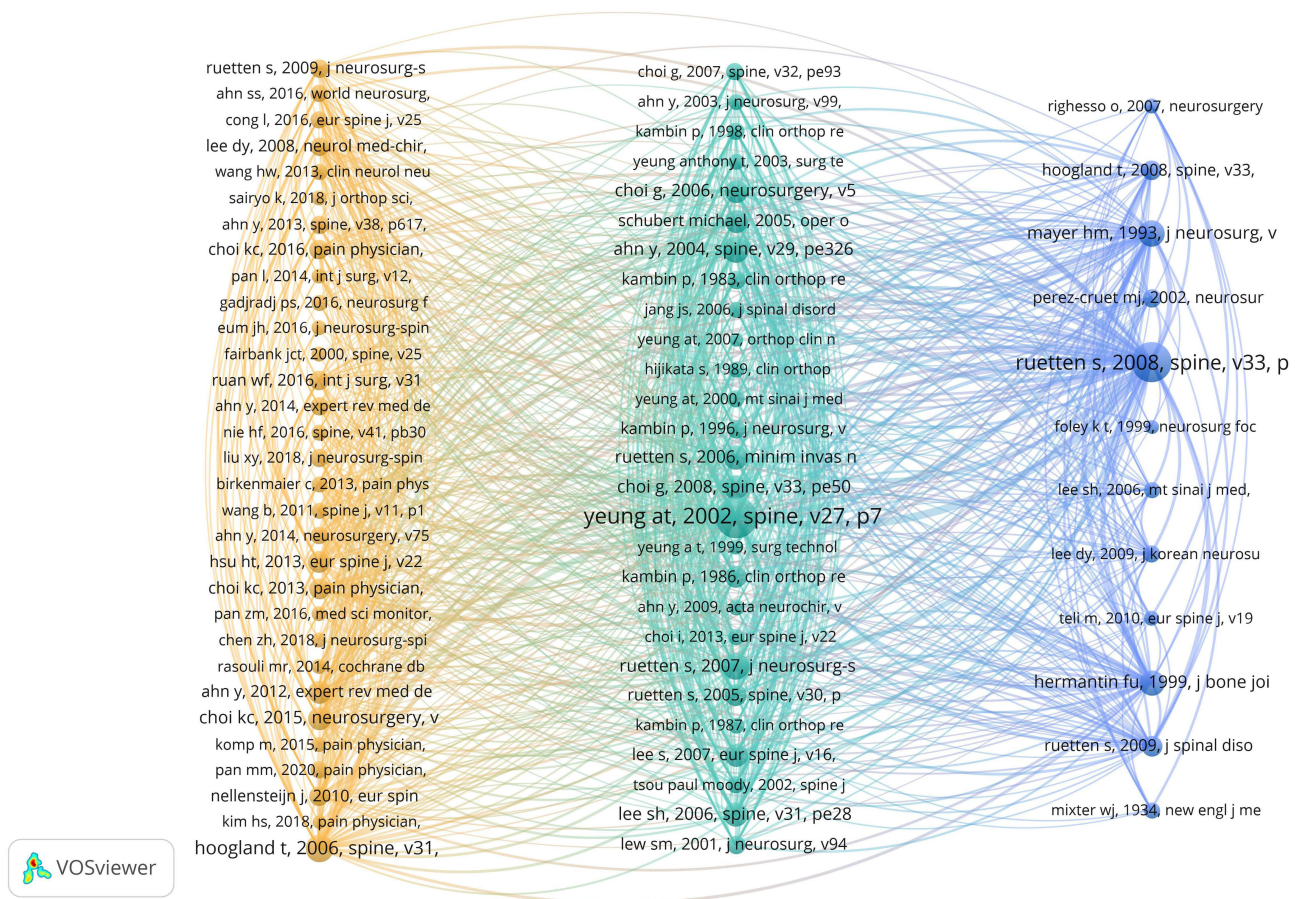
Figure 10 Reference co-citation network knowledge map.

Table 8 Top 10 Cited References

Rank	Co-Cited Reference	Author and Publication Year	Citations	TLS	Journal IF(2022)	H-index	Quartile in Category
1	Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complications in 307 consecutive cases.	Yeung AT, 2002	332	2558	Spine (IF: 3.0)	254	Q2
2	Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: a prospective, randomized, controlled study.	Ruetten S, 2008	314	2501	Spine (IF: 3.0)	254	Q2
3	Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280 consecutive cases.	Hoogland T, 2006	164	1389	Spine (IF: 3.0)	254	Q2
4	Use of newly developed instruments and endoscopes: full-endoscopic resection of lumbar disc herniations via the interlaminar and lateral transforaminal approach.	Ruetten S, 2007	153	1337	J Neurosurg-Spine (IF: 2.8)	100	Q2
5	Percutaneous endoscopic discectomy: surgical technique and preliminary results compared to microsurgical discectomy.	Mayer HM, 1993	145	1391	J Neurosurg (IF: 4.1)	210	Q1
6	Percutaneous endoscopic lumbar discectomy for recurrent disc herniation: surgical technique, outcome, and prognostic factors of 43 consecutive cases.	Ahn Y, 2004	145	1304	Spine (IF: 3.0)	254	Q2
7	A prospective, randomized study comparing the results of open discectomy with those of video-assisted arthroscopic microdiscectomy.	Hermantin FU, 1999	132	1258	J Bone Joint Surg Am (IF: 5.3)	260	Q1
8	A New full-endoscopic technique for the interlaminar operation of lumbar disc herniations using 6-mm endoscopes: prospective 2-year results of 331 patients.	Ruetten S, 2006	128	1076	Minim Invas Neurosur (IF: N.A.)	46	N.A.
9	Operative failure of percutaneous endoscopic lumbar discectomy: a radiologic analysis of 55 cases.	Lee SH, 2006	124	1073	Spine (IF: 3.0)	254	Q2
10	Percutaneous endoscopic approach for highly migrated intracanal disc herniations by foraminoplastic technique using rigid working channel endoscope.	Choi G, 2008	122	974	Spine (IF: 3.0)	254	Q2

discectomy combined with foraminoplasty for the treatment of 59 patients with soft highly migrated intracanal LDH. After an average follow-up period of 25.4 months, 91.4% of the patients achieved satisfactory results. As the third highest-cited paper, it was published by Hoogland et al[36] in *Spine* in 2006. This study compared the efficacy of standalone ELD versus ELD combined with intradiscal low-dose chymopapain injection for the treatment of LDH. The randomized controlled trial included 280 patients, and the results of the 2-year follow-up showed that 85.4% of patients in the standalone treatment group experienced satisfactory outcomes, while 7.7% were dissatisfied. In contrast, the combined treatment group had 93.3% of patients with satisfactory outcomes and only 4.2% dissatisfied. These differences in outcomes between the two groups were statistically significant, suggesting that ELD combined with intradiscal low-dose chymopapain injection has therapeutic advantages. In the same year, Lee et al[37] also published a highly-cited study in *Spine*, which analyzed the reasons for the failure of percutaneous ELD. The study found that herniations with high-canal compromise and high-grade migration had the highest failure rate, suggesting that open surgery should be considered for such cases, while percutaneous ELD could still be a suitable treatment option for other intracanal LDH. Furthermore, Mayer et al[38] published the fifth highest-cited paper in 1993 in *J Neurosurg*, comparing the clinical outcomes of percutaneous ELD and microdiscectomy for the treatment of LDH. The study included 20 patients for each treatment group, and a 2-year follow-up revealed that 80% of patients in the percutaneous ELD group experienced the disappearance of sciatica symptoms, 47% had relief from low back pain, and a remarkable 95% were able to return to their previous occupations. In comparison, the microdiscectomy group had 65% experiencing relief from sciatic pain, 25% from low back pain, and 72.2% returning to their previous occupations. Another highly-cited study by Ahn et al[39] in 2004, published in *Spine*, evaluated the effectiveness of percutaneous ELD for the treatment of recurrent LDH. The study included 43 patients who met the inclusion criteria, and with an average follow-up of 31 months, 81.4% of patients showed satisfactory results, indicating that this technique is an effective approach for treating recurrent LDH. The last highly cited literature was published by Hermantin et al[40] in 1999 in *J Bone Joint Surg Am*. The study randomized 60 patients with LDH into two groups: open laminotomy and discectomy, and video-assisted arthroscopic microdiscectomy. The results showed that both treatment approaches achieved comparable satisfactory outcomes. However, patients treated with arthroscopic microdiscectomy had shorter average durations of postoperative disability and use of anesthesia. Through the analysis of the aforementioned highly-cited papers, it is evident that ELD has become an effective treatment modality for LDH, with its efficacy further confirmed by multiple studies. These research findings provide a theoretical foundation for the optimization and clinical application of this technique, as well as clarify its indications, contraindications, and its effectiveness when used in combination with other treatment modalities. Overall, these studies have significantly contributed to the field and have established a knowledge base of high impact.
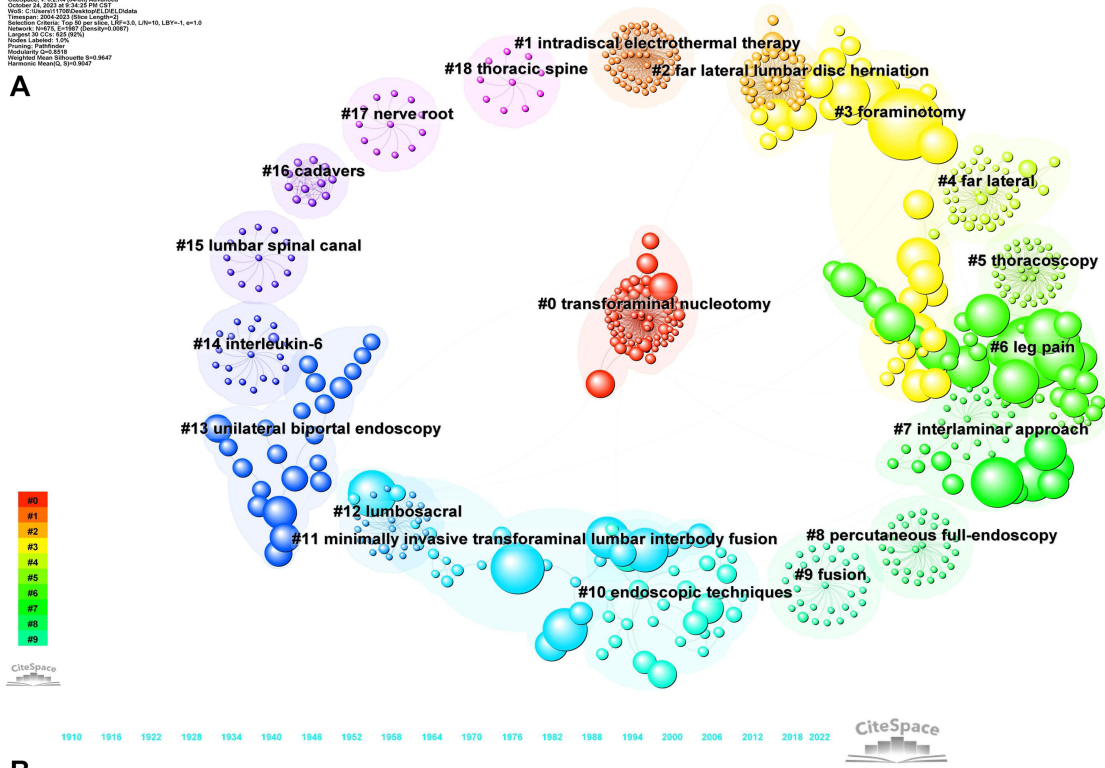
Figure 11A utilizes the log-likelihood ratio algorithm to form 19 literature clustering labels, which represent the main research topics in the field. The smaller the label number, the larger the cluster size. The modularity Q of this clustering is 0.8518, and the weighted mean silhouette S is 0.9647. Generally, Q > 0.3 indicates significant structural division, while S > 0.7 signifies efficient and convincing clustering.[41–43] To gain a more visual understanding of the evolving trends of each clustering label over time, this study also presents a map for display in Figure 11B. From the graph, it can be observed that #3 foraminotomy, #6 leg pain, #11 minimally invasive transforaminal lumbar interbody fusion, and #13 unilateral biportal endoscopy are recent hot research topics.

Analysis of References Burst

References burst refers to the phenomenon where certain papers are frequently cited within a specific period of time.[44,45] Through the analysis of burst literature, we can gain insights into the hot research topics during that period.[46,47] In this study, by setting the minimum burst duration to 3 years, we detected the top 30 references with high burst strength, as shown in Figure 12. The "Strength" in the graph represents the magnitude of literature burst, with higher values indicating stronger burst.[48] "Begin" and "End" respectively indicate the starting and ending time of the burst, while the blue lines represent the time intervals, and the red lines represent the duration of burst.[49,50] From the figure, it can be observed that 11 references have a burst duration extending until 2023 or beyond. These papers reflect, to some extent,
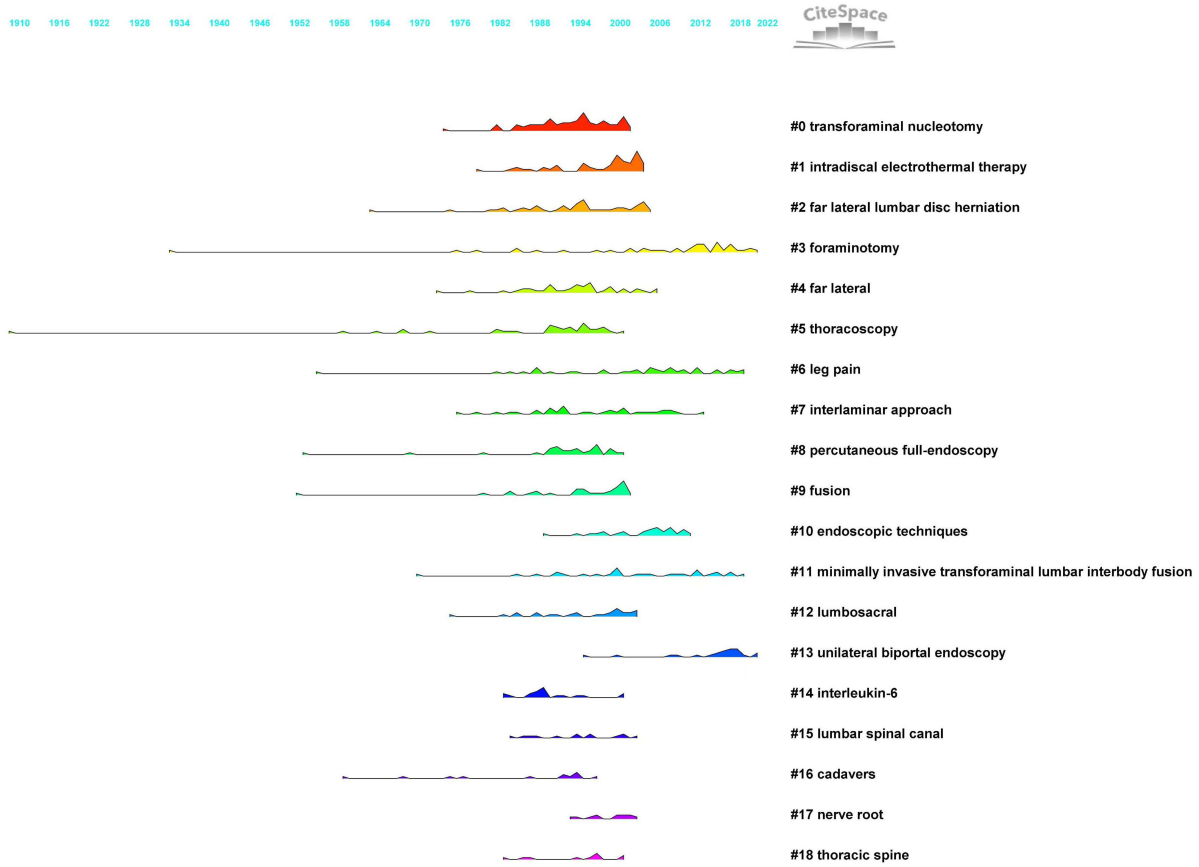
Figure 11 (**A**) Reference clustering map. (**B**) Reference landscape map.

Top 30 References with the Strongest Citation Bursts

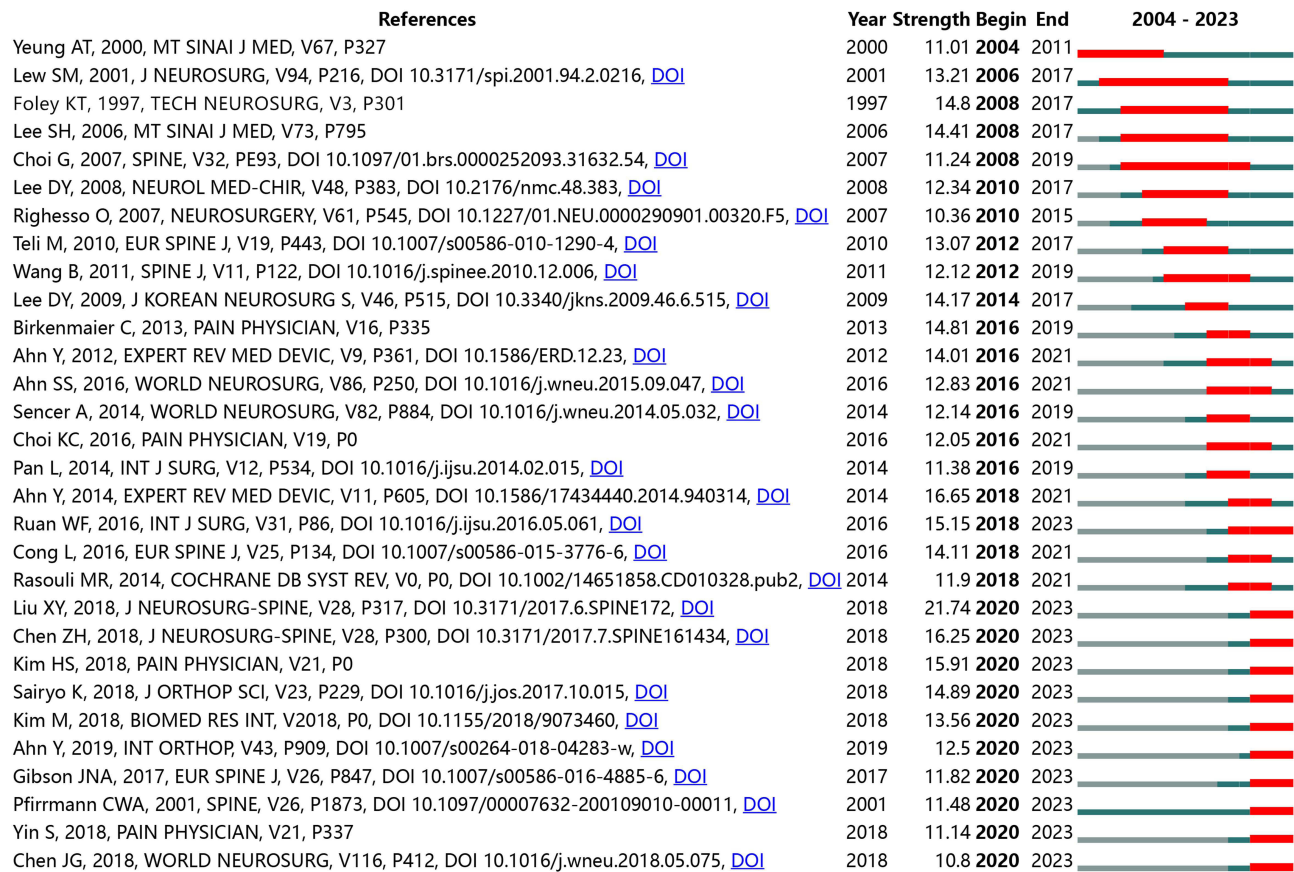| References	Year	Strength	Begin	End	2004 - 2023
Yeung AT, 2000, MT SINAI J MED, V67, P327	2000	11.01	**2004**	2011	
Lew SM, 2001, J NEUROSURG, V94, P216, DOI 10.3171/spi.2001.94.2.0216, DOI	2001	13.21	**2006**	2017	
Foley KT, 1997, TECH NEUROSURG, V3, P301	1997	14.8	**2008**	2017	
Lee SH, 2006, MT SINAI J MED, V73, P795	2006	14.41	**2008**	2017	
Choi G, 2007, SPINE, V32, PE93, DOI 10.1097/01.brs.0000252093.31632.54, DOI	2007	11.24	**2008**	2019	
Lee DY, 2008, NEUROL MED-CHIR, V48, P383, DOI 10.2176/nmc.48.383, DOI	2008	12.34	**2010**	2017	
Righesso O, 2007, NEUROSURGERY, V61, P545, DOI 10.1227/01.NEU.0000290901.00320.F5, DOI	2007	10.36	**2010**	2015	
Teli M, 2010, EUR SPINE J, V19, P443, DOI 10.1007/s00586-010-1290-4, DOI	2010	13.07	**2012**	2017	
Wang B, 2011, SPINE J, V11, P122, DOI 10.1016/j.spinee.2010.12.006, DOI	2011	12.12	**2012**	2019	
Lee DY, 2009, J KOREAN NEUROSURG S, V46, P515, DOI 10.3340/jkns.2009.46.6.515, DOI	2009	14.17	**2014**	2017	
Birkenmaier C, 2013, PAIN PHYSICIAN, V16, P335	2013	14.81	**2016**	2019	
Ahn Y, 2012, EXPERT REV MED DEVIC, V9, P361, DOI 10.1586/ERD.12.23, DOI	2012	14.01	**2016**	2021	
Ahn SS, 2016, WORLD NEUROSURG, V86, P250, DOI 10.1016/j.wneu.2015.09.047, DOI	2016	12.83	**2016**	2021	
Sencer A, 2014, WORLD NEUROSURG, V82, P884, DOI 10.1016/j.wneu.2014.05.032, DOI	2014	12.14	**2016**	2019	
Choi KC, 2016, PAIN PHYSICIAN, V19, P0	2016	12.05	**2016**	2021	
Pan L, 2014, INT J SURG, V12, P534, DOI 10.1016/j.ijsu.2014.02.015, DOI	2014	11.38	**2016**	2019	
Ahn Y, 2014, EXPERT REV MED DEVIC, V11, P605, DOI 10.1586/17434440.2014.940314, DOI	2014	16.65	**2018**	2021	
Ruan WF, 2016, INT J SURG, V31, P86, DOI 10.1016/j.ijsu.2016.05.061, DOI	2016	15.15	**2018**	2023	
Cong L, 2016, EUR SPINE J, V25, P134, DOI 10.1007/s00586-015-3776-6, DOI	2016	14.11	**2018**	2021	
Rasouli MR, 2014, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD010328.pub2, DOI	2014	11.9	**2018**	2021	
Liu XY, 2018, J NEUROSURG-SPINE, V28, P317, DOI 10.3171/2017.6.SPINE172, DOI	2018	21.74	**2020**	2023	
Chen ZH, 2018, J NEUROSURG-SPINE, V28, P300, DOI 10.3171/2017.7.SPINE161434, DOI	2018	16.25	**2020**	2023	
Kim HS, 2018, PAIN PHYSICIAN, V21, P0	2018	15.91	**2020**	2023	
Sairyo K, 2018, J ORTHOP SCI, V23, P229, DOI 10.1016/j.jos.2017.10.015, DOI	2018	14.89	**2020**	2023	
Kim M, 2018, BIOMED RES INT, V2018, P0, DOI 10.1155/2018/9073460, DOI	2018	13.56	**2020**	2023	
Ahn Y, 2019, INT ORTHOP, V43, P909, DOI 10.1007/s00264-018-04283-w, DOI	2019	12.5	**2020**	2023	
Gibson JNA, 2017, EUR SPINE J, V26, P847, DOI 10.1007/s00586-016-4885-6, DOI	2017	11.82	**2020**	2023	
Pfirrmann CWA, 2001, SPINE, V26, P1873, DOI 10.1097/00007632-200109010-00011, DOI	2001	11.48	**2020**	2023	
Yin S, 2018, PAIN PHYSICIAN, V21, P337	2018	11.14	**2020**	2023	
Chen JG, 2018, WORLD NEUROSURG, V116, P412, DOI 10.1016/j.wneu.2018.05.075, DOI	2018	10.8	**2020**	2023	

Figure 12 References burst map.

the recent research hotspots and future development trends. Therefore, further analysis will be focused on these selected literature pieces. Among these 11 papers, the one with the highest burst strength is a study by Liu et al[51] published in *J Neurosurg-Spine* in 2018. This study analyzed the comparative efficacy of percutaneous endoscopic transforaminal discectomy (PETD), microendoscopic discectomy (MED), and microdiscectomy for the treatment of symptomatic LDH. Through analysis of multiple outcome measures, it was found that all three techniques were effective in treating symptomatic LDH. However, under restricted indications and with a minimum follow-up of 2 years, PETD achieved faster recovery and better clinical outcomes. In the same year, Chen et al[52] also published a study in *J Neurosurg-Spine*, comparing the efficacy of PETD and MED in the treatment of LDH. After grouping 153 patients for treatment and following up for 1 year, it was found that PETD did not demonstrate superior clinical outcomes compared to MED, and PETD showed less satisfactory results for median disc herniation, whereas MED was not suitable for far lateral disc herniation. Another highly emergent paper, ranked third in burst strength, was published by Kim et al[53] in *Pain Physician* in 2018. This study evaluated the clinical efficacy of percutaneous ELD for different types of LDH. The results demonstrated a success rate of over 96% with percutaneous ELD, making it an effective alternative to microscopic lumbar discectomy. The subsequent highly emergent paper, published by Ruan et al[54] in *Int J Surg* in 2016, employed a systematic review and meta-analysis to evaluate the efficacy of percutaneous ELD and open lumbar microdiscectomy for LDH. Although percutaneous ELD had shorter operative and hospitalization times, the two treatment modalities were comparable in terms of functional outcomes, complications, and reoperation rates. Further, in 2018, Sairyo et al[55] published the fifth-ranked emergent paper in *J Orthop Sci*, which reviewed of the development of percutaneous ELD and

highlighted the application prospects of transforaminal percutaneous endoscopic surgery in lumbar spinal stenosis. In the same year, Kim et al[56] published a study in *Biomed Res Int*, evaluating the clinical efficacy of percutaneous ELD and open lumbar microdiscectomy for LDH in the Korean population. The results showed that percutaneous ELD had advantages in visual analog pain scale, Oswestry Disability Index, operative time, and hospitalization duration, while there were no statistical differences in complications, recurrence rate, and reoperation rate compared to open lumbar microdiscectomy. In the following year, Ahn Y[57] published the seventh highest burst strength paper on *Int Orthop*, which reviewed the indications, surgical techniques, and clinical outcomes of current spinal endoscopic surgery. The study predicted that with the development of technology, the indications of endoscopic surgery would expand, and clinical outcomes would become more practical and reliable. In 2017, Gibson et al[58] published the eighth highest burst strength paper in *Eur Spine J*, which compared and analyzed the clinical efficacy of transforaminal endoscopic discectomy and microdiscectomy. The results showed that transforaminal endoscopic discectomy had advantages in terms of post-operative hospitalization time and postoperative 2-year incidence of leg pain on the affected side. The ninth highest burst strength paper was published by Pfirrmann et al[59] in *Spine* in 2001, which developed a classification system for LDH based on magnetic resonance imaging and evaluated its reliability. In 2018, a systematic review and meta-analysis study conducted by Yin et al[60] and published in *Pain Physician* evaluated the incidence of recurrent herniation after percutaneous ELD. The results showed that the postoperative recurrence rate of percutaneous ELD was 3.6%, usually occurring within 6 months after surgery, and that advanced age, obesity, upper lumbar disc, and central disc herniation might be independent risk factors. Also in 2018, Chen et al[61] published the last high burst strength paper in *World Neurosurg*, comparing the efficacy of PETD and percutaneous endoscopic interlaminar discectomy (PEID) in treating L5-S1 LDH. The study found no statistically significant differences between the two procedures in estimated blood loss, postoperative bed rest time, hospitalization time, visual analog pain scale, Oswestry Disability Index, and complications, but PEID had advantages in terms of fluoroscopy times and operation time. Through the analysis of the above high burst strength references, it can be concluded that research in this area mainly focuses on the clinical efficacy, indications,
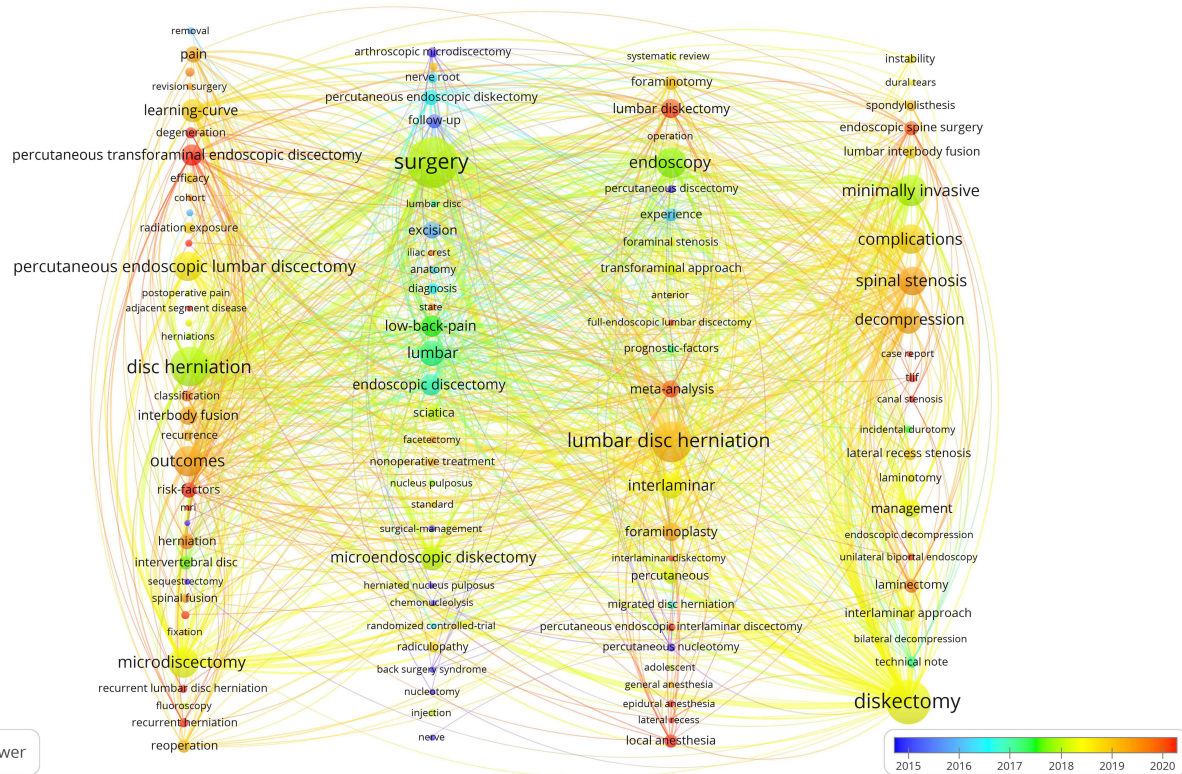

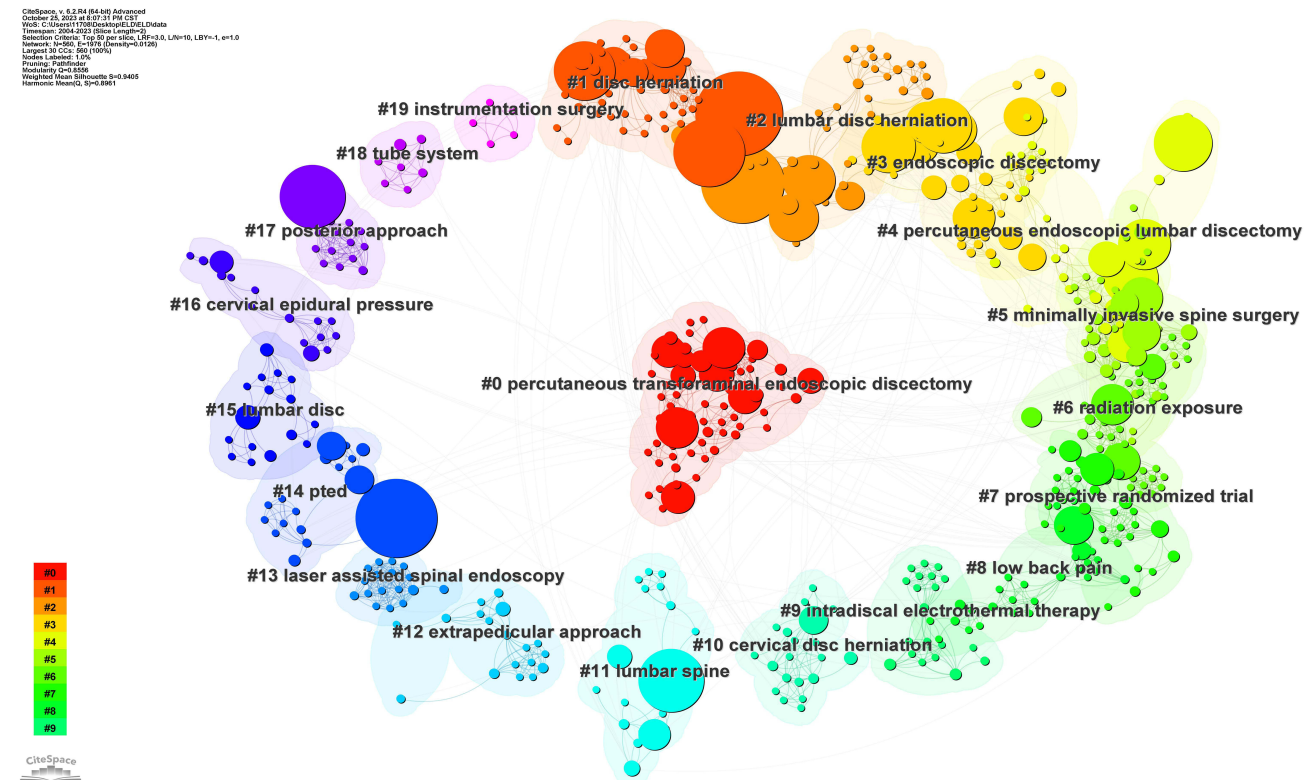**Figure 13** Keywords co-occurrence time overlay map.

Table 9 Top 20 Keywords in Frequency of Occurrence

Rank	Keyword	Frequency	TLS	Rank	Keyword	Frequency	TLS
1	Surgery	589	3256	11	Spinal stenosis	182	1075
2	Discectomy	450	2336	12	Decompression	161	1002
3	Lumbar disc herniation	370	1818	13	Interlaminar	149	894
4	Disc herniation	351	1979	14	Lumbar	149	780
5	Minimally invasive	229	1331	15	Microendoscopic diskectomy	135	826
6	Microdiscectomy	216	1282	16	Learning curve	125	798
7	Outcomes	213	1242	17	Endoscopic discectomy	107	556
8	Endoscopy	212	1189	18	Low back pain	107	530
9	Complications	194	1206	19	Percutaneous transforaminal endoscopic discectomy	105	494
10	Percutaneous endoscopic lumbar discectomy	192	834	20	Lumbar diskectomy	83	357

complications, and recurrence rate of ELD in treating LDH. Continuous optimization and improvement of ELD can expand its scope of application and improve its therapeutic efficacy.

Analysis of Keywords

Keywords are highly condensed summaries of research topics in a paper.[62] By analyzing high-frequency keywords, one can gain insights into the main research content and hot research topics in a specific field.[63,64] Figure 13 illustrates the co-occurrence relationships among keywords that appear at least 10 times, while Table 9 lists the top 20 high-frequency keywords. These high-frequency keywords provide a general overview of the main research content in the field. Additionally, from the figure, it can be observed that keywords such as PETD, degeneration, risk factors, recurrent herniation, lumbar discectomy, meta-analysis, local anesthesia, endoscopic spine surgery, and laminectomy are represented by nodes that are predominantly red in color. Since nodes that are closer to red indicate a later average appearance time, these keywords reflect recent hot research topics. Figure 14 presents 20 keyword cluster labels formed using the

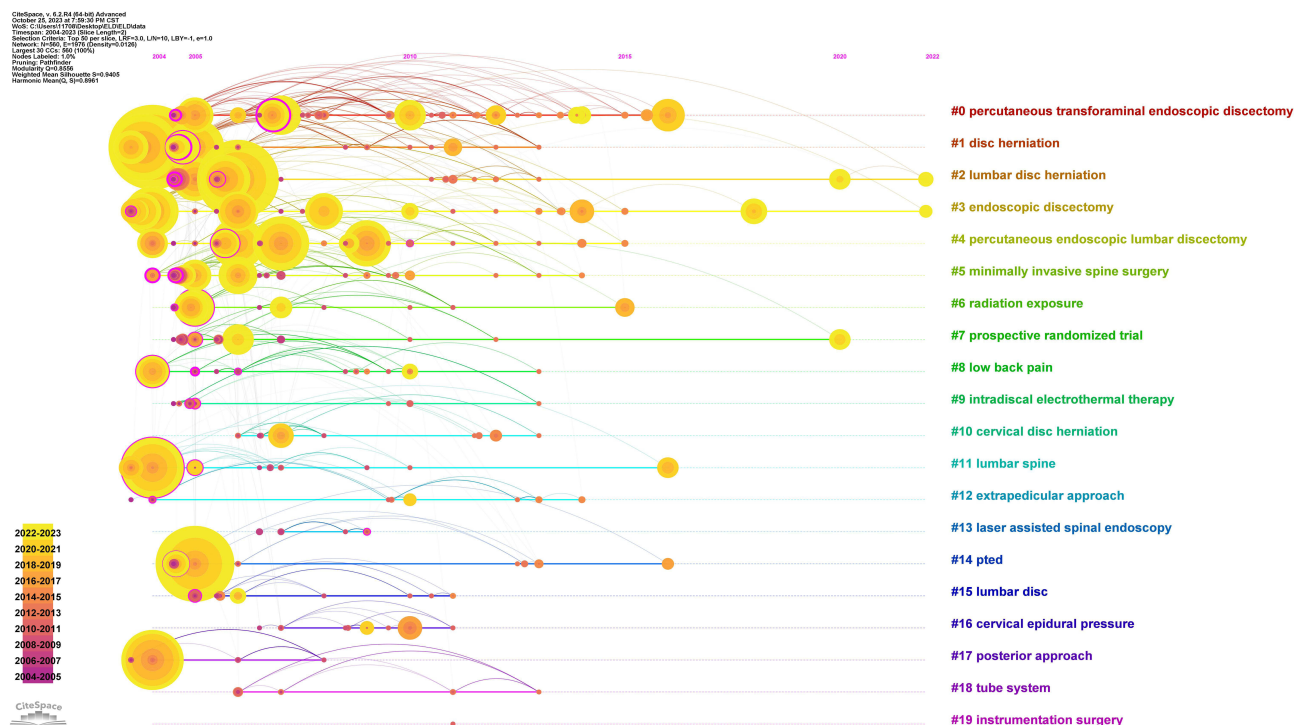**Figure 14** Keywords clustering map.

CiteSpace, v. 6.2.R4 (64-bit) Advanced
October 25, 2023 at 7:59:30 PM CST
WoS: C:\Users\17708\Desktop\ELD\ELD\data
Timespan: 2004-2023 (Slice Length=2)
Selection Criteria: Top 50 per slice, LRF=3.0, L/N=10, LBY=-1, e=1.0
Network: N=560, E=1976 (Density=0.0126)
Largest 30 CCs: 560 (100%)
Nodes Labeled: 1.0%
Pruning: Pathfinder
Modularity Q=0.8556
Weighted Mean Silhouette S=0.9405
Harmonic Mean(Q, S)=0.8961

#0 percutaneous transforaminal endoscopic discectomy
#1 disc herniation
#2 lumbar disc herniation
#3 endoscopic discectomy
#4 percutaneous endoscopic lumbar discectomy
#5 minimally invasive spine surgery
#6 radiation exposure
#7 prospective randomized trial
#8 low back pain
#9 intradiscal electrothermal therapy
#10 cervical disc herniation
#11 lumbar spine
#12 extrapedicular approach
#13 laser assisted spinal endoscopy
#14 pted
#15 lumbar disc
#16 cervical epidural pressure
#17 posterior approach
#18 tube system
#19 instrumentation surgery

2022-2023
2020-2021
2018-2019
2016-2017
2014-2015
2012-2013
2010-2011
2008-2009
2006-2007
2004-2005

Figure 15 Keywords timeline map.

log-likelihood ratio algorithm. These labels represent the main research content in the field, and the modularity Q is calculated as 0.8556, while the weighted mean silhouette S is 0.9405. These values indicate that the formed cluster structure is significant, efficient, and persuasive. In order to visualize the temporal evolution of these clusters, they are reorganized using a timeline in Figure 15. The timeline graphically illustrates the development trends of each cluster label over time. From the figure, it can be observed that the research topics represented by Cluster #2 LDH, Cluster #3 endoscopic discectomy, and Cluster #7 prospective randomized trial have been ongoing until the present. By setting the duration of keyword burst to 2 years, 30 keywords with high burst intensity were detected, as shown in Figure 16. From the figure, it can be observed that keywords such as risk factors, LDH, PETD, lumbar spinal stenosis, degeneration, laminectomy, local anesthesia, and foraminoplasty have consistently burst until 2023 or beyond. This indicates that they are hot research topics in recent years and may also reflect future research trends to some extent.

Strengths and Limitations

This study employed the research methods of bibliometrics to comprehensively summarize and analyze relevant literature in the ELD field, and presented the research results in the form of a visual knowledge map. Compared with traditional literature reviews or meta-analyses, the literature included in this study was more comprehensive, and the data processing and analysis were more detailed, free from the influence of subjective selection and judgment, thus presenting more objective and realistic research results.[65] However, even so, this study still has certain limitations. Firstly, the literature data included in this study only came from the SCI-Expanded database in the WoSCC database, which is commonly used in bibliometric research,[66–68] and the types and languages of literature were restricted, which may result in the omission of some literature that meets the inclusion criteria. But such operations can include more high-quality research while ensuring a sufficient amount of research data to ensure the quality of this study. Secondly, some high-quality research results published recently may be underestimated in their academic impact due to their low citations. Nevertheless, the results analyzed in this study still provide important reference value and guidance for scholars in this field.
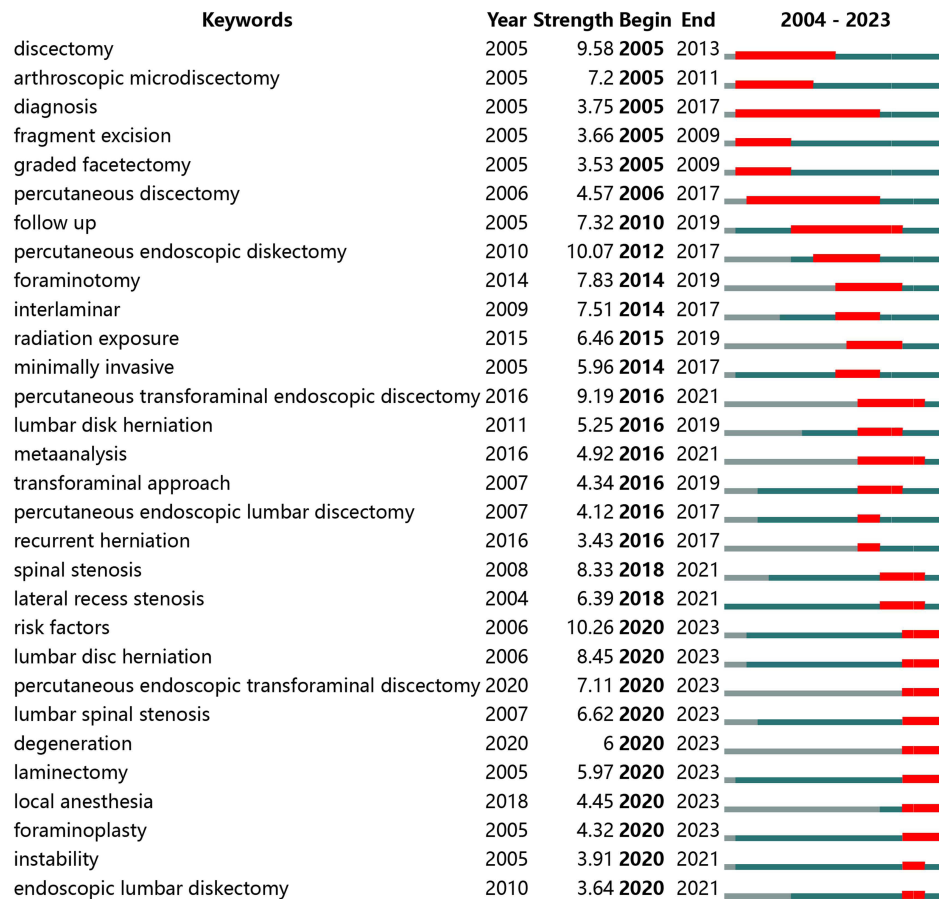
Top 30 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2004 - 2023
discectomy	2005	9.58	2005	2013	
arthroscopic microdiscectomy	2005	7.2	2005	2011	
diagnosis	2005	3.75	2005	2017	
fragment excision	2005	3.66	2005	2009	
graded facetectomy	2005	3.53	2005	2009	
percutaneous discectomy	2006	4.57	2006	2017	
follow up	2005	7.32	2010	2019	
percutaneous endoscopic diskectomy	2010	10.07	2012	2017	
foraminotomy	2014	7.83	2014	2019	
interlaminar	2009	7.51	2014	2017	
radiation exposure	2015	6.46	2015	2019	
minimally invasive	2005	5.96	2014	2017	
percutaneous transforaminal endoscopic discectomy	2016	9.19	2016	2021	
lumbar disk herniation	2011	5.25	2016	2019	
metaanalysis	2016	4.92	2016	2021	
transforaminal approach	2007	4.34	2016	2019	
percutaneous endoscopic lumbar discectomy	2007	4.12	2016	2017	
recurrent herniation	2016	3.43	2016	2017	
spinal stenosis	2008	8.33	2018	2021	
lateral recess stenosis	2004	6.39	2018	2021	
risk factors	2006	10.26	2020	2023	
lumbar disc herniation	2006	8.45	2020	2023	
percutaneous endoscopic transforaminal discectomy	2020	7.11	2020	2023	
lumbar spinal stenosis	2007	6.62	2020	2023	
degeneration	2020	6	2020	2023	
laminectomy	2005	5.97	2020	2023	
local anesthesia	2018	4.45	2020	2023	
foraminoplasty	2005	4.32	2020	2023	
instability	2005	3.91	2020	2021	
endoscopic lumbar diskectomy	2010	3.64	2020	2021	

Figure 16 Keywords burst map.

Conclusion

In the past 20 years, research related to ELD has undergone rapid development, especially since 2016, when a large number of academic achievements in this field began to emerge and gain extensive dissemination and citation. China has become the most productive country in this field, while South Korea and the United States have greater academic influence. Tongji University in China has contributed the most research achievements, while academic achievements from Wooridul Spine Hospital in South Korea are more popular among scholars. Lee SH from South Korea and Ruetten S from Germany are respectively the most productive author and the most highly cited author. *World Neurosurg* has produced the most publications, while *Spine* has become the most influential journal. Clinical Neurology and Surgery are the main subject categories. Research in this field mainly focuses on improving ELD technology, evaluating post-operative efficacy and predicting prognosis, studying complications and risk factors, and comparing ELD with other surgical techniques. Keywords such as risk factors, LDH, PETD, lumbar spinal stenosis, degeneration, recurrent herniation, laminectomy, local anesthesia, and foraminoplasty reflect the current research hotspots and future cutting-edge trends in this field.

Data Sharing Statement

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

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Disclosure

The authors declare that there are no conflicts of interest in this work.

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