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Exploring trends and key topics in anterior lumbar interbody fusion surgery

A medical text analysis approach

Cheng Li[a], Xin Du[b], Kun Chen[c], Guoyang Zhang[d,*]

Abstract

Background: Anterior lumbar interbody fusion (ALIF) is a widely adopted technique for managing lumbar degenerative disorders. However, comprehensive analyses of its research trends, technological developments, and public engagement are still lacking.

Objective: This study examines the research landscape, public perception, and innovation trends in ALIF, while also evaluating data extraction methods for managing ALIF-related information.

Methods: ALIF-related data from Web of Science, YouTube, and Lens were analyzed. Bibliometric analysis explored international collaborations, key authors, and leading journals. Artificial intelligence models were used to extract information on surgical techniques, diseases, and evaluation metrics. Sentiment analysis categorized YouTube comments as positive, negative, or neutral, while patent data were assessed based on jurisdiction, application type, and legal status.

Results: A total of 660 publications, 1311 YouTube comments, and 53 patents were identified. Scientific output increased, peaking in 2021, with the United States (USA) leading in collaborations and author contributions. Neurosurgeons accounted for most ALIF-related publications. World Neurosurgery published the highest number of ALIF articles among top journals from 2017 to 2023. Patents were largely focused on ALIF implants, with half still active. YouTube comments peaked in 2022, with sentiment analysis showing 41.6% positive responses, 36.2% neutral, and 22.2% negative responses.

Conclusions: ALIF research has grown significantly in academic output, technological innovation, and public engagement. The USA, China, and South Korea are major contributors, maintaining strong collaborations. Neurosurgeons possess extensive experience in ALIF surgical techniques, and the interest in ALIF-related articles in *WORLD NEUROSURGERY* has been progressively increasing. Artificial intelligence models demonstrated effectiveness in extracting surgical data, though challenges remain with disease-related information. The rise of ALIF-related YouTube content and sentiment analysis findings highlight growing public interest, with generally positive perceptions.

Abbreviations: AI = artificial intelligence; ALIF = anterior lumbar interbody fusion.

Keywords: anterior lumbar interbody fusion, data analysis, data mining, medical informatics, surgical techniques

1. Introduction

With the continuous advancement in spinal surgery instruments and techniques, spinal approaches have become more refined and sophisticated. Among the various fusion methods, anterior lumbar interbody fusion (ALIF) stands out due to its distinct advantages. ALIF allows direct access to the intervertebral disc space through an anterior approach, avoiding disruption of the posterior

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spinal muscles and ligaments.[1] This technique also offers the possibility of using larger interbody implants, facilitating better load distribution and height restoration.[2] Furthermore, ALIF has demonstrated superior effectiveness in restoring lumbar lordosis, which is crucial for maintaining spinal alignment and reducing adjacent segment degeneration.[3,4] These advantages make ALIF a preferred option in many clinical settings. However, despite the increasing utilization of ALIF in clinical practice,[5] there remains a lack of comprehensive research specifically dedicated to evaluating ALIF. Traditionally, bibliometric analysis has been used to assess research directions and trends within a specific field.[6,7] While this method provides valuable insights into the current state and future trends of research areas, it has limitations in offering a comprehensive understanding of patient perspectives and market dynamics.[8,9] Multidimensional assessments would provide a more accurate and clinically relevant understanding of the role and future potential of ALIF in spinal surgery. In addition, there is a growing trend of using artificial intelligence (AI) technology for text extraction and analysis, compared to traditional manual data extraction methods.[10,11] However, AI demonstrated potential in improving the efficiency and scalability of text analysis. Its superiority over manual extraction with respect to accuracy and relevance in the context of ALIF research has yet to be thoroughly assessed.

To address this gap, the present research aims to provide a holistic understanding of ALIF's current status in the literature, its perceived clinical relevance from public discussions, and its innovation status. A multidimensional analysis of ALIF-related information by collecting and synthesizing data from the Web of Science, YouTube, and Lens database. Furthermore, this study will investigate the applicability of AI models for automated data extraction and systematic content analysis in ALIF literature, aiming to assess their potential in providing a more effective and precise method for handling large-scale and complex datasets.

2. Materials and methods

2.1. Study design and search strategy

Data were systematically retrieved using the keywords "Anterior Lumbar Interbody Fusion" and "ALIF" from the Web of Science, YouTube, and Lens database. The search encompassed the period from January 1, 2000, to August 26, 2024. Two authors independently collected and screened all identified publications, YouTube comments, and relevant patent information. In case of discrepancies, the third author decided on inclusion or exclusion.

2.2. Data analysis

Data related to ALIF were retrieved from the Web of Science database in both text and Excel formats. Bibliometric analysis was performed using *bibliometrix* to examine international collaborations, author contributions, leading journals, and key clinical insights.[12] To assess the capability of AI in extracting and interpreting ALIF-related information, 2 pretrained models (*en_core_web_sm*, *en_core_sci_lg*) were used to extract details from titles and abstracts, including surgical techniques, associated diseases, research type (human or animal models), and key evaluation metrics.

To enhance extraction accuracy, a predefined list of abbreviations was incorporated, enabling the models to better recognize relevant terms. The extracted information was then compared to manually annotated data across the specified categories. Contextual embeddings were used to quantify the similarity between AI-generated and manually curated extractions, with each extracted element transformed into a word embedding using the pretrained models. Cosine similarity between the corresponding vectors was then computed to evaluate alignment between automated and manual extractions.

$$\text{Cosine Similarity} = \frac{A \cdot B}{\|A\| \, \|B\|}$$

Where:

- A and B are the vector representations of doc_1 and doc_2.
- $A \cdot B$ is the dot product of the vectors.
- $\|A\|$ and $\|B\|$ are the magnitudes (norms) of the vectors.

A web crawler (easyscraper) was used to obtain data from YouTube and Lens. Sentiment analysis was conducted on YouTube comments, which were collected from the top 50 most-viewed videos with comments related to ALIF. Comments were classified as positive, negative, or neutral after a thorough reading. WPS Office was used to perform statistical analysis on the filtered patent data (jurisdiction, year, type of application, and legal status) from the Lens database.

3. Results

3.1. General information

Following a systematic screening process, 660 publications related to ALIF were identified in the Web of Science database. A total of 1311 relevant comments discussing ALIF were retrieved from YouTube videos. The search of the Lens patent database identified 53 patents associated with ALIF technology (Fig. 1). From 2000 to 2024, the trends in literature publications, patents, and YouTube videos reveal distinct patterns of growth (Fig. 2).

3.2. Scientific publications

The number of academic publications demonstrated variability while maintaining an overall upward trend, starting at 17 in 2000 and peaking at 48 in 2021. Despite these fluctuations, the long-term trend reflects a sustained rise in academic output over the 25 years, particularly after 2020, where the publication count consistently remained above 30 per year.

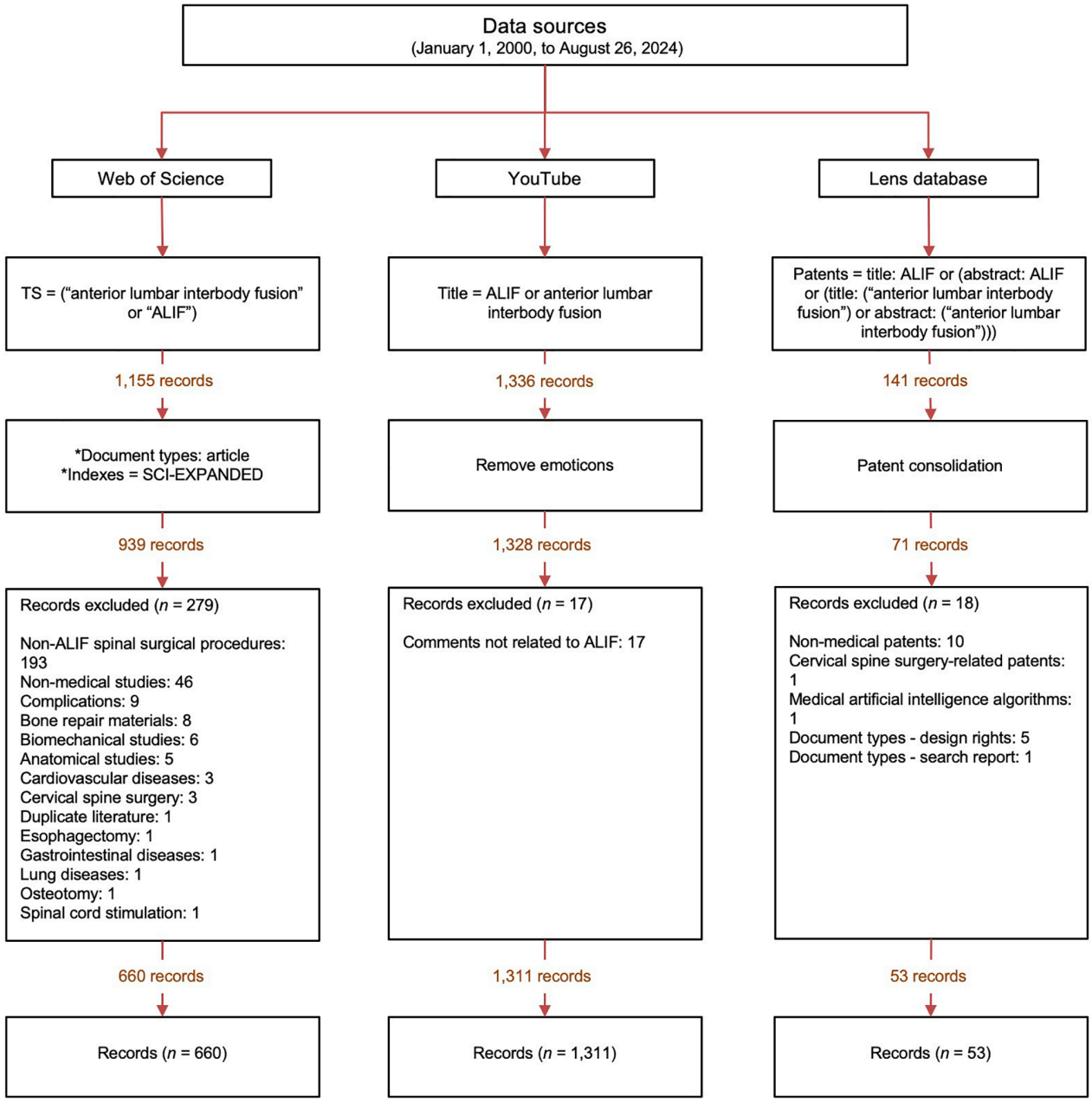

Figure 1. Screening flowchart.

3.3. International collaborations

Of the 47 countries/regions analyzed, data from England, Scotland, and Northern Ireland were merged under the United Kingdom, and data from Chinese Taiwan were incorporated into China. A total of 44 countries have contributed to ALIF research. Regarding international collaboration, 40 countries engaged in collaborative research efforts. Table 1 presents the top 10 international research collaborations based on co-publication frequency. The most frequent collaborations occurred between the United States (USA) and China (20), followed by the USA and Korea (10), and the USA and Canada (9). The USA demonstrated the highest number of international collaborations, engaging in partnerships with 30 countries worldwide. Switzerland ranked second with 13 collaborations, while China and Germany ranked third, each with 12 collaborations.

3.4. Author contributions

Based on the number of publications, the 5 most prolific contributors to ALIF-related research have been identified as Lee SH, Mobbs RJ, Phan K, Singh K, and Mummaneni PV (Table 2). Lee SH from Wooridul Spine Hospital in South Korea leads in productivity, with 30 publications, an H-index of 16, and 859 citations, demonstrating his significant impact in the field. Regarding the professional distribution of authors, 4 are neurosurgeons (Lee SH, Mobbs RJ, Phan K, Mummaneni PV), while 1 author specializes in orthopedic surgery (Singh K). This

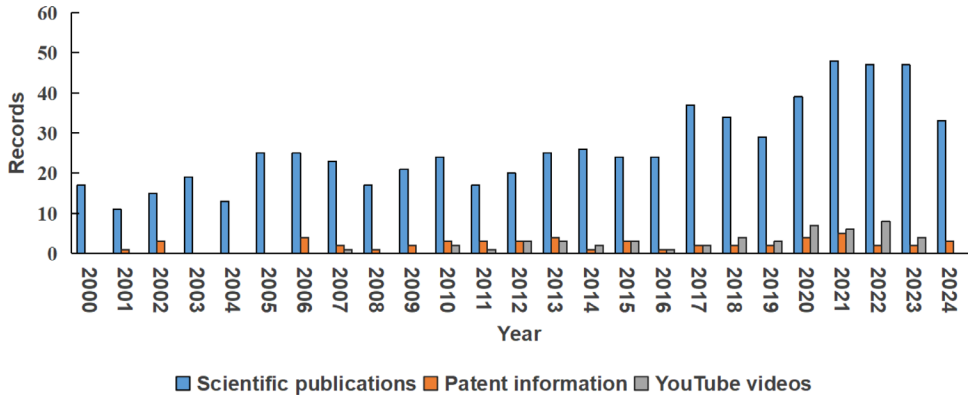

Figure 2. Annual trends in ALIF publications, YouTube comments, and patents. ALIF = anterior lumbar interbody fusion.

distribution highlights the importance of neurosurgical expertise in advancing knowledge in this field.

3.5. Top-tier journals

Of the 118 journals publishing research on ALIF, the top 5 by number of publications are *SPINE* (102 articles), *EUROPEAN SPINE JOURNAL* (70 articles), *JOURNAL OF NEUROSURGERY: SPINE* (62 articles), *WORLD NEUROSURGERY* (59 articles), and *SPINE JOURNAL* (38 articles); (Fig. 3).

SPINE ranks first with the highest number of ALIF-related publications, peaking in 2005 (12 articles). This journal has demonstrated consistent output, publishing ALIF-related research annually, which underscores its pivotal role in disseminating knowledge on spine surgery. Notably, *WORLD NEUROSURGERY* exhibited significant growth in publications between 2017 and 2023, consistently surpassing the other 4 journals during this period, reflecting its increasing influence in recent years.

Table 1

Top 10 most frequent international research collaborations between countries.

From	To	Frequency
USA	China	20
USA	Korea	10
USA	Canada	9
USA	Australia	8
China	Denmark	7
USA	Germany	6
France	Switzerland	5
Germany	Switzerland	5
USA	Brazil	4
USA	Switzerland	4

3.6. Key clinical information

As shown in Figure 4, 2 models demonstrate high similarity with manually extracted information. For surgical information, the mean similarity scores for the domain-specific (en_core_sci_lg) and general-purpose models (en_core_web_sm) are 0.838 and 0.858, respectively, while the median scores are 0.964 and 0.895, respectively. However, both models exhibit the lowest similarity in extracting disease information, with the domain-specific model achieving a mean of 0.665 and a median of 0.859, and the general-purpose model achieving a mean of 0.673 and a median of 0.872.

The notable gap between the mean and median values highlights the polarization in the performance of information extraction for disease-related content. This disparity is primarily due to the models' tendency to extract detailed disease-related descriptions, while manual annotations often provide concise summaries. This mismatch contributes to lower similarity scores in certain cases.

Table 3 presents 4 main categories, including surgical information, disease information, research type, and evaluation metrics. In surgical information, ALIF was the most frequently documented procedure. ALIF was most commonly paired with transforaminal lumbar interbody fusion, followed by pedicle screw fixation and total disc replacement. Disease information focuses on conditions including spondylolisthesis, degenerative spinal diseases, low back pain, and spinal deformity. Research type mainly

Table 2

Top 5 most prolific authors in ALIF research.

Author	Publications	Citations	H-index	Specialty	Institutions	Countries
Lee SH	30	859	16	Neurosurg	Wooridul Spine Hosp	South Korea
Mobbs RJ	18	594	12	Neurosurg	Prince Wales Hosp	Australia
Phan K	18	554	12	Neurosurg	Prince Wales Hosp	Australia
Singh K	17	89	6	Orthopedic surgery	Rush Univ	USA
Mummaneni PV	14	480	9	Neurosurg	Univ Calif San Francisco	USA

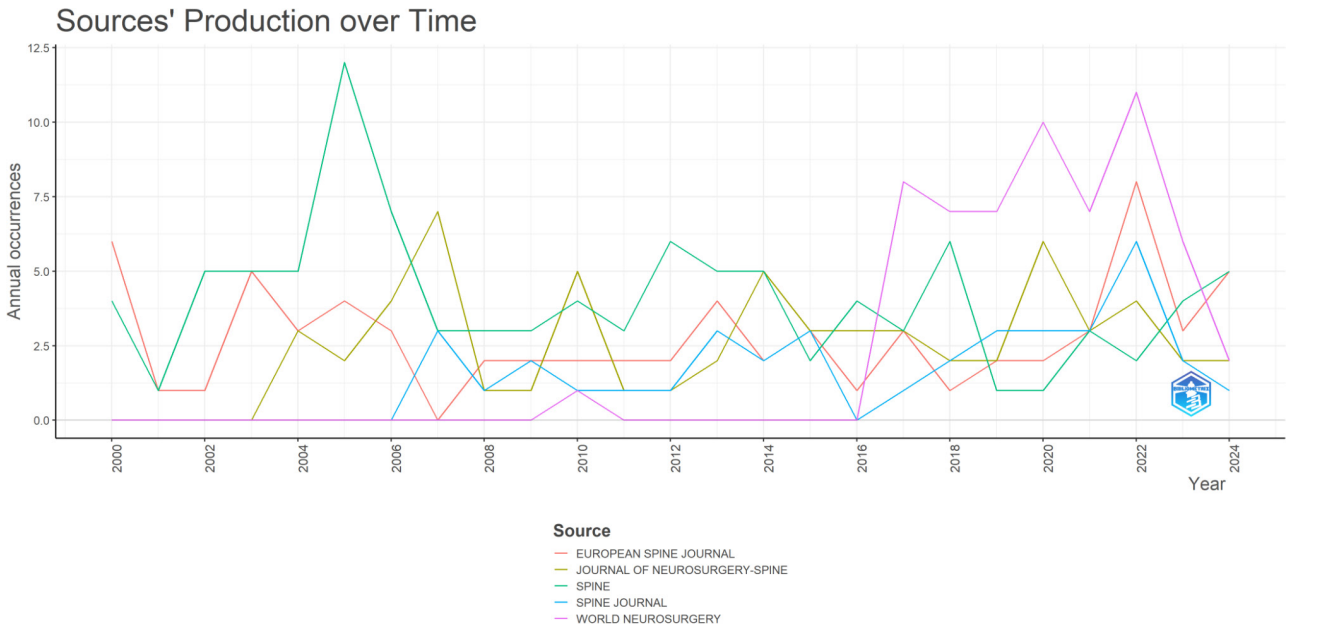

Figure 3. Annual output of the top 5 journals.

consisted of human studies (560), with a smaller portion dedicated to animal studies (31), and a few studies (3) that included both human and animal subjects. Among the evaluation metrics, the most frequently assessed outcomes were fusion rate, complication rate, and oswestry disability index.

3.7. YouTube comments

Among the top 50 most-viewed videos with comments on YouTube, the first video related to ALIF only emerged in 2007. From that point, video use remained minimal until 2020, when a significant increase occurred. The number of YouTube videos peaked at 8 in 2022, indicating a substantial rise in video-based dissemination. Sentiment analysis was performed on the comments from these videos, resulting in the following distribution: 41.6% (546) were positive, 36.2% (474) were neutral, and 22.2% (291) were negative. These findings provide an overview of public sentiment toward ALIF, with a majority of comments being positive or neutral, while a smaller proportion of comments expressed negative views.

3.8. Patent information

The ALIF patent first emerged in 2001, and patent filings became more frequent post-2006. The highest number of patents filed in a single year was recorded in 2021 (5 patents), followed by 2006, 2013, and 2020, each with 4 patents. The legal status of ALIF patents in the lens dataset is categorized into 5 types: active, discontinued, pending, expired, and inactive. Among these, active patents constitute the largest share, accounting for 49%, indicating that nearly half remain enforceable and in use. The remaining patents are categorized as follows: discontinued (17%), pending (15%), expired (13%), and inactive (6%). This distribution suggests that a considerable proportion of patents remain active and relevant in the field, while only a small fraction are discontinued, expired, or inactive. The USA leads with 33 patents, indicating the country's dominant position in ALIF patents. China and South Korea each follow with 6 patents.

Patents related to ALIF technologies were classified into 6 groups according to their primary focus. The largest category, comprising 27 patents, focuses on ALIF implants, highlighting the emphasis on developing specialized devices for ALIF. The second-largest category, with 14 patents, pertains to implants for broader spinal fusion applications, suggesting applicability beyond ALIF. Additionally, 5 patents encompass both surgical techniques and implant designs for ALIF, addressing innovations in procedural methods and device development. Another 4 patents pertain to implants and surgical techniques for spinal fusions, integrating advancements in both areas. Finally, 2 patents pertain to ALIF-specific surgical instruments, while 1 exclusively addresses ALIF-related surgical methods.

4. Discussion

Due to the completion of data collection in August 2024, the year 2024 does not represent a full year of publications, patent filings, and YouTube video counts. An analysis of data from 2000 to 2023 reveals a significant rise in cumulative annual output across literature publications, YouTube videos, and patent filings. Specifically, the period from 2012 to 2023 demonstrates a marked upward trend compared to the earlier period from 2000 to 2011, highlighting substantial growth in academic productivity, innovation, and digital dissemination in recent years.

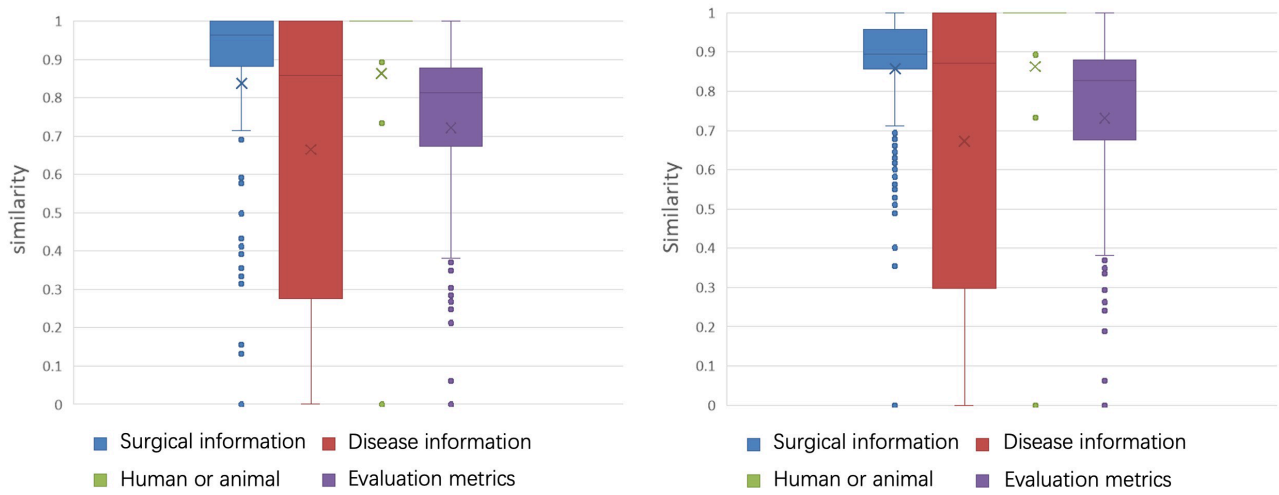

Figure 4. Similarity of manual and model-based information extraction (left: from domain-specific language model; right: from general-purpose language model).

Table 3

Research focus in surgical information, disease information, research type, and evaluation metrics.

Surgical information	Counts
ALIF	660
ALIF, TLIF	116
ALIF, pedicle screw fixation	37
ALIF, total disc replacement	34
ALIF, TLIF, LLIF, PLIF	13
Disease information	**Counts**
Spondylolisthesis	99
Degenerative disc disease	67
Low back pain	18
Adult spinal deformity	12
Degenerative lumbar disc diseases	6
Research type (human or animal)	**Counts**
Human	560
Animal	31
Human, animal	3
Evaluation metrics	**Counts**
Fusion rate	130
Complication	126
Oswestry disability index	121
Visual analog scale	100
Blood loss	91

ALIF = anterior lumbar interbody fusion, LLIF = lateral lumbar interbody fusion, PLIF = posterior lumbar interbody fusion, TLIF = transforaminal lumbar interbody fusion.

4.1. Scientific publications

The fluctuating but overall upward trend in ALIF publications over 25 years reflects growing academic interest in this surgical approach. Starting with 17 publications in 2000 and peaking at 48 in 2021, the field has witnessed significant growth, indicating its expanding relevance in spine surgery research. The consistent annual output exceeding 30 publications after 2020 highlights a critical phase of maturation for this research area.

The prominence of international partnerships underscores the importance of shared expertise and resources in advancing ALIF research. Future research initiatives should aim to expand collaboration with underrepresented regions to ensure a more equitable distribution of knowledge and expertise. The distribution of the top 5 most prolific contributors to ALIF research reveals a strong neurosurgical presence, with 4 of 5 authors specializing in neurosurgery. The top 5 journals most relevant to ALIF research account for approximately half of the total publications, highlighting their significant role in shaping the field. Among them, *SPINE* is the journal with the highest number of publications. *World Neurosurgery* has demonstrated a growing focus on ALIF-related research, reflected in a steady increase in publications.

The "en_core_web_sm" model is a lightweight, general-purpose language model from the spaCy natural language processing library. Designed for efficient English-language text processing, it balances computational efficiency with essential natural language processing capabilities. Its versatility and ease of integration make it widely used in both academic and industrial applications for text preprocessing and analysis.[13] In contrast, the "en_core_sci_lg" model is a domain-specific language model developed as part of the SciSpaCy library, tailored for processing scientific and biomedical text.[14] It excels in handling specialized terminology and complex linguistic structures commonly found in scientific literature. Built on the spaCy framework, it offers seamless integration into workflows for analyzing domain-specific text. The analysis of the performance of domain-specific and general-purpose language models in extracting ALIF-related clinical information reveals notable strengths and limitations. Both models show high similarity with manually extracted data for surgical information, with mean

similarity scores of 0.838 and 0.858 for the domain-specific and general-purpose models, respectively. The median similarity scores, which are even higher, suggest that the majority of extracted data closely aligns with manual annotations. This indicates that both models are effective in identifying surgical information, such as procedures and techniques, with minimal variation between them. However, disease information poses significant challenges, as reflected by the lower mean similarity scores (0.665 for the domain-specific model and 0.673 for the general-purpose model). The discrepancy between the mean and median scores underscores the polarization in performance. This polarization likely stems from the models' tendency to extract detailed descriptions of diseases, which differ from the concise summaries typically provided by manual annotations. Addressing this issue may require fine-tuning the models to better align with manual extraction practices in biomedical contexts.

High-frequency terms related to surgical techniques indicate that ALIF is most commonly compared with the traditional transforaminal lumbar interbody fusion approach.[2,15] Regarding surgical indications, ALIF is primarily indicated for degenerative lumbar spondylolisthesis and spinal deformities, emphasizing its clinical significance in managing these conditions.[16,17] Currently, human-related studies constitute the majority of research, but future efforts should encourage more high-quality animal experiments to better evaluate the safety and efficacy of this surgical approach before clinical application. In surgical evaluation, most surgeons focus on fusion rates and complications, and frequently utilize the oswestry disability index for preoperative and postoperative patient assessment.[15,18]

4.2. YouTube comments

The increasing amount of ALIF-related video content, especially since 2020, highlights the expanding role of digital media in disseminating medical information. YouTube has become increasingly important in providing potential patients and healthcare professionals with valuable information.[19] In addition, this trend is also likely correlated with the COVID-19 pandemic, which led to an increased reliance on digital media platforms, particularly during and after the crisis.[20,21] The predominance of positive comments suggests that ALIF is largely viewed favorably by the public; this likely reflects patient satisfaction, successful surgical outcomes, and the perceived benefits of ALIF. These findings align with the growing use of ALIF in clinical practice, where it is increasingly recognized as an effective solution for treating spinal conditions such as spondylolisthesis and spinal deformity.[22–25] However, 22.2% of the comments were negative, reflecting concerns or skepticism about ALIF. These comments may stem from concerns about the risks associated with readmission due to infection, vascular injury, other complications, or the need for revision surgery.[26–29] Reports of negative patient feedback may indicate concerns regarding the duration of postoperative recovery and potential surgical complications.

4.3. Patent information

The USA, China, and South Korea account for the majority of ALIF-related patents globally and are among the most active nations in this area. These countries also demonstrate the highest levels of international collaboration in ALIF research. The leading positions of the USA, China, and South Korea in ALIF-related patents reflect not only their individual technological advancements but also the significant role of international collaboration in driving innovation. The cooperation among these countries promotes the exchange of knowledge, expertise, and resources, accelerating the development of new technologies and surgical techniques related to ALIF.[30–33]

5. Conclusions

The current study examines ALIF surgery through a comprehensive analysis of 3 distinct sources including medical literature, social media comments, and patent data. Medical literature provides professional insights from clinicians and researchers. Social media comments offer insights into the perspectives of patients and the broader public, revealing societal attitudes and personal experiences related to ALIF. Furthermore, patent information highlights innovations and technological advancements in the field, reflecting the market potential and commercial significance of ALIF procedures. By integrating these diverse insights, this study provides a comprehensive understanding of the trends and dynamics shaping ALIF surgery, thereby enhancing knowledge of its clinical relevance and market impact.

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Not applicable.

Ethical statement

This article does not contain any studies with human or animal participants.

Conflicts of interest

The authors have no conflicts of interest to disclose.

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Author contributions

Conceptualization and design: Cheng Li, Xin Du, Guoyang Zhang.
Data acquisition and analysis: Cheng Li, Xin Du.
Data interpretation: Cheng Li, Xin Du, Kun Chen, Guoyang Zhang.

Drafting of the manuscript: Cheng Li, Xin Du.
Critical revisions to manuscript: Cheng Li, Xin Du, Kun Chen, Guoyang Zhang.
Overall supervision: Cheng Li, Guoyang Zhang.

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