

Dural Sealants in Spine Surgery: A Scientometric Analysis

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ABSTRACT

Introduction: This research aims to systematically and comprehensively evaluate the publication, citation, collaboration, and evolution of topics in dural sealant for cerebrospinal fluid leakage for spine surgery publications.

Methods: This is a scientometric study that systematically mined publications from the Web of Science last January 2023 using the keywords (dural sealant) AND (cerebrospinal fluid) AND (spine surgery). No exclusion criteria were used in the search. The analysis was divided into publication, citation, collaboration, and text-co-occurrence network analysis. R studio and VOSViewer were used for data management, analysis and visualization.

Results: A total of 53 documents published between 2002 to 2022 were analyzed. The countries with the most publications were the United States of America (39.62%), Italy (9.43%), and Japan (9.43%). Total citations for all publications were 859, with an overall H-index of 15. Institutions from South Korea, India, China, and the United States of America were found to have previous collaborations on the topic. In addition, neurosurgery publications had four clusters of co-occurring keywords, which include (1) neurological deficit, polyethylene glycol, efficacy, safety; (2) dural defect, prevention, cerebrospinal fluid (CSF) leak; (3) postoperative CSF leak, dural tear; and (4) prolene, fibrin sealant, watertight closure. In terms of evolution, publications focused initially on the types of sealants but are currently focusing more on the effects of these sealants on different outcomes.

Discussion: This study provided an overview of the scientific output, trend, and research topics in dural sealant for CSF leakage for spine surgery publications worldwide. More research is still needed using varied designs and more subjects on this topic. Results may serve as a valuable guide for researchers, practitioners, and educators to find the future direction of research agenda and projects about using dural sealant to prevent CSF leak in spine surgeries.

Keywords: CSF, Leak, Spine Surgery, Scientometric

Introduction

Cerebrospinal fluid (CSF) leakage is one of the most difficult post-operative complications after spinal surgery and branches out to many further complications including epidural infections, inflammations, and an overall prolonged post-operative recovery [1]. The primary risk factors for CSF leakage include the advanced age of patients and the level of surgeon's training, while other risk factors such as the significant history of repeated spinal surgery are also considered [2]. Since CSF leakage can result in a myriad of complications that can potentially result in a prolonged hospital stay, higher incidence of reoperation, and an overall decline in prognosis, treatment is imperative [1].

Treatment of CSF leak entails the closure of the dura to stop fluid leakage, which can be achieved by a direct suture or augmented closure, and CSF pressure adjustments [3]. While these treatment strategies have been tested for their effectiveness after incidences of CSF leakage, they also have corresponding complications. For example, direct suture repair creates pin holes upon puncture sites by the suture needles, which can alter the pressure system

in the dural defect and can result in more persistent CSF leakage [3]. In addition to this, CSF pressure adjustments as a potential approach for dural repair can result in spinal fluid over drainage, entry of gas to the subarachnoid space, and entry of infectious agents [3]. With these challenges in the treatment approach for CSF leakage, dural repair calls for a more secured and airtight intervention that can also prevent the other complications of the previous approaches [3].

At present, scientometrics has been used to understand the trend for specific neurosurgery techniques such as pallidotomy and spine surgery, publications from certain journals, and publications of neurosurgeons from specific areas like China, and Africa [4-9]. To the authors' knowledge at the time of writing, there is no scientometric study analyzing the use of dural sealants in the prevention of CSF leak in spine surgery. Therefore, the aims of the study are to elaborate on

1. publication and citation trends of dural sealants in spine surgery research publications.
2. which countries and affiliations collaborate to create research publications regarding dural sealants.
3. cluster of keywords in dural sealants in spine surgery

- publications using text co-occurrence analysis.
4. What are the areas in dural sealants and csf leak that need further development.

To expound on this matter, the objective of the study is to compare the publication trend, and topic trend on dural sealants in spine surgery using scientometric techniques.

Methods

Design

In this study, scientometric methods were utilized, based on the research to conduct a comparative analysis of the research productivity in dentistry and genetics across different countries [9,10]. The use of this approach provides valuable insights into the current state and potential future directions of research, policy, education, and health-related to a specific topic.

Data Source

In January of 2023, a comprehensive search was conducted of the Web of Science's core collection to retrieve pertinent articles. With millions of records from prominent healthcare science, health policy, and systems research journals, utilized this database to chart the patterns and insights of global health systems research publications [11].

Search Strategy and Data Extraction

The terms ("dural sealants" AND "spine surgery" AND "cerebrospinal fluid") were used as the keywords to search following the reviews of Kanmounye et al. Complete records of each publication were extracted as plain text files from WoS [8]. No exclusion criteria were used in the search.

Data Analysis and Visualization

In order to effectively manage and analyze the results of our research, various tools including the WoS result analysis feature, R Studio, and VOSviewer (version 1.6.18) were utilized. The WoS result analysis feature was instrumental in examining the publication and citation characteristics of the included articles, enabling us to gain a more comprehensive understanding of the data.

To further aid in the analysis, full publication and citation records were downloaded as a plain text file for text co-occurrence network analysis. This was particularly helpful in identifying connections and patterns within the data that may have otherwise gone unnoticed.

In addition to these tools, VOSViewer and R Studio were employed to create various maps based on network and text data, helping us to better visualize and interpret our findings [12]. To ensure accuracy, VOSViewer thesaurus file was utilized to merge different variants of author, journal names, institutional affiliations, and synonyms, resulting in a more cohesive and comprehensive analysis of the data.

Results

A total of 53 documents published between 2002 and 2022 were analyzed. All publications were in the English language and included the following document types: article (n=45), review (n=10), and editorial material (n=1). Total citations for all publications were 859, with an overall H-index of 15. Figure 1 below reports dural sealant spine research's overall publication and citation over time.

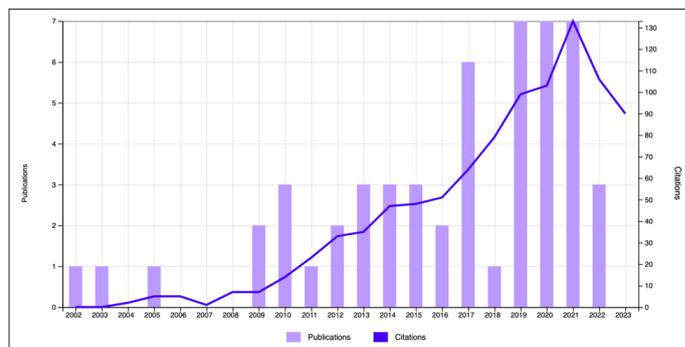


Figure 1: Overall Publication and Citation of Dural Sealant Spine Research from WoS

Figure 2 illustrates the research productivity per country on the topic. Analysis revealed that as of 2022, 23 countries from all continents around the world have published an article about dural spine sealant. Countries with the most significant number of publications are the United States (n=22), Italy and Japan (n=5), and France, Germany, India, and South Korea (n=3). This result is further supported by the top publishing institution identified, the University of California System (n=4). In terms of evolution, the analysis revealed that the United States, India, and South Korea were the countries that initially published articles on the topic in the early 2000s, which were followed by publications from other European and South American countries. In addition, institutions from South Korea, India, China, and the United States of America were found to have previous collaborations on the topic.



Figure 2: Neurosurgery Research Productivity of ASEAN Countries

Tables 1 summarizes the top three journals with the most dural sealant spine publications. Aside from these, other journals that have published articles related to this topic included journals on pediatrics (Journal of Neurosurgery Pediatrics), orthopedics (Orthopaedics Traumatology Surgery Research), and clinical neuroscience (Journal of Clinical Neuroscience). Upon further review, most of the publications have utilized the following study designs: retrospective chart review (n=15), quasi-experimental (n=13), systematic or literature review (n=10), case reports (n=10), and randomized controlled trial (n=4). All primary research used data from human subjects except for five papers that used cadavers (n=1) and animal subjects (n=4).

Table 1: Top Three Journals with most Publications on Dural Sealant Spine

Publication Titles	n	%	Impact Factor
World Neurosurgery	8	20.811	2.0
Spine	7	9.639	3.0
Spine Journal	5	7.01	4.16

Figure 3 presents the text map of the frequently occurring keywords in the title and abstracts of all publications included. These words were clustered together based on the frequency of their co-occurrence in each publication. Results revealed that publications in spine surgery have four clusters of co-occurring keywords which include:

1. “neurological deficit,” “polyethylene glycol,” “efficacy,” “safety” [yellow];
2. “dural defect,” “effect,” “prevention,” “cerebrospinal fluid leak” [green];
3. “postoperative csf leak,” “dural tear,” “review” [red]; and
4. “leakage,” “prolene,” “fibrin sealant,” “waterlight closure” [blue].

These cluster of keywords were further supported by the top three most cited publications, which include: “Effect of fibrin glue on the prevention of persistent cerebral spinal fluid leakage after incidental durotomy during lumbar spinal surgery” by Janwitz et al. “Polyethylene Glycol Hydrogel Spinal Sealant (DuraSeal Spinal Sealant) as an Adjunct to Sutured Dural Repair in the Spine Results of a Prospective, Multicenter, Randomized Controlled Study” by Kim and Wright, and “Dural repair with four spinal sealants: focused review of the manufacturers’ inserts and the current literature” by Epstein. It is also worth noting that in terms of evolution, keywords related with primary studies like “retrospective review,” “background data,” and “effectiveness” were found in earlier publications compared with words like “literature review,” and “systematic review”. Also, keywords related with outcomes were identified like “leakage,” “primary outcomes,” and “safety.”

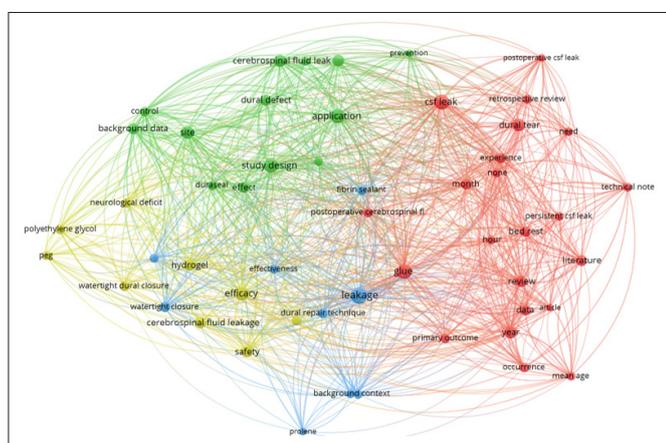


Figure 3: Network Map of Frequently Occurring Keywords of Dural Sealant Spine Publications

Discussion

This study described the publication and topic trend in dural sealant spine research in the last decade. The movement in research publications supports this intervention’s growing importance and development in spinal neurosurgery.

Scarcity of Studies Regarding different Strategies for Dural Repair The study’s findings indicate that the majority of current research on dural sealant spine consists of retrospective studies and case reports involving individuals who have undergone spinal surgery and there is scarcity in studies reviewing the efficacy of different strategies for dural repair. This aligns with previous reviews of spinal sealants and techniques for spinal dural tears [13,14]. It is worth noting, however, that recent publications on the subject include studies with higher levels of evidence, such as randomized controlled trials and systematic reviews. This development suggests that the evidence for dural sealant spine is growing and becoming more robust. Surgeons and researchers must prioritize the continued research of dural sealants in spine surgery to fully understand its features and effectiveness. It is crucial that we invest in this technology to improve patient outcomes and advance the field of spinal surgery.

Economic Burden of Treatment

Incidental durotomy and subsequent cerebrospinal fluid (CSF) leakage is an established complication following spinal surgery, occurring in 2 to 20%. This entails an increase in hospital expenses to as high as fifty percent. Therefore, minimizing complications during surgery with prompt repair of dural tears is important for a fast recovery and the avoidance of further complications. Hence, there is an increase in pressure on the surgeons to be careful in avoiding, as well as treating, this complication. Again it is emphasized that further research is prioritized to develop effective treatment strategies to prevent csf leak in spine surgery [15].

Limitation and Recommendations

As with any research endeavor, it is important to acknowledge the limitations encountered in this study. Firstly, the scope was restricted to publications indexed in the WoS database, potentially overlooking valuable information published in other journals. To gain a more comprehensive understanding of the topic, future studies may consider including a broader range of publications from diverse sources. Secondly, the text network maps in this study analyzed words occurring in the title abstract with frequency of occurrence as the primary criterion. While providing valuable insights, this approach represents a relatively fundamental analysis. Future research could benefit from using more sophisticated topic modeling techniques, like Latent Dirichlet Allocation, to enhance categorization and classification of publications. By adopting these advanced methods, researchers can achieve a more nuanced and accurate representation of the various research topics within the field of spinal surgery.

Conclusion

This study provided an overview of the scientific output, trends, and research topics from dural sealants for prevention of csf leak in spine surgery. The study revealed that although the publications and citations about dural sealants have been getting considerable interest for the past years, gaps in the publication about the topic per institution and country are still evident. Most collaboration was found between countries with high publications and advanced neurosurgery practices and training. This study provides an overview and valuable guidance for neurosurgery researchers, practitioners, educators, and policymakers to find the future direction of use of dural sealants in preventing csf leak. The authors highly suggest neurosurgeons to consider the results of the study identifying future capacity-building projects, research agendas, and policy guidelines, and possibly collaborative projectives between countries, to further improve research.

Disclosures

The authors have no affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter discussed in the manuscript.

Previous Presentations (if any)

Not applicable

Credit Author Statement

Pochollo Miguel Rosales: Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft

Catherine Joy Escudra: Conceptualization, Methodology, Investigation, Data Curation, Writing – Review and Editing, Supervision

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