



Research Progress and Prospects on the Treatment of Osteoporotic Vertebral Compression Fractures with Bone Cement Based on Bibliometrics

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Abstract

We analyzed literature from the Web of Science Core Collection (2005-2023) using VOSviewer and CiteSpace for author and keyword cluster analysis, to explore the role of bone cement in Osteoporotic Vertebral Compression Fractures (OVCF) treatment. The research primarily focused on middle-aged and elderly OVCF patients, evaluating bone cement types, usage, efficacy, and prognosis. Major contributors were orthopedic (spine surgery) departments in comprehensive hospitals and medical universities. The analysis revealed diverse international research on bone cement's role in OVCF treatment, covering outcomes, techniques, materials, and postoperative conditions. While the findings support bone cement application, they also highlight unresolved issues such as postoperative complications and quality of life.

Keywords: Bone cement; Percutaneous vertebral augmentation; Osteoporotic vertebral compression fractures; Spinal compression; Visual analysis; Bibliometrics

Introduction

Osteoporotic Vertebral Compression Fractures (OVCF) are prevalent and significantly impact the quality of life in an aging society. Therefore, timely and effective prevention and treatment of OVCF are crucial. Typically, symptoms of osteoporotic vertebral compression fractures can be summarized as follows: 1) Persistent pain in the lower back and chest, sometimes accompanied by rib pain. Pain may lessen or disappear when lying down or at rest, but worsens with changes in posture. Spinal kyphosis and nonunion fractures may also occur, 2) Physical examination may reveal restricted movement in the thoracic and lumbar regions, tenderness upon palpation of the fractured vertebrae, and percussion tenderness. Generally, there are no signs of lower limb neurological impairment (although signs of nerve damage may occur in severe cases with compression or severe kyphosis), 3) Combining physical examination with imaging studies can help determine the responsible vertebra for the pain [1]. Although the clinical manifestations of OVCF are complex and varied, diagnosis can typically be made based on characteristic presentations and imaging examinations. Early systematic treatment for osteoporosis and minimally invasive surgical interventions are necessary [2].

Over the past few decades, the medical community has been continuously exploring various treatment methods to seek more effective and reliable solutions for OVCF. Among them, the application of bone cement (such as polymethyl methacrylate, hydroxyapatite, etc.) has attracted significant attention as a treatment modality, especially in patients with osteoporosis, with high expectations for its ability to repair damaged vertebrae [3]. In this context, researchers and clinicians have conducted extensive studies and discussions on the efficacy and potential risks of bone cement treatment in patients with OVCF. The emergence of bone cement has made minimally invasive treatment options such as Percutaneous Vertebral Augmentation (PVA) and Percutaneous Kyphoplasty (PKP) possible.

To comprehensively understand and evaluate the role of bone cement in the treatment of OVCF, we will conduct a bibliometric analysis using visualization software such as CiteSpace and VOSviewer to explore the research progress on bone cement in OVCF treatment internationally. International research on bone cement for OVCF treatment exhibits rich diversity, covering various aspects such as treatment outcomes,

surgical techniques, implant materials, and postoperative conditions of patients. These research findings not only provide empirical support for the application of bone cement but also reveal some unresolved issues and areas for improvement, such as postoperative complications and postoperative quality of life for patients. This paper aims to present a comprehensive visualization of the research progress on bone cement in OVCF treatment based on citation data using visualization software like Citespace and VOSviewer, including core studies, major research trends, and international collaboration in the field. We will pay special attention to the influence and knowledge structure of bone cement in different research areas, providing a clear academic landscape for orthopedic surgeons and researchers to better understand and evaluate the role and development trends of bone cement in OVCF treatment. Visualizing the research status of bone cement in OVCF treatment through bibliometric analysis will help gain a more comprehensive international perspective on the forefront dynamics in this field. This study will provide valuable references for scholars in related fields in China and serve as a direction and basis for future research. Additionally, it will promote academic exchanges and collaborations in the field of orthopedics regarding OVCF treatment, contributing to the advancement of research on osteoporosis-related issues.

Methodology

The literature search strategy

Based on the 2015 edition of the Chinese Guidelines for the Diagnosis and Treatment of Osteoporosis Fractures, we conducted a comprehensive literature search using the Web of Science core article database. Considering the relevance of the topic, the workload and accuracy of manual data collection, and the previous research on this

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subject, we focused our search on the Web of Science platform. The search period was set from January 1, 2004, to December 31, 2023. By narrowing down the search to this specific timeframe, we aimed to include the most recent and relevant studies on the use of bone cement in the treatment of osteoporotic vertebral compression fractures.

Search query: (((TS= (bone cement)) AND TS= (treatment)) AND TS= (OVCF)) AND TS= (treatment)) OR (((TS= (bone cement)) AND TS= (treatment)) AND TS= (OVCF)) AND (TS= (therapy)))

Inclusion and exclusion criteria

Inclusion criteria: Articles published in various Web of Science Core Collection journals related to the treatment of osteoporotic vertebral compression fractures using bone cement.

Exclusion criteria: 1) Animal experimental studies, bibliographies, translation articles, or articles unrelated to the treatment of osteoporotic vertebral compression fractures using bone cement, 2) Articles without full-text availability.

Duplicate literature

After reading the titles and abstracts, 161 articles were included for bibliometric analysis and full-text reading.

Please note that the number of articles included may vary based on the search results and the specific criteria used for article selection.

Bibliometric analysis

For data extraction and analysis, the VOSviewer 1.6.20 software and CiteSpace 6.2R6 (64-bit) basic software were used. These software tools complement each other in knowledge mapping and visualization.

CiteSpace utilizes a set-theoretic approach to measure the similarity between knowledge units and generate temporal and time zone views. It provides insights into the evolution of knowledge and the historical span of literature, thus aiding in understanding the development trends within the field [4].

On the other hand, VOSviewer employs a probabilistic approach to standardize data and offers various visualization views, including network, overlay, and density views. It excels in displaying keywords, co-occurring institutions, co-authors, and other areas [5].

By combining the usage of both software tools, we can conveniently and intuitively identify key points from a large number of articles and extract relevant data for analysis. This approach allows for a more accessible presentation of information through the combination of visualizations and text.

The “Web of Science Core Collection” serves as the primary data source for our study. This database is widely accepted for its excellent quality and is considered the optimal choice for bibliometric analysis, as supported by Ding, et al. [6].

Note that the specific procedures and parameters for data extraction and analysis may vary based on the research objectives and requirements.

Bibliometrics first emerged in the early 20th century and became an independent discipline in 1969 [7]. It has been widely applied in the field of orthopedics for literature analysis, providing a powerful quantitative method for reviewing and investigating current orthopedic literature [8,9]. During the analysis process, detailed information about authors, keywords, journals, countries, institutions, and references can be obtained through computerized data processing. Therefore,

bibliometric analysis has become an important tool for evaluating the development of the orthopedic field, including performance and productivity aspects [10]. Modern computer technology enables the enhancement of bibliometric analysis through graphical and visual representations, as well as the visualization of relationships through co-citation analysis. In this study, visualization will aid in uncovering the underlying connections between these pieces of information, such as the research themes shared by different authors, the research focus of different institutions, and the emergence of new theories from existing institutions.

To identify the research object, research purpose, information related to the treatment of Osteoporotic Vertebral Compression Fractures (OVCF), distribution of researchers' departments, main research directions, and publication date of the article, it would require reading the full text and references of the article.

Results

Literature search and screening results

Based on the information you provided, out of the initial 168 articles retrieved, 3 articles were related to animal experiments, 2 articles were not relevant to the treatment of Osteoporotic Vertebral Compression Fractures (OVCF) with bone cement, 1 article was a low-quality meta-analysis, and 1 article was found to be a duplicate. Hence, a total of 161 articles were ultimately included for further analysis.

Bibliometric analysis

Bibliometric analysis reveals that the 161 articles were published in a total of 63 journals, with an average of 2.55 articles per journal. The top 8 journals based on the number of articles published are listed in Table 1. From the table, it can be observed that the journal with the highest number of publications is “Journal of Orthopaedic Surgery and Research” with 16 articles. By dividing the citation count by the number of articles, the journal with the highest citations per article is “International Orthopaedics” with an average citation rate of 24.8 citations per article. Additionally, “Pain Physician” closely follows with an average citation rate of 24.3 citations per article, similar to “International Orthopaedics”.

The 161 articles involved a total of 192 institutions, with an average of 0.839 articles per institution. Among them, the top 13 institutions based on the number of articles published contributed a total of 82 articles, accounting for 50.9% of the total publications. Refer to Table 2 for the distribution of article counts per institution (n represents the number of articles published by each institution). From the information in the table, it can be concluded that Suzhou University is the institution with the highest number of publications in this field.

The author data has been imported into the VOSviewer software. The maximum number of publications by an author is 7. According to Price's law, the minimum number of publications for a core author, N, can be calculated as $N=0.749\sqrt{M_{max}}$ (where M_{max} is the maximum number of publications by any author). In this case, the calculated minimum value for the number of publications by a core author is 1.98, indicating that authors with 2 or more publications can be considered as core authors. There are a total of 79 authors with 2 or more publications, which aligns with Price's law. By setting the threshold of 2 or more publications, a density plot of the author collaboration network (Figure 1) can be generated.

A total of 929 authors were involved in 161 literatures, including 111 core authors, and a total of 277 articles (97.19%) were published. Among them, the team represented by Yang Huilin, Zhang Kai, Liu Hao and the team represented by Liao Yifeng.

Journal	Load	Quantity
Journal of Orthopaedic Surgery and Research	16	225
Bmc Musculoskeletal Disorders	10	98
Medicine	12	138
Pain Physician	10	243
International Journal Of Clinical And Experimental Medicine	5	20
International or Thopaedics	5	124
Medical Science Monitor	5	46
World Neurosurgery	6	43

Table 1: Top 8 journals by article volume.

Institution	n
Soochow Univ	14
Xi An Jiao Tong Univ	9
Nanjing Med Univ	9
Xuzhou Med Univ	8
Capital Med Univ	8
Chongqing Med Univ	5
Jilin Univ	5
Shanghai Jiao Tong Univ	4
Hanyang Univ	4
Guangzhou Univ Chinese Med	4
Shanghai Univ Tradit Chinese Med	4
Southern Med Univ	4
Hebei Med Univ	4

Table 2: Top 13 institutions by publication volume.



Figure 1: Illustration of author collaboration network density.

The team represented by Li Hua, as well as Yan Liang, Hao Dingjun, have close internal cooperation and are the core team in the field of OVCF bone cement treatment. The research team composed of some authors with 3 articles also has a certain scale, which plays a role in promoting the application of OVCF bone cement therapy.

The keyword data was imported into vosviewer software, and the keywords with frequency ≥ 2 were taken for analysis, and the keyword co-occurrence map (Figure 2), keyword time series map (Figure 3) and keyword co-occurrence density map (Figure 4) were obtained. The keyword data was imported into CiteSpace software, and all keywords were analyzed to obtain the keyword clustering diagram (Figure 5) and keyword timeline diagram (Figure 6). Among them, balloon kyphoplasty, bone cement, hypercutaneous vertebroplasty, and vertebral compression are the main keywords for the study of osteoporotic vertebral compression fractures.

From the keyword clustering plot (Figure 2), it can be observed that the keywords form 8 distinct clusters, namely “osteoporotic vertebral compression fracture,” “quality of life,” “osteoporotic vertebral compression fractures,” “surgical treatment,” “bone cement,” “cemented vertebrae,” “vertebral compression fracture,” “clinical efficacy,” and “percutaneous kyphoplasty.” The clustering module value $Q=0.4524$, indicating a significant clustering structure. The average silhouette value $S=0.7457$, suggesting a reasonable and highly reliable clustering. The keyword density plot (Figure 4) shows that “vertebroplasty,” “percutaneous vertebroplasty” and “osteoporotic vertebral compression fracture” have the highest keyword densities. From the keyword clustering plot (Figure 5), it can be observed that there is some overlap among the 8 distinct clusters. By combining the keyword temporal plot (Figure 3) and the keyword timeline plot (Figure 6), it can be concluded that research related to “osteoporotic vertebral compression fracture,” “quality of life,” “osteoporotic vertebral compression fractures,” “surgical treatment,” “bone cement,” “cemented vertebrae,” “vertebral

compression fracture,” and “clinical efficacy” has been ongoing since at least 2005. The overall research focuses on various aspects, including treatment, prognosis, efficacy, and materials such as bone cement, in the context of osteoporotic vertebral compression fractures. This research direction is expected to continue to be a major focus in the future.

Through co-citation analysis, researchers can identify frequently cited papers and the journals in which these papers are published in a specific field. This helps them establish a theoretical and practical foundation in their research area. In order to conduct co-citation analysis of journals, we used VOSviewer to create a co-citation network map. In this map, we set a threshold of at least 20 co-citations for each journal and selected 45 journals for the analysis. The resulting co-citation network map, as shown in Figure 7, displays the co-citation relationships among these journals, revealing their interactions and connections in the research field. By studying these co-citation relationships, researchers can further understand the collaborative relationships between journals, the intersections of research directions, and the hotspots of academic exchange. This provides important guidance for finding suitable publication channels, accessing the latest research findings, and exploring new research directions. The visualization of the network map makes complex co-citation relationships more clear and visible, providing researchers with an intuitive and comprehensive tool to understand the research field. Based on the co-citation network depicted in Figure 7, we observe that the journals are clustered into four distinct groups, each represented by a unique color. Among the top three most cited journals, “Spine” leads with an impressive 563 citations, followed closely by “European Spine Journal” with 303 citations and “Osteoporosis International” with 289 citations. Notably, “Spine” and “Osteoporosis International” are recognized as outstanding journals in JCR2 category, while “European Spine Journal” is an excellent journal in JCR3 category. The citation counts of these journals not only underscore their significance in the academic community but also highlight their exceptional contributions in their respective fields.

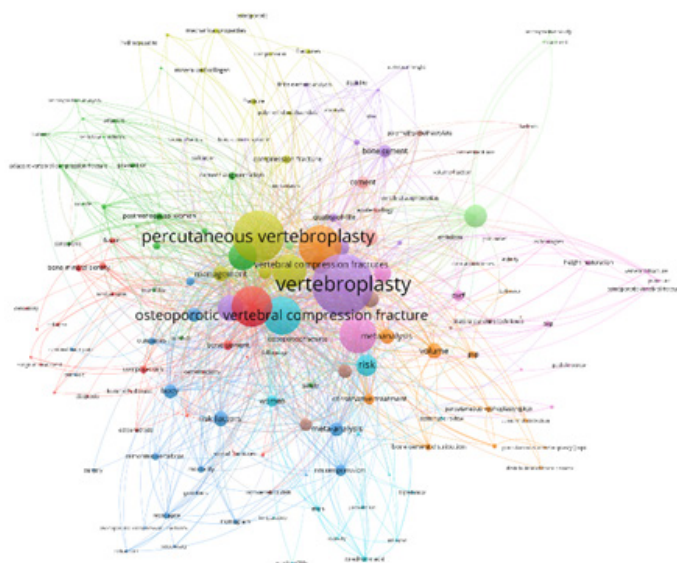


Figure 2: Keyword Co-occurrence network analysis.

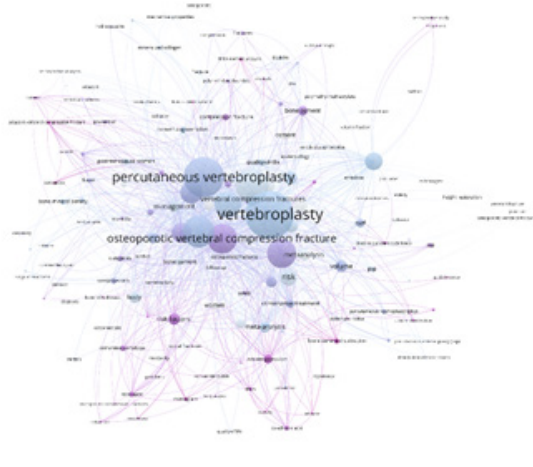


Figure 3: Depiction of keyword time-series analysis.

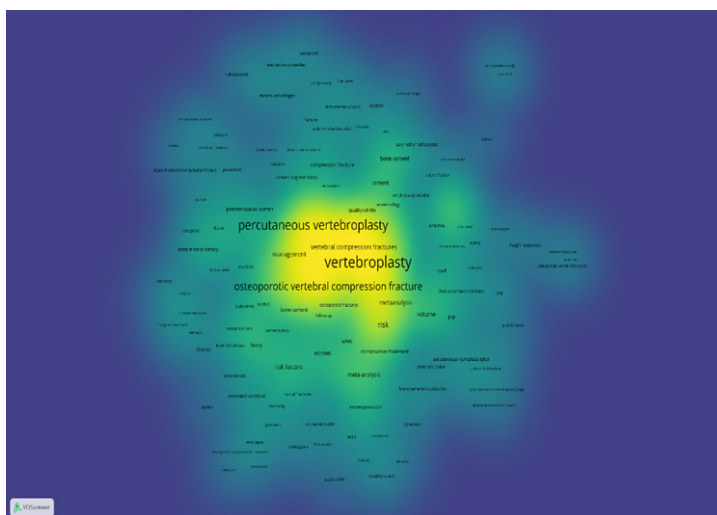


Figure 4: Keyword co-occurrence density mapping connections.

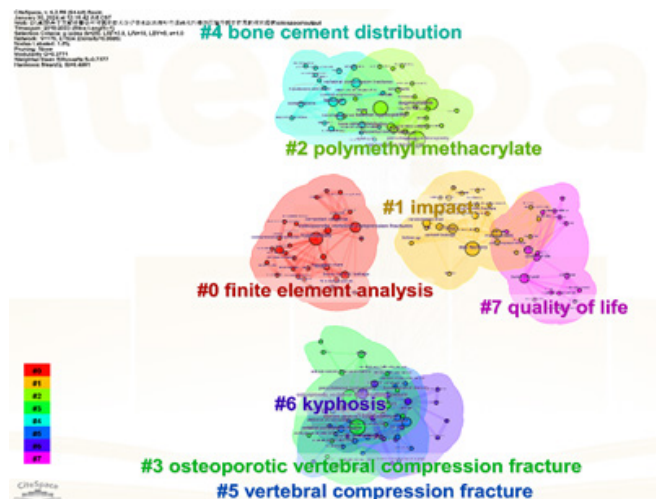


Figure 5: Keyword clustering revealing thematic groupings.

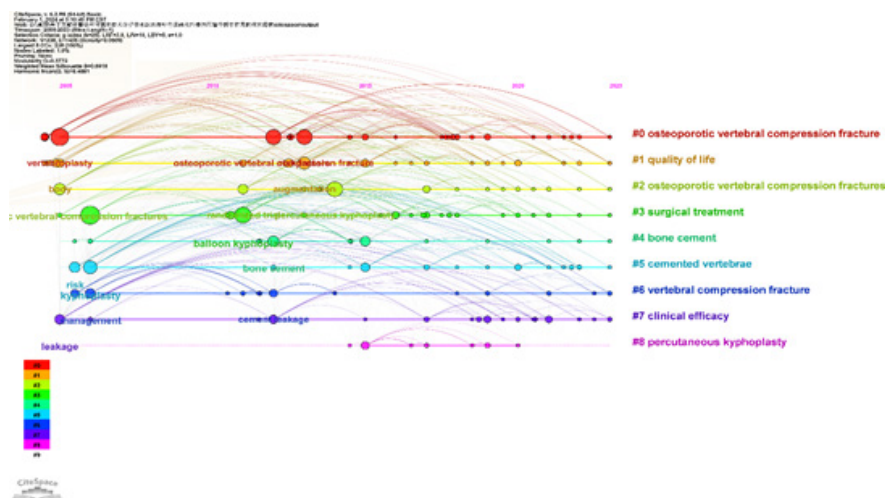


Figure 6: Keyword timeline showing trends and frequency over time.

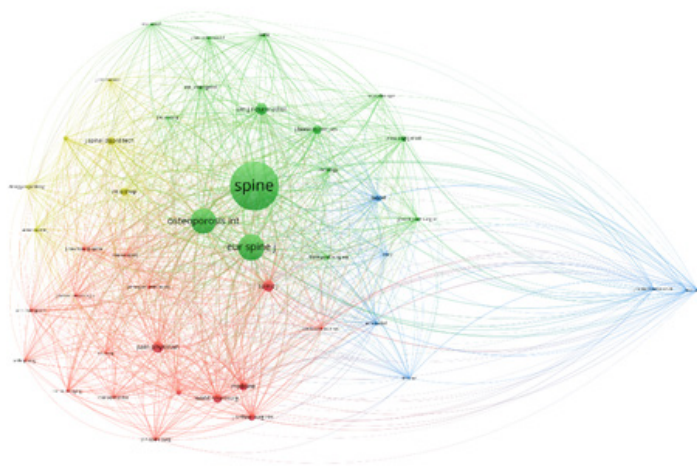


Figure 7: Journal co-citation analysis illustrating citation network.

Within these four clusters, the yellow and red clusters primarily focus on trauma and surgical fields, specializing in the application of surgical techniques for treating fractures and other traumas. Citations of these journals are aimed at reviewing and analyzing existing research to provide theoretical and empirical support for one's own studies. In contrast, the green cluster encompasses journals dedicated to spinal specialties, exploring research related to spinal diseases and treatments. The blue cluster journals focus on advancements in bone cement materials, often involving technical aspects such as data collection, cleaning, and analysis. Citations from these journals serve to provide technical support and guidance for research. By citing these journals, researchers can access the latest developments and authoritative perspectives on trauma treatment, spinal diseases, and bone cement materials, thereby obtaining accurate and reliable support for their own research.

Further analysis of the co-citation of literature reveals, with the help of VOSviewer, the top five most cited articles in the field from 2005 to 2023, as shown in Table 3. As indicated in Table 3, among the five highly co-cited articles, three are randomized trials. These randomized trials are instrumental in validating previously proposed theories and

establishing causal relationships. Notably, all five articles mention vertebroplasty, a procedure involving bone cement, underscoring the pivotal role of vertebroplasty with bone cement in the treatment of Osteoporotic Vertebral Compression Fractures (OVCFs)

Discussion

In the treatment of Osteoporotic Vertebral Compression Fractures (OVCFs) with bone cement has been a focal point of research in orthopedics in recent years, primarily in the following aspects:

Clinical efficacy validation and long-term outcomes observation

Clinical studies have consistently validated the effectiveness of bone cement treatment for OVCF patients, encompassing pain relief, restoration of vertebral height, and improvement in quality of life. The observation of long-term effects post-treatment has also become a research focus. In terms of postoperative prognosis, Li's study indicated that a subset of patients undergoing percutaneous vertebroplasty experienced postoperative vertebral cement collapse. Through a retrospective analysis of patients with single-level vertebral

augmentation, Li et al., suggested that those with low bone density or receiving small volumes of bone cement injection had a relatively higher risk of postoperative collapse [11]. Lee et al., research on postoperative patients found that those with osteoporotic vertebral compression fractures and low bone density who underwent vertebroplasty with bone cement had a higher risk of new OVCFs [12]. Both studies highlighted that lower bone density is a significant factor contributing to increased postoperative complications of vertebroplasty. Regarding the volume of bone cement injection, Park et al., study, which utilized larger-sized needles to inject more bone cement, demonstrated that a larger dose of bone cement yielded superior results in restoring vertebral height or kyphotic angle compared to traditional PVP methods [13].

Technological and material innovations in treatment

With advancements in technology and materials, innovations in bone cement treatment techniques and materials are ongoing. For instance, the use of novel materials such as Calcium Phosphate Cement (CPC) is being explored to enhance treatment efficacy and reduce complication rates [14]. Additionally, the incorporation of various trace elements into bone cement can influence treatment outcomes. The addition of strontium to bone cement can improve its mechanical properties and bioactivity, promoting bone formation and integration with the implant. Researchers are continuously working on enhancing the mechanical characteristics, porosity, and biodegradability of materials, along with additional benefits such as osteoconductivity and drug delivery capabilities. These materials should also possess appropriate injectability, curing properties, cohesion, and radiopacity for better handling. Moreover, the appropriate porosity of bone cement is crucial for promoting fluid circulation, cell migration, and new bone growth. Research also emphasizes the importance of biodegradability, osteoconductivity, and osteoinductivity of bone cement, as well as efficient drug delivery [15]. Through innovations in bone cement technology and materials, the risk of postoperative complications in vertebroplasty is decreasing, and patient outcomes are becoming increasingly favorable.

Complication and risk assessment studies

In-depth research is being conducted on potential complications associated with bone cement treatment, such as cement leakage and spinal stenosis. A larger distribution of bone cement is associated with both better treatment outcomes and a higher risk of postoperative leakage [16]. Tan observed that if bone cement adequately contacts the superior and inferior endplates, it can better restore vertebral strength, maintain vertebral height, and reduce the risk of compression and chronic pain [17]. In Percutaneous Kyphoplasty (PKP) procedures,

both bilateral and unilateral approaches are relatively safe and effective methods for treating pain from osteoporotic vertebral compression fractures. However, unilateral PKP involves lower radiation doses and shorter surgery times, achieves greater deformity correction (more restoration of the kyphotic angle), and has fewer complications compared to bilateral PKP [18].

Postoperative rehabilitation and prevention efforts

Research also focuses on postoperative rehabilitation management and prevention of new fractures, including discussions on patient rehabilitation training, dietary nutrition guidance, and treatment of osteoporosis to enhance patient quality of life and prevent disease recurrence. Postoperative follow-up studies have identified age and low bone density as major risk factors post-surgery. However, increased Outdoor Activities (ODA) have been shown to reduce the risk of subsequent vertebral compression fractures postoperatively [19]. Higher BMI, lower bone density, multiple vertebral fractures, no prior treatment for osteoporosis, and steroid use are independent risk factors for new vertebral fractures. Meanwhile, the volume of bone cement injected, surgical duration, and multiple vertebral fractures are risk factors for cement leakage in Percutaneous Vertebroplasty (PVP) [20].

Comprehensive understanding of extensive literature research in the field of bone cement treatment for Osteoporotic Vertebral Compression Fractures (OVCF) reveals four primary aspects. Firstly, regarding treatment efficacy, literature consistently demonstrates significant therapeutic effects of bone cement in OVCF treatment, with both Percutaneous Kyphoplasty (PKP) and Percutaneous Vertebroplasty (PVP) being safe and effective [21]. Notably, PKP is reported to yield better outcomes than PVP [22]. Specifically, unilateral PKP involves less radiation and surgical time, achieves greater deformity correction, and has fewer complications compared to bilateral PKP [18]. Quantitative research data and case-control studies highlight the positive role of bone cement in alleviating pain, promoting vertebral healing, and improving quality of life, supported by multiple studies, providing reliable scientific evidence for its practical application in OVCF treatment.

Secondly, from the perspective of surgical methods, literature covers various technical approaches for bone cement treatment. Different studies include steps such as puncture positioning and bone cement injection, demonstrating the diversity of this treatment [23]. Additionally, research also addresses potential complications such as cement leakage, offering suggestions for surgical improvements. This provides valuable references for clinicians in selecting surgical protocols and postoperative management.

Number	Title	Publication date	Citation
1	Vertebroplasty <i>versus</i> conservative treatment in acute osteoporotic vertebral compression fractures (Vertos II): an open-label randomised trial	2010	24
2	A randomized trial of vertebroplasty for painful osteoporotic vertebral fractures	2009	21
3	Vertebroplasty and kyphoplasty: a systematic review of 69 clinical studies	2006	20
4	A randomized trial of vertebroplasty for osteoporotic spinal fractures	2009	20
5	An estimate of the worldwide prevalence and disability associated with osteoporotic fractures	2006	19

Table 3: Top 5 literature co-citation.

Literature on implant materials focuses on the exploration of various types of bone cement and their application in OVCF treatment, involving studies on composition, biocompatibility, and biodegradability of bone cement [24-28]. Comprehensive analysis of these studies helps better understand the differences among materials in treatment, providing scientific basis for future clinical choices.

Furthermore, literature on postoperative patient conditions presents detailed research, including assessments of postoperative pain, improvements in quality of life, and restoration of vertebral morphology [29]. Researchers, through long-term follow-up and systematic data collection, comprehensively reflect the overall condition of patients post bone cement treatment. This offers valuable insights into understanding treatment effects, surgical indications, and potential postoperative management.

Through an in-depth study of 161 articles, a comprehensive and profound understanding of the application of bone cement in the treatment of Osteoporotic Vertebral Compression Fractures (OVCF) has been formed. These articles provide rich information covering aspects such as treatment efficacy, surgical methods, implant materials, and postoperative patient conditions, laying a solid foundation for understanding the research progress in this field. Combining keyword time maps with relevant literature, the current and future research hotspots in the bone cement field can be predicted as follows:

Long-term effects and prevention of complications: Continuous monitoring of the long-term effects of bone cement treatment and research on strategies for preventing and managing postoperative complications [15,16]. In terms of complications, particular attention should be paid to issues related to cement leakage. A more extensive distribution of bone cement often accompanies better vertebral repair and a higher risk of postoperative cement leakage [30]. Scholars have explored new injection techniques to achieve more uniform cement distribution and reduce postoperative complications [31].

Development of new bone cement materials: Material issues remain one of the main factors limiting the efficacy of bone cement. Continued research and development of new bone cement materials to improve treatment outcomes and reduce complications are ongoing efforts in the field. For example, Mineralized Collagen-Modified Polymethyl Methacrylate (MC-PMMA) represents a successful attempt at material improvement, showing excellent potential in the treatment of OVCF [32].

Development of personalized treatment plans: Designing personalized treatment plans based on patients' clinical characteristics and pathophysiological mechanisms to enhance the specificity and precision of bone cement treatment, reducing postoperative complications and risks. Digital Subtraction Angiography (DSA) technology can guide needle placement during surgery, shorten operation time, improve puncture accuracy, reduce fluoroscopy frequency and dosage, reduce cement leakage, and achieve better cement distribution [33].

Multidisciplinary cross-research: Combining research from orthopedics, radiology, materials science, and computer modeling to provide more comprehensive and in-depth insights into OVCF treatment. New surgical technique improvements from the orthopedic field, real-time fluoroscopy optimization, and a wider variety of material choices, supplemented by computer modeling to optimize surgical procedures, are providing more comprehensive and secure treatment for osteoporotic vertebral compression fractures.

Postoperative rehabilitation and preventive measures: Focusing

on postoperative rehabilitation training, treatment of osteoporosis, diet, and exercise management to enhance patient recovery. Reducing the impact of risk factors for recurrent fractures and improving postoperative prognosis [34,35]. Real-time intraoperative CT may also reduce the incidence of postoperative pulmonary embolism, but this result awaits further validation.

Overall, research in the OVCF field is moving towards greater precision, efficiency, and comprehensiveness. Through continuous research and innovation, future OVCF treatments are expected to further improve clinical outcomes, reduce complication rates, and provide more personalized medical solutions.

However, these articles also reveal some urgent issues. The primary concern is postoperative complications such as cement leakage and infection, which require further research and clinical practice to find solutions [36]. In terms of postoperative management, how to better promote patient recovery and prevent new vertebral fractures also needs in-depth research.

In summary, these previous articles provide a comprehensive understanding of the research progress of bone cement in OVCF treatment. Through systematic analysis of treatment efficacy, surgical methods, implant materials, and postoperative patient conditions, we can gain a deeper understanding of the advantages and limitations of this treatment. This provides valuable references for future research and clinical practice, while also indicating that there are many issues in this field that need in-depth research and resolution. Based on accumulating new data and research results, we can further improve and optimize the application of bone cement in OVCF treatment, providing more effective and safe treatment options for patients.

Bone cement, as a novel method for treating vertebral compression fractures, is increasingly becoming one of the most commonly used treatments in clinical practice. This paper, utilizing VOSviewer and CiteSpace software, examines research on bone cement treatment for vertebral compression fractures from 2004 to 2023, systematically reviewing the development trends in this field. It also validates the applicability of Price's law and Bradford's law in scientometrics within this domain, and explores and analyzes the core authors, key publishing institutions, keyword clustering, and keyword temporal distribution in this field. Overall, the research based on quantitative analysis concludes as follows:

- A collaborative group of authors in the field of bone cement treatment for vertebral compression fractures is gradually forming, with several renowned scholars emerging. Notably, Yang, Huilin has significant influence in the field with 7 published papers. Additionally, teams represented by Zhang, Kai and Liu, Hao have also made their own contributions, with 3 papers each in the field. These scholars have made important contributions to the development of bone cement treatment for vertebral compression fractures through their research, gradually forming a collaborative research group. Their research provides strong support for the theory and practice in this field and is of great significance for further promoting its development.
- The core journals publishing papers in this field are *International Orthopaedics* and *Journal of Orthopaedic Surgery and Research*.
- Through co-occurrence and clustering analysis of keywords, several stable themes have emerged in the field of bone cement treatment for vertebral compression fractures. Keywords such

as “balloon kyphoplasty,” “bone cement “and” percutaneous vertebroplasty” are frequently mentioned, representing the main methods of treatment. The frequent mention of these keywords indicates that these methods are widely studied and explored in the field. Researchers are dedicated to improving these techniques, studying their efficacy and safety, and exploring related diagnostic and therapeutic methods. These stable themes provide a clear direction for researchers, driving progress and innovation in the field of bone cement treatment for vertebral compression fractures.

- Co-citation analysis of authors reveals that research hotspots in this field are continuously evolving. A detailed analysis of the annual rings of highly cited authors’ literature can further understand the trends of hotspot changes, and it is noted that several authoritative scholars in the field have emerged, such as Rachelle Buchbinder and Klazen CAH, who have greatly influenced the development of this field.
- The clustering and evolution analysis of high-frequency keywords in this study can help scholars understand the focus and hotspots of research in educational management, including osteoporotic vertebral compression fracture, quality of life, osteoporotic vertebral compression fractures, surgical treatment, bone cement, cemented vertebrae, vertebral compression fracture, clinical efficacy, and percutaneous kyphoplasty. Osteoporotic vertebral compression fracture has long been a central topic, leading to various surgical techniques, material improvements, and auxiliary method upgrades, serving as a bridge linking other disciplines and facilitating interdisciplinary research. Percutaneous kyphoplasty, a minimally invasive orthopedic technique developed after the advancement of bone cement, has played a significant role in the treatment of OVCF since its inception. These high-frequency focus points and research hotspots are hoped to provide guidance for scholars in selecting research topics.
- This study has analyzed the core journals and authors in the field of bone cement treatment, which can assist scholars in quickly identifying relevant literature for reference during their research. Additionally, it provides a degree of guidance for scholars when selecting journals for submitting papers on this topic.

Conclusion

In conclusion, we have reason to believe that bone cement, as an emerging bone repair material, is increasingly being applied to osteoporotic vertebral compression fractures, and hold a promising future in this era of continuous change. Therefore, this study still holds significant meaning and value for further deepening. In future research, it is essential to integrate literature from multiple databases to ensure the comprehensiveness of the selected data and actively communicate with scholars in the field of educational management to understand the latest developments. This will enhance and deepen the objective understanding of the field, leading to a more objective and rational perception of the research area.

On the other hand, this study also has certain limitations. Firstly, the scope of articles considered for this visual analysis was limited to the WOS Core Collection, excluding literature from other databases such as CNKI, PubMed, Embase, and Scopus, which may overlook some

relevant research domestically and internationally. However, the WOS database is still widely accepted for its outstanding quality and is one of the most suitable databases for visual analysis. Secondly, the sample of articles spans from January 1, 2004, to December 31, 2023, which may miss some recently published high-quality core SCI journal articles due to its time specificity. Despite these limitations, the analysis results can still provide valuable references and research ideas for researchers and doctors in the OVCF field.

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