

Knowledge Graph of Endoscopic Techniques Applied to the Treatment of Lumbar Disc Herniation

A Bibliometric Analysis

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Study Design: Bibliometric analysis.

Objective: This study explored the current research status, hot-spots, and trends in the application of endoscopic techniques for treating lumbar disc herniation (LDH).

Background: Endoscopic techniques are widely used to treat LDH, but there are no bibliometric studies on endoscopic technology and LDH.

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Methods: The Web of Science Core Collection database was used as the data source. Based on the principles of bibliometrics, we apply VOSviewer and CiteSpace software to conduct the data statistics and visual analysis.

Results: A total of 965 studies were included, with 11893 citations (12.32 per study). The top 3 countries with the largest number of papers published are China (529), South Korea (164), and the United States (108). Yong Ahn and Jin-Sung Kim are prolific authors in this field. Representative academic journals are *World Neuroscience*, *Pain Physician*, and *BioMed Research International*. The results of keyword cooccurrence analysis indicate that the research topics in this field in the past decade have mainly focused on microdiscectomy, complications, percutaneous endoscopic lumbar discectomy, decompression, and the learning curve. Keyword burst analysis suggested that endoscopic drug injection and the identification of risk factors for LDH are the frontiers and trends for future research.

Conclusion: The application of endoscopic techniques for LDH has received widespread attention from researchers, and research in this field has focused on percutaneous endoscopic lumbar discectomy, endoscopic decompression, complications, and the learning curve of endoscopic techniques. Future research trends will focus on the efficacy of endoscopic drug injection therapy for LDH and the identification of risk factors for LDH treatment failure.

Key Words: knowledge graph, endoscopic techniques, lumbar disc herniation, bibliometric

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Lumbar disc herniation (LDH) is a series of symptoms caused by degeneration of the lumbar intervertebral disc, rupture of the fibrous ring, and protrusion of the nucleus pulposus tissue, which can stimulate or compress the nerve root, leading to lower back and leg pain and limb numbness.^{1,2} Nerve root pain caused by LDH accounts for 36.6% of cases of low back pain,³ and its pain symptoms can reduce patients' activity and quality of life. In addition, the expenditure for nonsurgical treatment of LDH accounts for 26.3% of the total treatment cost.⁴

LDH has become one of the main causes of disability in both developed and developing countries.^{5,6} In recent years, the incidence rate of LDH has increased, which has drawn increasing attention to the treatment of LDH.

With the development of minimally invasive techniques, endoscopic techniques have been applied for the treatment of LDH, providing orthopedic doctors and patients with new options. Percutaneous endoscopic lumbar discectomy (PELD) is currently an important method for the treatment of LDH^{7,8} and mainly includes micro-endoscopic discectomy (MED) and percutaneous transforaminal endoscopic discectomy (PTED). PELD does not require extensive dissection of the paravertebral muscles⁹ and is a mature technology for the minimally invasive treatment of various types of LDH. Compared with traditional open surgery, endoscopic technology can significantly reduce surgical trauma, reduce bleeding, and accelerate the postoperative rehabilitation of patients.¹⁰ However, endoscopic technology can limit the free operation of surgical instruments due to the stenosis of tubular channels, which increases the difficulty of surgery.¹¹ In addition, recurrent lumbar disc herniation (RLDH) after PELD also increases physical injuries and economic burdens to patients and has a negative impact on doctors' treatment decisions. Therefore, an objective analysis of the current situation of endoscopic technology applied to the treatment of LDH can help doctors comprehensively grasp the advantages and disadvantages of endoscopic technology and make correct medical decisions.

Currently, there are no bibliometric studies on endoscopic technology or LDH, which is not conducive to summarizing the research status and development trend of this topic (TS). This study will visually analyze the development status, research hotspots, and cutting-edge knowledge of the application of endoscopic technology in LDH research in the past 10 years from a bibliometric perspective based on literature information from the Web of Science Core Collection (WOSCC) database, with a view to providing directions for in-depth research and clinical application in this field.

METHODS

Data Collection

The data source for this study is the WOSCC database. The WOSCC database is a citation-based database that includes literature abstracts and citation information, which will facilitate our citation analysis. In addition, the WOSCC database is also considered a reliable source of bibliometric analysis. The inclusion criteria were as follows: (1) The publication or inclusion time of the literature ranged from January 1, 2012 to December 31, 2022. (2) The document type was only an article or review. (3) The language was limited to English. The format of each data download record was full record and reference. The retrieval strategy was TS (lumbar disc herniation OR lumbar disk herniation OR LDH OR lumbar disc protrusion OR lumbar herniated disk OR lumbar intervertebral disc herniation OR lumbar intervertebral disc prolapse OR prolapse of lumbar intervertebral disc) AND TS (endoscopic OR endoscopy OR arthroscopy OR endoscop*). We obtained a total of 1176 relevant documents published between 2012 and 2022. After removing duplicates and documents that did not meet the inclusion criteria, 965 documents were ultimately obtained. The process and specific details of document retrieval are shown in Figure 1.

Data Statistics and Visual Analysis

CiteSpace (version 6.1. R6) software and VOSviewer (version 1.6.12) were used for data statistics and visual analysis. To evaluate the current status and trends of endoscopic technology in the treatment of LDH, we conducted collaborative network analysis, cooccurrence analysis, and burst analysis. According to the purpose of this study, node types can be selected from countries, authors, institutions, keywords, or journals.

Interpretation of the Atlas

The size of the node represents the amount of literature, country, institution, and frequency of keyword occurrences, whereas the thickness of the connection

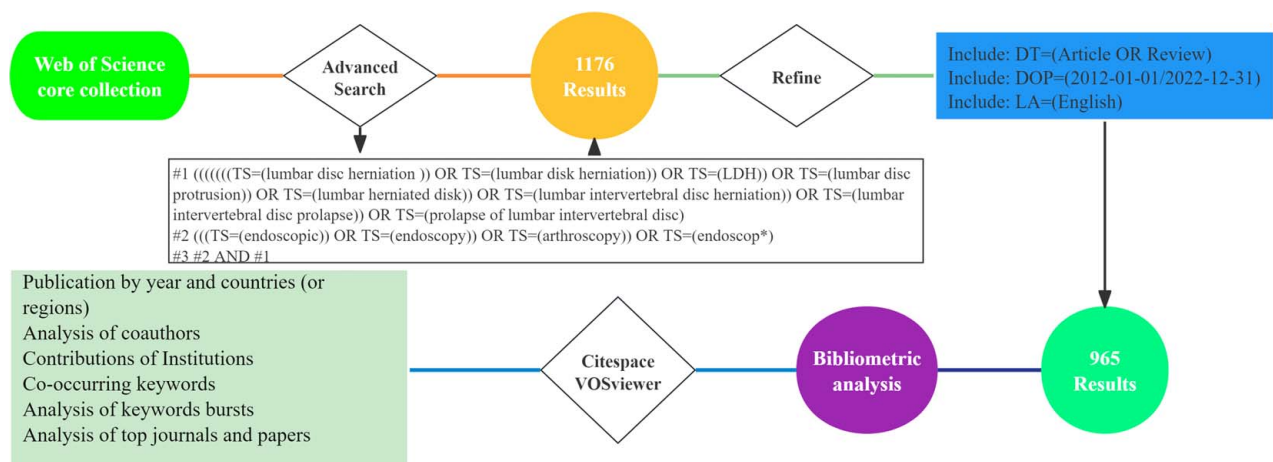


FIGURE 1. Flowchart of the literature screening and analysis methods. DT indicates document type; DOP, publication date; LA, language; LDH, lumbar disc herniation; TS, topic.

between nodes represents the strength of the association. In addition, we used CiteSpace software to calculate the burst indices of keywords. The burst index reflects the sudden increase in node frequency in the graph.

RESULTS

Publication Outputs and Citation Trends by Year

During the period from 2012 to 2022, the output and citations of papers on endoscopic technology and LDH increased annually (Fig. 2A), indicating that more scholars will participate in research on this TS in the future. The 965 studies included in this meta-analysis were cited 11893 times, with an average of 12.32 times per article. In 2022, the total number of citations reached 2977, indicating that the application of endoscopic techniques in the treatment of LDH has received increasing attention from researchers.

Publication Contributions of Countries/Regions

A total of 51 countries or regions worldwide have contributed to research on the subject of endoscopic technology and LDH (Fig. 2B). China is the country with the highest publication volume in this field (529 articles), followed by South Korea (164 articles) and the United States (108 articles), and it can be inferred that these three countries have high research interest in this field. The top 10 countries/regions with the greatest number of publications are shown in Figure 2C.

Bibliometric Analysis of Coauthors and Institutions

We constructed an author cooperation network map (Fig. 3A) based on author information with a published volume of more than 5 articles. Yong Ahn and Jin-Sung Kim are the most prolific authors in this field, and their research was cited 919 and 652 times, respectively. Their research focused on the efficacy and safety of endoscopic laser ablation and endoscopic discectomy for the treatment of LDH. Their research has made great efforts to promote the progress of endoscopic techniques in the treatment of LDH. Table 1 shows the details of the top ten authors with published articles. We also conducted a collaborative network analysis of institutions conducting research on this topic (Fig. 3B). The academic institution with the largest volume of publications was Tongji University (42 articles), followed by Capital Medical University (27 articles). The top 10 institutions with the most documents are shown in Table 2.

Analysis of Top Journals

We have included journals that publish content related to endoscopic technology and LDH, which will help researchers select appropriate journals to obtain cutting-edge information in this field. The top 10 journals on this TS published 447 articles (Table 3), accounting for 46.32% of the total number of articles published. The total number of citations for these 10 journals reached 4768, indicating that these 10 top journals basically represent the current

research situation on this TS. The 2 journals with the largest number of publications are *World Neuroscience* and *Pain Physician*, and their total citations are 1550 and 1632, respectively (Table 3). We calculated statistics on the average number of citations for the top 10 journals with published papers. The results showed that the three journals with the highest average number of citations were *Pain Physician*, *Biomed Research International*, and *World Neuroscience*, with average numbers of citations of 22.36, 12.63, and 10.99, respectively.

Highly Cited Papers

In the past 10 years, the 10 most highly cited papers^{12–21} on the application of endoscopic technology to LDH have been mainly clinical research papers (Table 4). The most frequently cited literature (280 times) is mainly the clinical treatment and diagnostic guidelines for LDH with radiculopathy,¹² indicating that the formulation of the guidelines has played a key guiding role in the standardized treatment of LDH. Second, the research topics of the most highly cited papers have focused on the efficacy and safety of endoscopic discectomy for the treatment of LDH or lumbar spinal stenosis,^{13,15–19,21} with PELD receiving the most attention. In addition, we found that the learning curve of PELD has also received widespread attention from researchers,¹⁴ indicating that endoscopic surgery is a learning process that requires the time and energy of surgeons. The impact of radiation exposure on surgeons during PELD is also a TS of concern in academia.²⁰ Based on a comprehensive analysis of highly cited papers, we found that the efficacy and safety of PELD for the treatment of LDH, the learning curve, and the impact of radiation during PELD surgery on surgeons are among the topics of concern to the academic community.

Bibliometric Analysis of Cooccurring Keywords

Keyword cooccurrence analysis can be used to quickly understand the development status of the field and the interaction between keywords, which helps to quickly read the research content in the field of the discipline. A visual map of keyword cooccurrence is shown in Figure 4. The results of the top 30 keyword frequency rankings are shown in Table 5. Excluding the 2 keywords of endoscopic technology and LDH that this study focused on, we found that the high-frequency keywords in this field were “microdiscectomy,” “complications,” “percutaneous endoscopic lumbar discectomy,” “decompression,” and “learning curve.” These high-frequency keywords collectively reflect the current research content in this field, mainly focusing on minimally invasive lumbar discectomy, complications, PELD, decompression, and the learning curve of endoscopic technology.

Keyword Bursts

Burst words are keywords that have increased in intensity and frequency of use during a certain period. The analysis of burst words reflects forward-looking issues in the research field by detecting trends in the frequency of

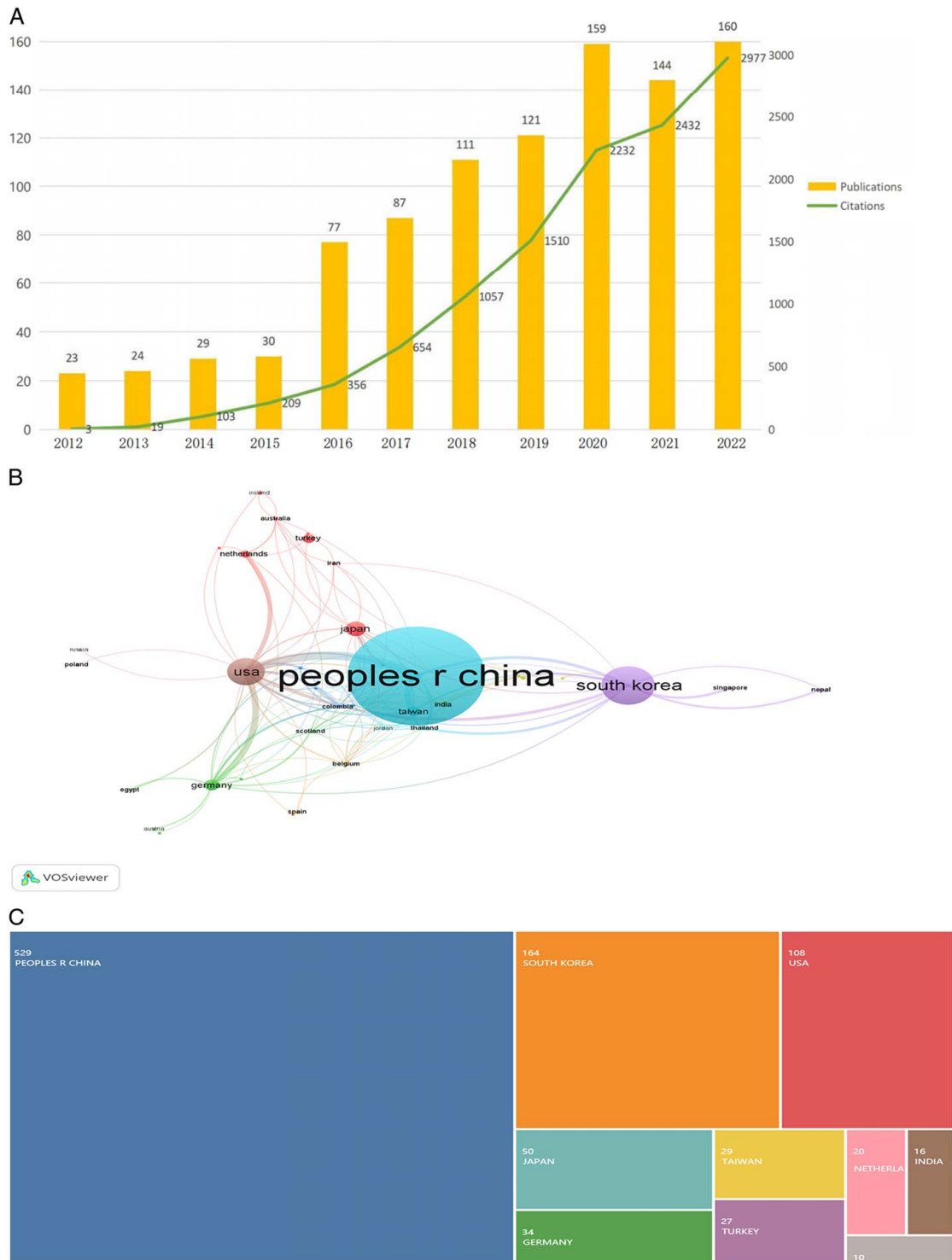


FIGURE 2. A, Global trend of annual publications and citations related to endoscopic techniques and LDH research from 2012 to 2022. B, Country collaboration network. C, The 10 most productive countries/regions with publications. LDH indicates lumbar disc herniation.

words in cited documents and cited contributions, which can be used to determine research hotspots and dynamic evolution trends in the field. The strength is the intensity of keyword mutation, and the higher the intensity is, the

greater the impact. The keyword highlighting results of endoscopic techniques and LDH are shown in Figure 5. In the past decade, the 2 keywords with the highest emergence intensity were interlaminar (strength: 6.62)

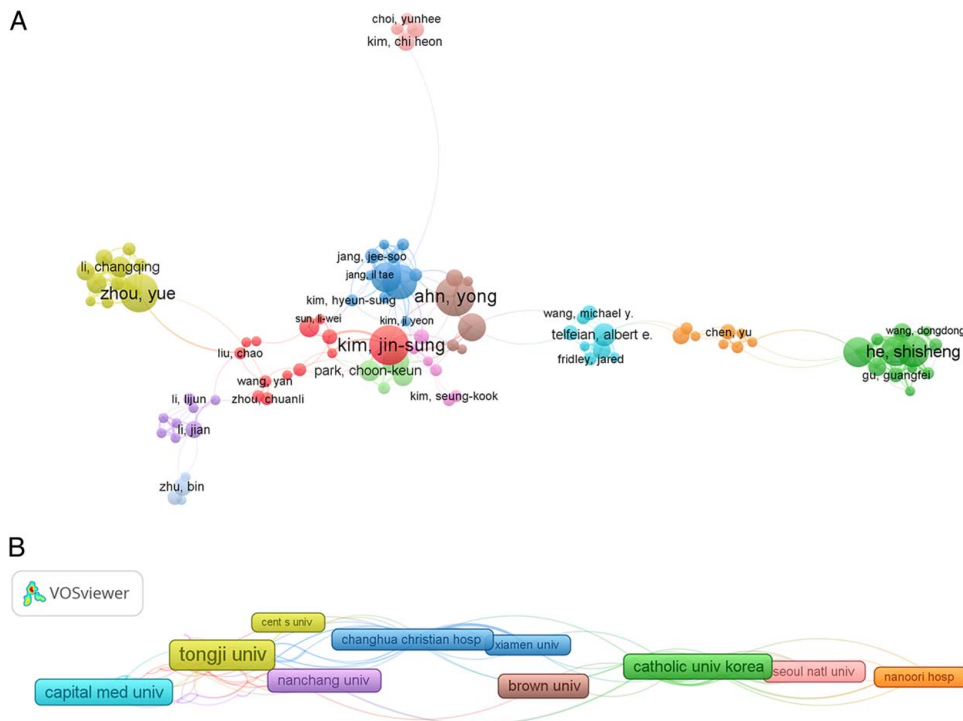


FIGURE 3. A, Network visualization of authors involved in studies on endoscopic techniques and LDH. B, Visualization of institutions participating in research on endoscopic techniques and LDH. LDH indicates lumbar disc herniation.

and percuticular endoscopic discectomy (strength: 5.45). The keywords that emerged from 2020 to the present are injection, generation, instability, spinal endoscopy, and risk factor, indicating that the future research focus may be the efficacy of PELD combined with endoscopic drug injection in the treatment of LDH, and the study of risk factors for the failure of endoscopic treatment of LDH is also crucial.

DISCUSSION

General Information

Between 2012 and 2022, a total of 965 studies involving the application of endoscopic techniques to LDH were published worldwide. Our research results show

rapid growth in both the output of papers and the number of citations, indicating that the TS of the application of endoscopic techniques in LDH has received considerable attention from researchers. Although many countries have published papers in this field, China has an absolute advantage in publishing volume, followed by South Korea, which indicates that there are significant differences in research output between countries. Yong Ahn (Gachon University Gil Medical Center) and Jin-Sung Kim (The Catholic University of Korea) are the most prolific authors in this field. Their research focused mainly on the efficacy and safety of endoscopic laser ablation or discectomy for the treatment of LDH.^{22–25} Their research results may, to a certain extent, represent the foundation and direction of research in this field. The 2 academic

TABLE 1. The Ranking of the Top 10 Authors With Highest Publications

Rank	Name	Country	Institution	TP	Citations
1	Yong Ahn	Korea	Gachon University Gil Medical Center	26	919
2	Jin-Sung Kim	Korea	The Catholic University of Korea	26	652
3	Yue Zhou	China	Third Military Medical University	25	599
4	Hyeun Sung Kim	Korea	Nanoori Hospital Gangnam	22	387
5	Shisheng He	China	Tongji University	20	259
6	Guoxin Fan	China	Sun Yat-sen University	18	242
7	Xin Gu	China	Second Military Medical University	18	218
8	Il-tae Jang	Korea	Nanoori Hospital Gangnam	18	259
9	Sang-ho Lee	Korea	Wooridul Hospital	17	649
10	Kyung-Chul Choi	Korea	Leon Wiltse Memorial Hospital	16	585

TP indicates total number of publications.

TABLE 2. The Ranking of the Top 10 Institutions With Highest Publications

Rank	Institution	Country	TP	Citations
1	Tongji University	China	42	532
2	Capital Medical University	China	27	106
3	Catholic University of Korea	Korea	25	540
4	Leon Wiltse Memorial Hospital	Korea	25	663
5	Gachon University	Korea	22	315
6	Southern Medical University	China	22	123
7	Wooridul Spine Hospital	Korea	22	971
8	Third Military Medical University	China	19	523
9	Brown University	USA	18	270
10	Nanchang University	China	16	131

TP indicates total number of publications.

institutions with the largest volume of publications, Tongji University and Capital Medical University, are located in China. From the analysis of the results of authors, institutions, or national cooperation networks, we find that the degree of cooperation between countries, institutions, and authors is still weak. Therefore, exchanges and cooperation between countries, authors, and institutions should be strengthened to meet the new challenges in this field. In addition, we found that the number of publications or citations by *World Neuroscience*, *Pain Physician*, *BioMed Research International*, and *Journal of Orthopedic Surgery and Research* were high, indicating that the results published in these journals have high academic value.

Research Status of Endoscopic Techniques and Lumbar Disc Herniation

The results of keyword cooccurrence analysis comprehensively summarize the current research status of endoscopic techniques and LDH. This study revealed that research on the application of endoscopic techniques for LDH mainly focused on PELD, the learning curve of endoscopic techniques, endoscopic decompression, and complications. PELD is considered the primary choice for the treatment of LDH,²⁶ with the advantages of less

TABLE 3. The Ranking of the Top 10 Journals with Highest Publications

Rank	Journal	Citations	TP	Average citations
1	World Neurosurgery	1550	141	10.99
2	Pain Physician	1632	73	22.36
3	Medicine	304	46	6.61
4	The Journal of Neurological Surgery Part A: Central European Neurosurgery	214	32	6.69
5	Orthopedic Surgery	105	28	3.75
6	Neurospine	260	27	9.63
7	Biomed Research International	341	27	12.63
8	Journal of Orthopedic Surgery and Research	257	25	10.28
9	BMC Musculoskeletal Disorders	84	25	3.36
10	Frontiers in Surgery	21	23	0.91

TP indicates total number of publications.

TABLE 4. Top 10 Cited Papers in the Field of Endoscopic Techniques Applied in LDH

Rank	Count	Title	Year	Journal	First Author
1	280	An evidence-based clinical guideline for the diagnosis and treatment of lumbar disc herniation with radiculopathy	2014	Spine Journal	D Scott Kreiner ¹²
2	129	Bilateral spinal decompression of lumbar central stenosis with the full-endoscopic interlaminar versus microsurgical laminotomy technique: a prospective, randomized, controlled study	2015	Pain Physician	Martin Komp ¹³
3	129	Learning curve of full-endoscopic lumbar discectomy	2013	European Spine Journal	Hsien-Ta Hsu ¹⁴
4	123	Unsuccessful percutaneous endoscopic lumbar discectomy: A single-center experience of 10 228 cases	2015	Neurosurgery	Kyung-Chul Choi ¹⁵
5	122	Incidence of low back pain after lumbar discectomy for herniated disc and its effect on patient-reported outcomes	2015	Clinical Orthopedics and Related Research	Scott L Parker ¹⁶
6	122	Transforaminal percutaneous endoscopic lumbar discectomy: Technical tips to prevent complications	2014	Expert Review of Medical Devices	Yong Ahn ¹⁷
7	116	Percutaneous endoscopic lumbar discectomy for L5-S1 disc herniation: Transforaminal versus interlaminar approach	2013	Pain Physician	Kyung-Chul Choi ¹⁸
8	113	Percutaneous endoscopic decompression for lumbar spinal stenosis	2014	Expert Review of Medical Devices	Yong Ahn ¹⁹
9	113	Radiation exposure to the surgeon during percutaneous endoscopic lumbar discectomy: A prospective study	2013	Spine	Yong Ahn ²⁰
10	112	Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: A meta-analysis	2016	International of Surgery Journal	Wenteng Ruan ²¹

LDH indicates lumbar disc herniation.

Top 20 Keywords with the Strongest Citation Bursts

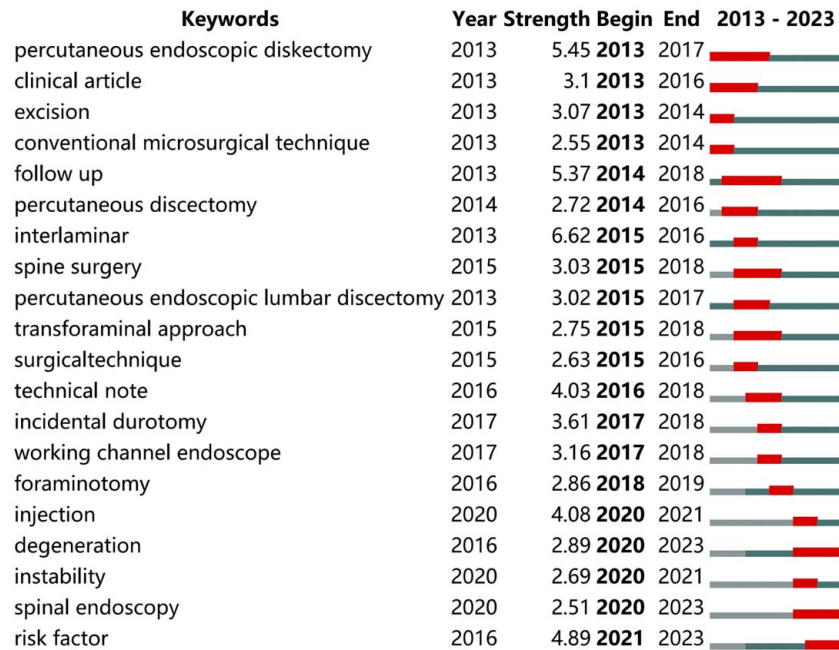


FIGURE 5. Top 20 keywords with the strongest citation bursts (sorted by the beginning year of the burst).

severe nerve compression symptoms. In addition, RLDH after PELD is also a possible complication of endoscopic treatment for LDH³³ and is also a TS of concern for surgeons. Although training and surgical teaching are believed to slow the learning curve of PETD, the learning curve of PETD is still relatively steep.³⁴ One study showed that³⁵ assisted PELD for LDH under x-ray fluoroscopy is safe and effective and can improve the learning curve, reduce the surgical difficulty, and reduce radiation exposure. Improving the technique of endoscopic LHD treatment can help surgeons overcome the learning curve, which can help reduce surgical complications.³⁶

Hotspots and Frontiers

Research on endoscopic technology and LDH may focus on the efficacy of endoscopic drug injection therapy for LDH and the identification of risk factors for LDH treatment failure. PELD can fully remove the dislocated nucleus pulposus or lumbar intervertebral disc, avoid residual tissue in the spinal canal, and fully relieve the physical compression of the nerve root, but the inflammatory reaction around the nerve is not immediately eliminated. Therefore, drug injection after PELD can inhibit the inflammatory reaction of nerve roots and promote postoperative functional recovery.^{37,38} Commonly used endoscopic drug injections can include steroids and ozone.³⁹⁻⁴¹ In addition, PELD combined with epidural drug injection has many advantages in the treatment of LDH, such as direct access to the inflammatory site, safety and efficiency, and a long duration of drug action. Plate-

let-rich plasma (PRP) contains a variety of growth factors⁴² that can promote wound healing. The intervertebral disc is composed of an outer fibrous ring and an inner nucleus pulposus, and in adults, it lacks blood supply,⁴³ with only a small number of blood vessels on the surface of the fibrous ring. In this special anatomic context, the self-repairing ability of intervertebral discs is poor. Therefore, endoscopic injection of PRP may promote the repair of the lumbar fibrous ring.^{44,45} However, the efficacy and safety of PELD combined with PRP injection for the treatment of LDH still need to be further verified. RLDH is one of the most concerning postoperative complications of PELD for surgeons, and it is also an important factor affecting surgical outcomes. Research shows that the incidence rate of RLDH is 0%–11%.⁴⁶⁻⁴⁸ Therefore, early identification of modifiable risk factors leading to RLDH is important, and RLDH should be a research hotspot in the future. Research has shown that⁴⁹⁻⁵³ age, male sex, body mass index, physical labor, smoking status, diabetes status, disc height index, and facet orientation may be factors related to RLDH after PELD. In future research, it will be of great clinical value to further clarify the risk factors for RLDH and propose targeted preventive suggestions.

Limitations

This study is the first bibliometric and visualization study on endoscopic technology and LDH, which will provide a foundation for researchers to understand the current research situation and research trends in this field.

However, the content of this study also has the following limitations: (1) This study included only English-language literature, and it may have ignored some important research findings published in other languages. (2) We analyzed only the relationship between endoscopic technology and LDH from a macro perspective, without supplementing the conclusions of this study with expert consultation, empirical research, or other methods. (3) The results of this bibliometric analysis are based on information in the literature, and their theoretical results may differ from those of actual research. (4) The possibility of manual errors cannot be ruled out during document data cleaning.

CONCLUSION

This study used a bibliometric approach to conduct quantitative analysis and visual research on the application of endoscopic techniques to LDH over the past 10 years, demonstrating the current research status and hotspots in this academic field. Over the past 10 years, the main research content in this field has focused on PELD, complications, endoscopic decompression, and the learning curve of endoscopic technology. Future research trends or hotspots in this field may focus on the efficacy of PELD combined with endoscopic drug injection in the treatment of LDH and the risk factors for failure in the endoscopic treatment of LDH.

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