Observational Study

Medicine

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Mapping knowledge structure and themes trends in geriatric spine surgery

A bibliometric analysis

Guang-Xun Lin, MD, PhD[a,b], Chien-Min Chen, MD, PhD[c,d,e,*], Hong-Qi Liu, MD[f], Ming-Tao Zhu, MD, MS[g]

Abstract

To analyze the status, hotspots, and frontiers of spine surgery in the geriatric using bibliometric method, the Web of Science Core Collection was searched for all papers concerning the use of spine surgery in the elderly from January 1, 1982 to August 3, 2022. VOSviewer and R software were used to perform the bibliometric analysis, which included retrieving the country, institution, author, journal, and keyword. A total of 663 articles were identified. The investigation revealed a growing number of publications over the past 20 years. The country with the highest number of publications was the United States (195 papers). The institution with the highest number of publications was the University of California (31 papers). H. Hassanzadeh and A. Jain were the most productive authors (14 publications), while R. A. Deyo was the most co-cited author. The journal with the most published papers was *Spine* (67 papers). According to Bradford Low, *Spine*, *World Neurosurgery*, and *European Spine Journal* were core journals in the field of geriatric spine surgery. The most recent trend topic was "readmission," "vertebroplasty," "kyphoplasty," "risk," "osteoporosis," "outcomes," "surgery," "complications," "scoliosis," and "management." In particular, osteoporosis has been a topic of attention in the field of geriatric spine surgery since 2005. Over time, research on spinal surgery in the elderly and allied topics has grown in importance and scope, indicating a tendency toward globalization. Researchers should pay more attention to the outcomes, complications, and management associated with spine surgery in the elderly.

Abbreviations: DVT = deep vein thrombosis, PKP = percutaneous kyphoplasty, PVP = percutaneous vertebroplasty, WoS = Web of Science.

Keywords: bibliometric, elderly, geriatric, spine surgery, VOSviewer

1. Introduction

As global life expectancy steadily increases leading to an increased number of older people (>60 years old) worldwide, the number of age-related diseases, such as degenerative spinal pathologies, is subsequently increasing.[1–4] Degenerative spinal changes accompany advanced age, including osteophyte growth and protrusion or herniation of the intervertebral discs, which can lead to spinal stenosis.[5–7] Clinical symptoms vary, but this age-related, progressive illness produces chronic pain and functional impairment, which limit the mobility and capacity to conduct activities of daily living.[8,9] In properly selected individuals, surgical spinal intervention for degenerative spinal diseases can relieve pain and improve the quality of life of elderly patients. Thus, the number of elderly patients requiring surgery is likely to increase. Accordingly, research on spinal surgery in geriatric patients is becoming increasingly available.

Bibliometrics is a technique for assessing the development patterns and hotspots of published articles and study subjects using mathematical and statistical methodologies.[10] Systematic bibliometric analysis entails collecting articles from many sources and analyzing the trends in the literature, study foci, and distributions, as well as forecasting research frontiers, using a set of systematic statistical methodologies.[11] Based on the bibliometric concept, VOSviewer and R (package bibliometrix) software can conduct visual and systematic research on clinical

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[a] Department of Orthopedics, The First Affiliated Hospital of Xiamen University, School of Medicine, Xiamen University, Xiamen, China, [b] The Third Clinical Medical College, Fujian Medical University, Fuzhou, China, [c] Division of Neurosurgery, Department of Surgery, Changhua Christian Hospital, Changhua, Taiwan, [d] Department of Leisure Industry Management, National Chin-Yi University of Technology, Taichung, Taiwan, [e] School of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan, [f] Department of Orthopedics, Zhangpu Country Hospital, Zhangzhou, China, [g] Department of Neurosurgery, The First Affiliated Hospital of Xiamen University, School of Medicine, Xiamen University, Xiamen, China.

** Correspondence: Chien-Min Chen, Division of Neurosurgery, Department of Surgery, Changhua Christian Hospital, No. 135, Nanxiao Street, Changhua City 500209, Taiwan (e-mail: 96015@cch.org.tw).*

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issues and identify the key scholars, institutions, and nations in a specific topic, as well as the collaborative relationships that exist between them. Keyword or term co-word analysis can reveal worldwide research patterns and issue hotspots. Furthermore, co-citation analysis might reveal the scientific basis of the topic and produce visual knowledge maps.

No bibliometric study was discovered on geriatric spine surgery after reviewing the literature to date. Therefore, this study aimed to comprehensively assess the current status of spinal surgery research and progress on related research topics in the elderly and identify trends and frontier issues to help fill the vacuum of bibliometric analysis on this topic.

2. Method

2.1. Data collection and search strategy

Data were acquired using a sophisticated search method from the Web of Science (WoS) Core Collection database, which is frequently used in bibliometric research. All articles published between January 1, 1982 and August 3, 2022 on the topic of spinal surgery in the elderly were searched regardless of language or document type. The studies were carefully vetted by 2 independent observers based on their titles and abstracts. The following was the search strategy: ([spine surgery] OR [spinal surgery] OR [discectomy] OR [decompression] OR [laminectomy] OR [interbody fusion] OR [pedicle screw] OR [foraminoplasty] OR [vertebroplasty] OR [kyphoplasty] OR [corpectomy] OR [deformity] OR [osteotomy] OR [disc replacement OR [interspinous device] OR [atlantoaxial fixation]) AND ([elderly] OR [older] OR [geriatric]).

2.2. Data analysis

All documents were obtained and exported as plain text files for records and cited references. Each bibliographic record contains the title, author, abstract, keywords, and references, as well as other pertinent analytical data. A WoS-based literature analysis was undertaken to obtain the general information on yearly output, authors, journals, institutions, countries, languages, and sources. After removing duplicates, VOSviewer and R software were used for quantitative analysis of total literature, analysis of author, institution, regional influence and collaborative relationships, and analysis of keywords and co-citation relationships. We use VOSviewer and R (bibliometrix) software for data extraction, descriptive statistics, co-occurrence creation, data normalization, and visualization mapping.

The node size in the visual network diagram shows the degree of co-occurrence or citation frequency. Node connections represent collaboration, co-occurrence, and co-citation relationships. The thickness of the connections and the distance between nodes indicate the degree of cooperation between countries, institutions, and authors.

Statistics of high-frequency keywords over the years to discover research hotspots and trends.

3. Results

3.1. Publication output

Based on the search formula, 991 papers were initially screened, and then carefully reviewed by 2 independent reviewers, 663 papers related to this topic were finally selected. The possibility of spine surgery in the elderly has been continually investigated over the last 40 years. Researchers have become more interested in spine surgery in the elderly, and several fundamental scientific studies and clinical trials have been concurrently conducted. Figure 1 depicts a general increasing trend in the number of annually published papers from 1982 to August 3, 2022, with average annual growth rate of 9.05%. We can roughly divide it into 3 periods: 1982 to 2000 is a relatively stable period; 2000 to 2014 is the first explosion of the number of papers, which can be considered as a period of rapid growth; 2014 to present ushers in the explosion of the number of papers, compared with the previous rapid growth period, the number of papers published is more and more ferocious. The number of papers published in 2020 is the highest until August 2022, with 66 papers published. The number of publications has significantly increased each year, indicating that research related to spine surgery in the elderly has been growing and more studies are being conducted.

3.2. Distribution of countries/regions

Table 1 shows the top 10 countries by corresponding author with the highest number of publications in the field of geriatric spine surgery. The United States produced the most publications (195 articles [29.4%]), followed by China (139 articles [21.0%]), Japan (76 articles [11.5%]), South Korea (57 articles [8.6%]), and Germany (35 articles [5.3%]). It can be assumed that these countries have a greater influence in the field of geriatric spine surgery. As shown in the map of international cooperation between relevant countries/regions in Figure 2A, cooperation between the United States and the top 10 countries

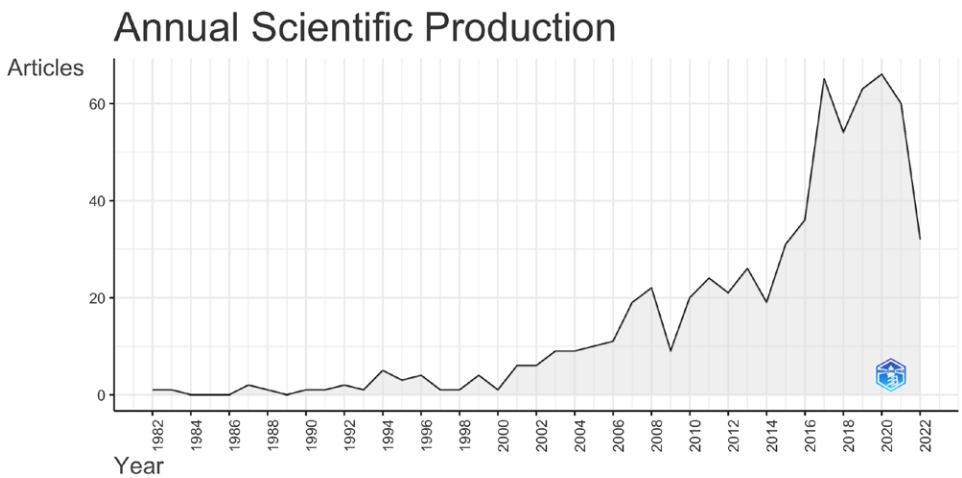

Figure 1. The annual trends of publications.

Table 1

The top 10 countries/regions by corresponding author with the highest number of publications in the field of geriatric spine surgery.

Rank	Country	Documents
1	USA	195
2	China	139
3	Japan	76
4	South Korea	57
5	Germany	35
6	Turkey	19
7	Israel	18
8	France	17
9	Canada	13
10	Italy	12

of influence is mostly frequent, with closer cooperation with China, Japan, and Germany.

3.3. Analysis of institutions

Table 2 shown the top 10 institutions with the most publications in the field of geriatric spine surgery. Of the 663 publications, most were published by the University of California (31 articles [4.7%]), followed by Yonsei University (24 articles [3.6%]), University of Virginia (23 articles [3.5%]), Johns Hopkins University (21 articles [3.2%]), and Capital Medical University (20 articles [3.0%]). As shown in the visual map of inter-institutional collaboration in geriatric spine surgery presented in Figure 2B, intra-regional inter-institutional collaboration is relatively frequent, but inter-country collaboration is more lacking.

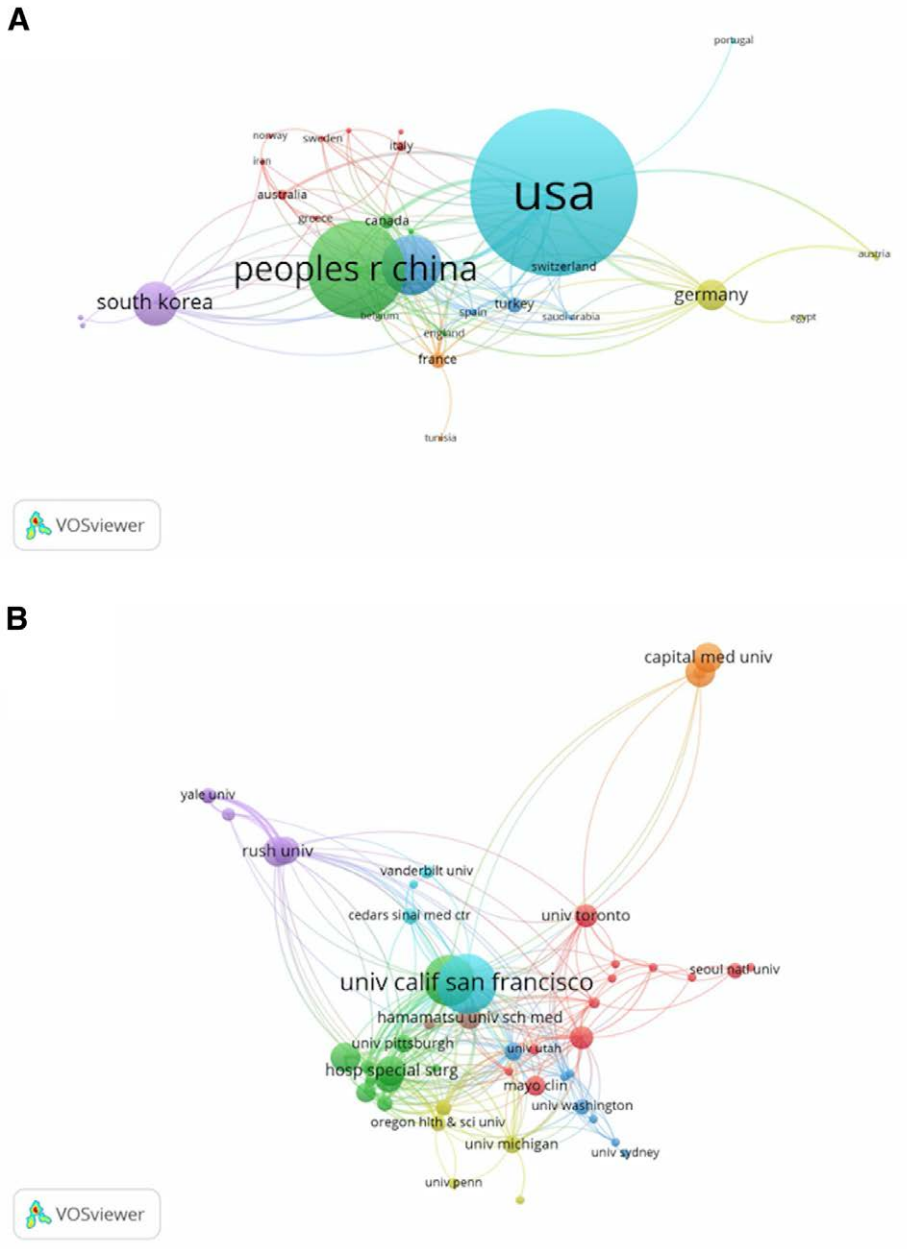

Figure 2. (A) Cooperation of productive countries. (B) Co-operation network of productive institutions.

Table 2

The top 10 institutions with the highest number of publications in the field of geriatric spine surgery.

Rank	Affiliation	Country	Documents
1	University of California	USA	31
2	Yonsei University	South Korea	24
3	University of Virginia	USA	23
4	Johns Hopkins University	USA	21
5	Capital Medical University	China	20
6	Hamamatsu University	Japan	15
7	Duke University	USA	14
8	Seoul National University	South Korea	14
9	University of Toronto	Canada	14
10	Rush University	USA	13

3.4. Analysis of journals

Figure 3A shown the top 10 journals with the most publications in the field of geriatric spine surgery. Of the 663 articles about spine surgery in the elderly, the most were published in *Spine* (67 articles [10.1%]), followed by *World Neurosurgery* (44 articles [6.6%]), *European Spine Journal* (29 articles [4.4%]), *Journal of Neurosurgery: Spine* (23 articles [3.5%]), and *Neurosurgery* (23 articles [3.5%]). According to Bradford Low (Fig. 3B), *Spine*, *World Neurosurgery*, *European Spine Journal*, *Journal of Neurosurgery: Spine*, *Neurosurgery, Global Spine Journal*, and *Journal of Korean Neurosurgical Society* are core journals in the field of geriatric spine surgery. Articles published in these core journals received greater attention, and thus were cited more frequently than articles published in other journals.

3.5. Analysis of authors

Figure 4A shown the top 10 authors with the most publications in the field of geriatric spine surgery. The most productive authors were H. Hassanzadeh (14 of 663 articles [2.1%]) and A. Jain (14 of 663 articles [2.1%]), followed by Y. Matsuyama (12 articles [1.8%]), V. Puvanesarajah (12 articles [1.8%]), and C. I. Shaffrey (12 articles [1.8%]). According to the author co-citation analyses visual map (Fig. 4B), the authors formed multiple research clusters, with different colors denoting the various clusters. Each cluster was radiated by several core authors, and the authors had fewer connections between the clusters, indicating less collaboration in this field.

To find major authors in the co-citation network of a discipline, author co-citation analysis is frequently utilized. In general, authors who are frequently cited in the field of geriatric spine surgery are more influential. More references to an author are represented by a larger node (Fig. 4C). The most co-cited author is R. A. Deyo.

3.6. Analysis of citations

The top 10 most cited articles are listed in Table 3. These articles received the most and least number of citations, 897 and 124, respectively. Of the 10 most cited articles, 9 were from the United States, the remaining 1 was from Japan. Six articles were published in *Spine*. Analyzing the given references will provide the knowledge basis for this topic.

3.7. Analysis of keywords and research hotspots

Keywords can appropriately reflect the focus of research over time. Summarizing high-frequency keywords and strong-burst keywords in a paper can help summarize the progress of research frontiers and emerging ideas.

The Word Cloud in Figure 5A displays the 50 most frequent keywords. The more centrally located and voluminous the keyword is, the more frequently it occurs. The most cited keywords in the field of geriatric spine surgery were "outcomes," "complications," "surgery," "mortality," and "management."

With regard to these co-occurring keywords, we conducted clustering analysis. These clusters highlighted the subjects that have received the greatest attention in the study on geriatric spine surgery to date. A density visualization map for keywords with a co-occurrence of more than 10 times was created, as depicted in Figure 5B.

From the 663 publications, 1494 keywords were filtered out and examined by Bibliometrix (R software). As shown in Figure 5C, "readmission," "vertebroplasty," "kyphoplasty," "risk," "osteoporosis," "outcomes," "surgery," "complications," "scoliosis," and "management" were the most recent trend topics. Among them, osteoporosis has been a topic of attention and focus in the field of geriatric spine surgery since 2005.

4. Discussion

A bibliometric analysis and visualization of the field of geriatric spine surgery was performed using VOSviewer and R software. Our findings give insight into spine surgery in the elderly, as well as some useful information. We have seen a rapid growth in the number of publications over the last 20 years. In particular, 2014 to date has seen a surge in the number of papers published. The United States and the University of California were the most productive country and institution, respectively. *Spine* was the core journal of the field of geriatric spine surgery. The most productive authors were H. Hassanzadeh (14 of 663 articles [2.1%]) and A. Jain (14 of 663 articles [2.1%]). The most co-cited author is R. A. Deyo. The most cited keywords in the field of geriatric spine surgery were "outcomes," "complications," "surgery," "mortality," and "management." Osteoporosis has been a topic of attention and focus in the field of geriatric spine surgery since 2005. The most recent trend topics were "readmission," "vertebroplasty," "kyphoplasty," "risk," "osteoporosis," "outcomes," "surgery," "complications," "scoliosis," and "management."

It can be noticed that the number of papers in the field of geriatric spine surgery has significantly started to increase since 2000. Population aging is an inevitable consequence of the demographic transition and an important issue facing human society in the 21st century. Many researchers are dedicated to this specialized research topic and have achieved more meaningful scientific results, which is indirectly manifested by the increase in the number of publications. Minimally invasive spine surgery has evolved rapidly in the last decade and is widely used throughout the world.

The various advantages of minimally invasive spine surgery can be useful in elderly patients, such as the benefits of minimal tissue trauma, less bleeding, high operative precision, and rapid postoperative functional recovery. Obviously, there has been a surge in publications in the field of geriatric spine surgery in the last decade. The improvement of health management systems and the improved writing abilities of surgeons are also an underlying factor.

Distribution analyses in countries/regions, institutions, and authors might aid in boosting collaboration and worldwide cooperation on this subject. Making the greatest use of available resources to maximize efficiency is also beneficial for researchers. North America (the United States and Canada), East Asia (China, Japan, and South Korea), West Asia (Turkey and Israel), and Europe (Germany and Italy) were among the top productive and influential countries. The number of publications was the highest in the United States. Most of the top 10 contributing institutions and authors in spine surgery in the elderly are from the United States. Among them, the top 5 institutions

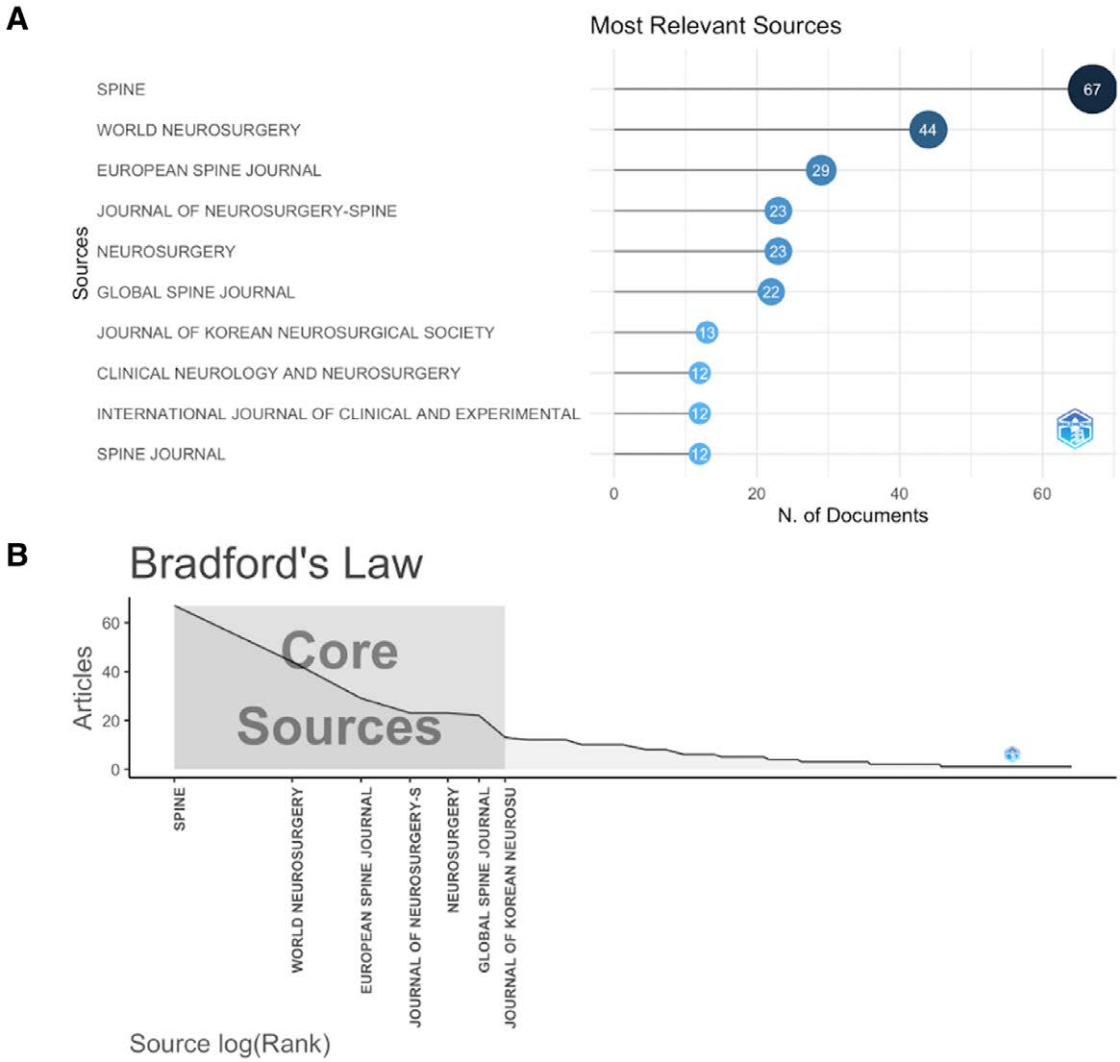

Figure 3. (A) The top 10 journals with the most publications in the field of geriatric spine surgery. (B) Using Bradford law of scattering to identify the core journals of geriatric spine surgery.

and authors are most from the United States. Additionally, of the 10 most cited articles, 9 were from the United States. In addition, contacts between these researchers and institutions within the United States were frequent. It can be argued that the United States has made a large academic contribution to the field of geriatric spine surgery, due to the powerful economic base of the United States, as well as a considerable investment in research.[11,12] Fast economic growth has contributed to increased funding for the medical industry (the United States National Institutes of Health is the most important source of funding) and a corresponding increase in research output. In addition, China has a large population with a large number of patients with spinal disorders who can participate in research; and Chinese spine surgeons are becoming more adept at writing and publishing papers.[13,14] Furthermore, Japan, South Korea, and Germany, as established economic powers, have a more balanced development in various fields, as well as in the field of geriatric spine surgery, and their influence should not be underestimated.

With the most publications, the University of California and has made the most essential academic contributions to spine surgery in the elderly. Of the top 10 institutions in terms of number of publications, 5 are from the United States, 2 are from Korea, and the remaining 3 are each from China, Japan, and Canada. In summary, the core competencies of the United States, China, South Korea, Japan, and Germany in the field of geriatric spine surgery can be demonstrated once again.

Among the top 10 most prolific authors, 6 were from the United States, 3 were from Japan, and 1 was from Israel. H. Hassanzadeh and A. Jain (Johns Hopkins University, USA) were the most prolific authors in this field, with the highest number of publications. In addition, V. Puvanesarajah also from Johns Hopkins University, was in third rank with 12 papers. Interestingly, these authors were from the same institution and were coauthors on most of the papers. The most co-cited author is R. A. Deyo from Oregon Health and Science University (USA).

The journal analysis might assist researchers in selecting relevant journals for paper submission. The top 5 journals (*Spine*, *World Neurosurgery*, *European Spine Journal*, *Journal of Neurosurgery: Spine*, and *Neurosurgery*) published 28.1% of the publications, while the top 10 journals published 43.1% of the publications. Of the top 10 most cited articles, 6 articles were published in *Spine*. It is certain that *Spine* is the most influential journal in the field of geriatric spine surgery, indicating that papers related to spine surgery in the elderly published in *Spine* will receive the most attention. In addition, based on Low of Bradford, *Spine*, *World Neurosurgery*, *European Spine Journal*, *Journal of Neurosurgery: Spine*, *Neurosurgery*, *Global Spine Journal*, and *Journal of Korean Neurosurgical Society* are core journals in the field of geriatric spine surgery. The majority

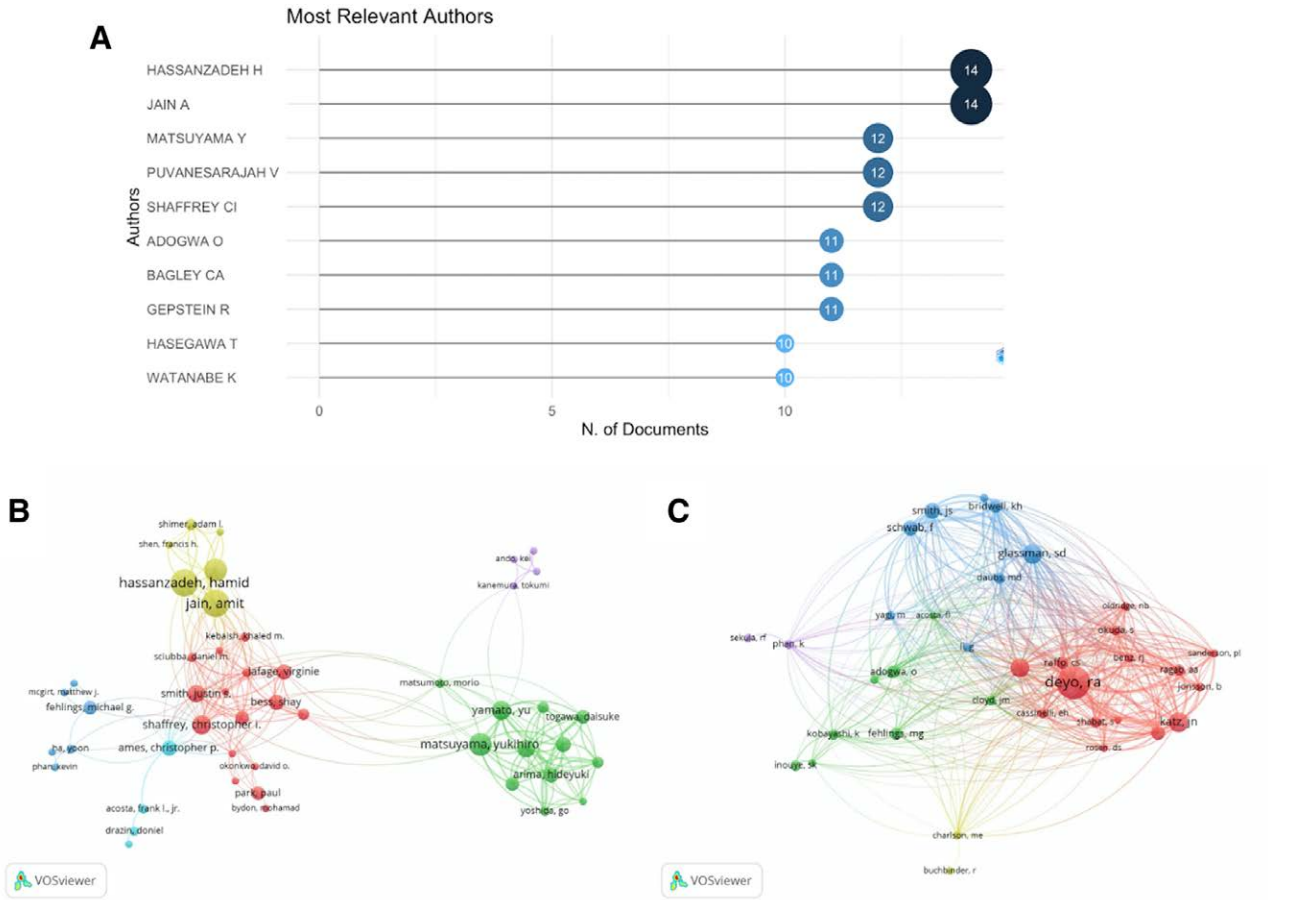

Figure 4. (A) The top 10 authors with the most publications in the field of geriatric spine surgery. (B) Co-operation network of productive authors. (C) Co-operation network of cited authors.

of these journals are core journals in the fields of geriatric spine surgery, and they should be followed to keep up with important research trends.

Keywords represent not just the authors' study emphasis and outcomes, but also the research trends. A crucial basis for analyzing the evolution of essential phrases in spinal surgery in the elderly was the investigation of popular research. We discovered the most important hot spots in the field during the previous 40 years using a co-word analysis of keywords. "Osteoporosis" has been a topic of attention and focus in the field of geriatric spine surgery since 2005. As the population ages, osteoporosis and the resulting fractures are increasing, posing a serious threat to the health of middle-aged and elderly people. The symptoms of osteoporosis itself are not visible in daily life, but a fall or fracture can lead to serious problems. An osteoporotic vertebral compression fracture is the most serious result of osteoporosis and can cause sudden back pain and some morphological changes such as kyphosis and height loss. Nonsurgical treatment is the traditional recommended pain management treatment for osteoporotic vertebral compression fracture. However, depending on the level of pain and the degree of vertebral collapse, surgical treatment is used, with minimally invasive procedures being the most advanced and percutaneous vertebroplasty (PVP) or percutaneous kyphoplasty (PKP) being the most used minimally invasive procedures. PVP and PKP both obtain therapeutic effects by injecting bone cement, which stabilizes fractured trabeculae and improves vertebral mechanical conduction after solidification; improves the strength and stability of the anterior mid-column and relieves the irritation of nerve endings; forms mechanical support for the injured spine and improves the biomechanical properties of the spine. PVP is a relatively simple operation, in which bone cement is injected directly into the injured vertebra via the pedicle or laterally to strengthen the injured vertebral body, correct the posterior convexity deformity, and prevent the aggravation of collapse. Theoretically, it has little effect on the repositioning of the compressed vertebral body. The difference between PKP and PVP is that PKP injects bone cement into the relatively closed bony space formed by the expansion, which allows the height of the vertebral body to be reset and the kyphosis to be corrected.

Based on the most cited keywords in the field of geriatric spine surgery, the main research hotspots can be broadly categorized as "outcomes," "complications," and "management." It is evident that the main concerns of researchers in the field of geriatric spine surgery are clinical safety and effectiveness, complications, and perioperative and postoperative management of elderly patients.

In elderly patients, surgical safety is paramount; however, the elderly patients' own higher number of medical comorbidities and poorer bone quality may lead to an increased incidence of perioperative complications.[15] Previous studies have shown that increased medical comorbidities, increased intraoperative blood loss, and longer hospital stays are associated with an increased incidence of perioperative complications.[16,17] In addition, the high proportion of malnutrition in elderly patients can cause a decrease in basal immunity and predispose them to wound infections, poor wound healing, and lung infections. In addition, elderly patients with degenerative spine disease have a long course, and the imaging is mostly multi-level degenerative changes, with atypical physical signs, and some patients have combined hip and knee disease, which makes the surgical plan more difficult to develop.

Table 3

Top 10 most cited articles in the field of spine surgery in the elderly.

Rank	Title	Authors	Institution of the corresponding author	Country of the corresponding author	Journal	Year	Citation
1	Trends, Major Medical Complications, and Charges Associated with Surgery for Lumbar Spinal Stenosis in Older Adults	R. A. Deyo et al	Oregon Health and Science University	USA	JAMA-Journal of the American Medical Association	2010	897
2	Perioperative complications of posterior lumbar decompression and arthrodesis in older adults	L. Y. Carreon et al	Norton Hospital	USA	Journal of Bone and Joint Surgery-American Volume	2003	423
3	Adult spinal deformity surgery - Complications and outcomes in patients over age 60	M. D. Daubs et al	Washington University	USA	Spine	2007	327
4	Defining Spino-Pelvic Alignment Thresholds Should Operative Goals in Adult Spinal Deformity Surgery Account for Age?	R. Lafage et al	NYU Langone Medical Center	USA	Spine	2016	180
5	Surgery of the lumbar spine for spinal stenosis in 118 patients 70 years of age or older	A. A. Ragab et al	Case Western Reserve University	USA	Spine	2003	145
6	Surgical outcomes of posterior lumbar interbody fusion in elderly patients	S. Okuda et al	Osaka University	Japan	Journal of Bone and Joint Surgery-American Volume	2006	140
7	Predicting morbidity and mortality of lumbar spine arthrodesis in patients in their ninth decade	C. S. Raffo et al	Georgetown University	USA	Spine	2006	139
8	Risk factors for the development of perioperative complications in elderly patients undergoing lumbar decompression and arthrodesis for spinal stenosis - An analysis of 166 patients	E. H. Cassinelli et al	University Hospitals Spine Institute	USA	Spine	2007	133
9	Minimally invasive lumbar spinal decompression in the elderly: Outcomes of 50 patients aged 75 years and older	D. S. Rosen et al	University of Chicago	USA	Neurosurgery	2007	127
10	Balloon kyphoplasty for symptomatic vertebral body compression fractures results in rapid, significant, and sustained improvements in back pain, function, and quality of life for elderly patients	S. R. Garfin et al	University of California	USA	Spine	2006	124

In elderly patients, surgical opportunities are limited, and a precise surgical treatment is crucial. Previous studies have shown that nerve root block can clarify the responsible segment in patients with multi-segmental degeneration, thus enabling precise treatment, reducing surgical trauma and damage to spinal stability, reducing operative time and bleeding, and ensuring surgical outcomes and safety in elderly patients.[18,19] In addition, there is a great deal of controversy regarding the surgical treatment of the spine in patients of advanced age. In theory, minimally invasive techniques allow for precise release of compression with less trauma. Spine surgery requires a minimally invasive and precise operating concept throughout the procedure. Since spine surgery is mostly performed in the prone position and the operation takes a long time, it can lead to an increase in intraocular pressure causing optic nerve ischemia, while abdominal compression can lead to poor inferior vena cava reflux and increased paravertebral venous reflux, so care is needed to avoid ocular compression and abdominal suspension and to reduce abdominal compression in order to reduce bleeding in the operative area. Intraoperative operations should be standardized, and bipolar electrocoagulation should be routinely used for intravertebral surgery to reduce injury and bleeding; appropriate use of microscope-assisted techniques or head-mounted surgical magnification facilitates magnification of the surgical field, enhances the light source in the operative area, and reduces neurovascular injury. For spinal surgery, the use of intraoperative neurophysiological monitoring is beneficial to improve the safety of surgery. However, the limited decompression range of minimally invasive surgery can, to a certain extent, aggravate lumbar instability and lead to a high postoperative recurrence rate. Therefore, complete decompression, firm fixation, and reliable fusion have also been suggested.[1] For elderly patients with limited surgical opportunities, complete decompression in a single operation should be the preferred treatment option.

Previous paper has noted complication rates for spine surgery in older patients ranging from 2.5% to 80%, although there are differences in patient populations, surgical indications, and surgical techniques.[1] In another previous study, 34,418 patients (65 years of age or older) undergoing lumbar spine surgery in the elderly were found to have an overall inhospital mortality rate of 0.52%, with surgery-related mortality in patients over 80 years of age being twice as high as in patients 65 to 69 years of age.[20] In our previous research, we reviewed 76 patients who underwent single-segment minimally invasive transforaminal lumbar disc fusion and found no statistical difference in complication rates between patients older than 65 years and those younger than 65 years (17.07% vs 14.29%).[21]

Recently, we can use the enhanced recovery after surgery concept to decrease perioperative physiological and psychological traumatic stress, complications, and achieve fast recovery, which is a series of perioperative and postoperative management approaches that rely on evidence-based medical data.[22–24] *(1) Preoperative education*: preoperative education is an important component of accelerated rehabilitation surgery, and preoperative knowledge of the neurophysiology of pain can lead to better postoperative outcomes for patients undergoing spinal surgery. Elderly patients can suffer from chronic pain, deformity, and dysfunction, which can affect their psychological health, and psychological disorders can affect their pain relief.[25,26] The impact of psychological status on the patient's quality of life is even greater than that of the physical illness itself, while depression itself can manifest itself as somatic pain, numbness, weakness and other discomforts, which should be distinguished during treatment.[27] Moreover, elderly patients often have reduced respiratory function, and preoperative respiratory exercises can improve lung function. Anterior cervical spine surgery often results in postoperative pharyngeal discomfort or dysphagia due to intraoperative strain. Preoperative tracheal nudge exercises can reduce the occurrence of postoperative dysphagia. *(2) Preoperative preparation and evaluation*: the spine specialist

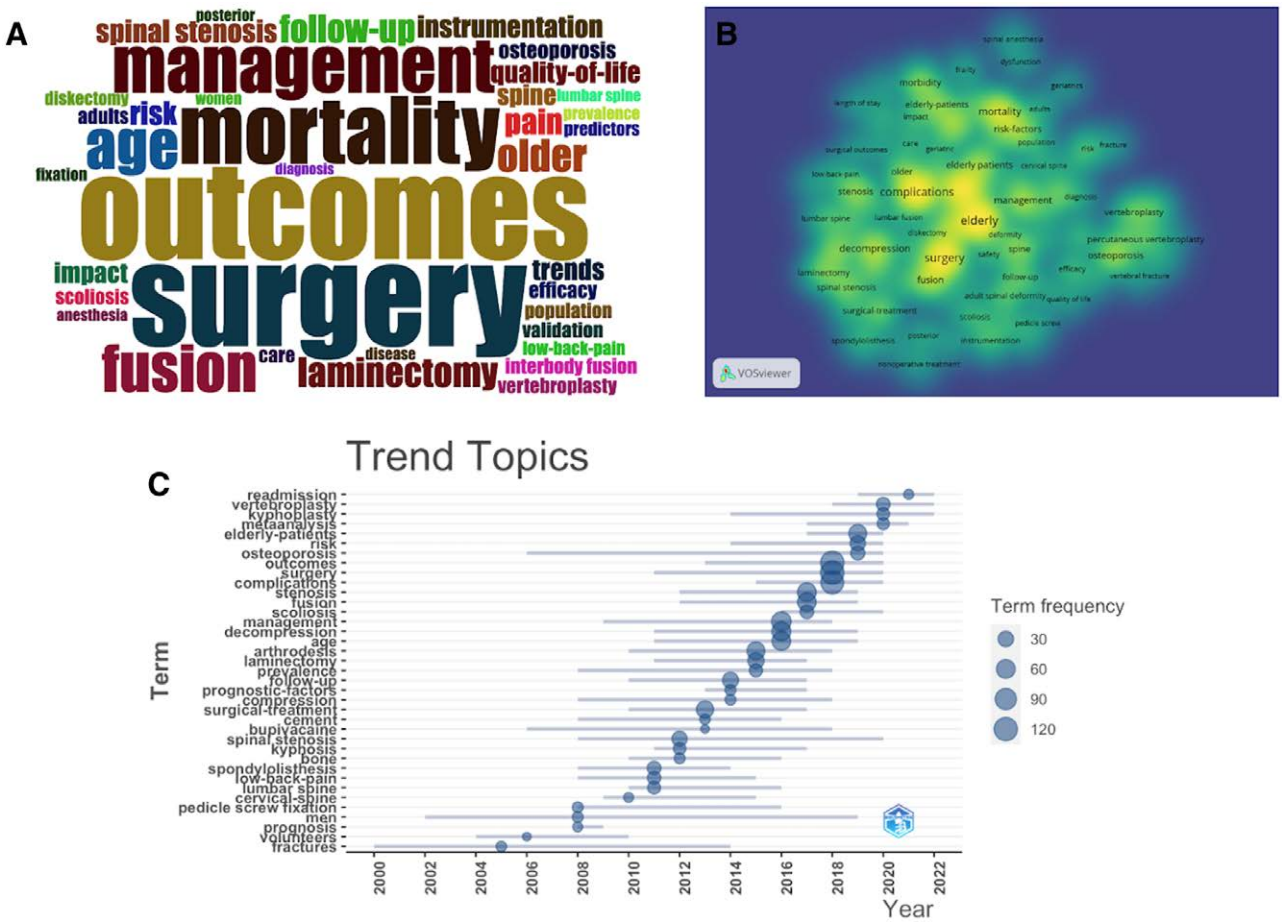

Figure 5. (A) The Word Cloud in displays the 50 most frequent keywords. (B) A density visualization map for keywords with a co-occurrence of more than 10 times was created. (C) Trend topics.

combines the symptoms, signs and symptoms of the elderly patient, preoperative routine examination, multidisciplinary assessment results, and the patient's and family's willingness to operate to develop a surgical plan, and discusses with the multidisciplinary team treatment model team to develop a phased, individualized rehabilitation plan to accelerate the patient's postoperative recovery. *(3) Surgical anesthesia*: the purpose is to objectively evaluate the tolerance and risk of anesthesia and surgery in elderly patients and to make recommendations for preoperative preparation in order to maximize the patient's tolerance for anesthesia and surgery and reduce the risk of perioperative complications and death. In addition to the multidisciplinary assessment described above, a more comprehensive understanding of the patient's condition based on the American Society of Anesthesiologists (ASA) classification, the presence of a suspected difficult airway, and endotracheal assessment is recommended.[28] Furthermore, most spine surgeries are performed with general anesthesia, and the traditional preoperative water fast of 6 to 8 hours may lead to patient discomfort, as well as increased insulin resistance and increased protein catabolism. Currently, several national anesthesia societies have been modified to allow the consumption of a clean fluid net without solids 2 hours before surgery and 400 mL of a beverage containing 12.5% carbohydrate 2 hours before surgery to reduce preoperative hunger and thirst, reduce postoperative insulin resistance, maintain glycogen levels, reduce protein catabolism and increase postoperative muscle strength recovery, and improve patient satisfaction rates.[29,30] *(4)* Postoperative management: (a) postoperative pain, including peri-incisional and radicular pain, is more severe than other types of surgery, and therefore requires a more sophisticated perioperative pain control program. More widely used in spine surgery are perioperative analgesic protocols based on nonsteroidal anti-inflammatory drugs that promote over-the-top and multimodal analgesia.[31,32] In recent years, the use of intra-incisional and epidural infiltration and pumping of local anesthetic analgesic drugs has gained increasing attention. In cases where oral medications are contraindicated or difficult to administer, patient-controlled analgesia can achieve good analgesic effects. However, in patients without a history of opioid use, continuous basal infusion of opioids does not improve analgesia, but increases the chance of postoperative nausea and vomiting.[33] Combining multiple drugs to reduce the number of opioids and their adverse effects can effectively promote postoperative recovery. For the management of perioperative neurogenic pain, the addition of nerve repair agents, muscle relaxants and anticonvulsants to the regular use of nonsteroidal anti-inflammatory drugs in adequate amounts can improve the overall efficacy and patient satisfaction. (b) Glucocorticoids are widely used in the perioperative period of spinal surgery to suppress the inflammatory response, reduce spinal cord and nerve root edema, and improve local blood circulation.[34,35] The application of glucocorticoids before anesthesia can effectively reduce airway spasm, laryngeal edema, and other complications caused by intubation. Epidural application of hormones during discectomy reduces nerve root edema and decreases pain in the early postoperative period, but does not reduce late pain and shorten hospital stay. (c) Intravenous use of tranexamic acid for major spine surgery significantly reduces intraoperative and postoperative bleeding and transfusions and does not increase the incidence of deep vein thrombosis (DVT). (d) Paraplegia, malignancy,

advanced age, obesity, varicose veins, cerebral infarction, history of thrombosis and family history, increased D-dimer, long duration of surgery, and emergency surgery are high-risk factors for postoperative DVT and pulmonary embolism after spine surgery.[36,37] Thrombosis prevention mainly includes basic prevention, physical prevention, and pharmacological prevention. Studies have shown that physical measures such as active and passive postoperative limb activities, compression stockings, and inflatable compression devices can significantly reduce the incidence of postoperative DVT after spine surgery. (e) Epidural hematoma is a more serious postoperative complication of spine surgery and can lead to mild paralysis; therefore, it is still controversial whether to perform postoperative pharmacological prophylaxis.[38] In high-risk patients such as paraplegics and malignancies, pharmacological prophylaxis should be combined without the risk of bleeding, and pharmacological prophylaxis (mainly low-molecular heparin) should be started within 24 to 36 hours after surgery, and prophylaxis should be continued until 3 months after injury in paraplegics. (f) Leaving an incisional drain in place after spine surgery may reduce swelling in the operative area, but it may also lead to increased postoperative hemoglobin loss and increased risk of transfusion, and there is no significant effect of whether a drain is placed on incisional infection, hematoma, dehiscence, or reoperation. There is no high-level evidence to support the need for drain placement in posterior spine surgery. Cerebrospinal fluid leakage is one of the most common and sometimes unavoidable complications of spinal surgery and can be effectively managed by postoperative placement of drains after spinal surgery, but the jury is still out on whether to remove the drains early or late. (g) Postoperative indwelling urinary catheter can relieve urinary retention after spinal surgery and promote bladder function recovery, but too long postoperative indwelling urinary catheter obviously increases the incidence of urinary tract infection and is not conducive to early functional exercise, reduces patient satisfaction and prolongs hospital stay, so it should be removed as early as possible. For patients at high risk of urinary retention, such as men, advanced age, and anesthesia time over 200 minutes, the extubating time can be extended appropriately. For patients with spinal cord injury and resulting voiding dysfunction, when the hemodynamics are stable and the volume is balanced, indwelling catheterization can be stopped and intermittent catheterization can be performed as early as possible. (*5) Postoperative rehabilitation*: early postoperative functional exercise is beneficial to reduce postoperative pain, promote functional recovery, reduce complications, shorten hospitalization time, and improve patient satisfaction.[22,39] Under the principles of "improving patients' self-confidence," "leaving the bed as early as possible," "safe but not aggravating pain," "active exercise as the main and passive Under the principles of "improving patients' self-confidence," "leaving bed as early as possible," "safe but not aggravating pain," "active exercise as the main activity and passive exercise," and "adaptive start with gradual increment," a relatively individualized rehabilitation exercise program was developed, with specific items including: early postoperative adaptive training (such as toe flexion and extension, ankle pump exercise, straight leg lift, etc), spinal stability training (transverse abdominis muscle, multi-cleft muscle exercise), cardiovascular function training (balloon blowing), walking training, spinal junction area (cervicothoracic segment, thoracolumbar segment) and adjacent limb joint distraction training.

4.1. Strengths and limitations of the study

This is the first bibliometric analysis of publications in the field of geriatric spine surgery, and it has played an important role. This study thoroughly examines advances, research hotspots, and trends in geriatric spine surgery.

1. The current research, like previous bibliometric analyses, has several limitations. The first constraint is the time lag. Some newly published, high-quality studies were not included. Second, only the publications included in the WoS core library were analyzed. Thus, our findings may be incomplete. Moreover, the definition of geriatric spine varies over time and in different papers. Furthermore, while the search parameters outlined the study's topic, we cannot ensure that each item was relevant to the topic. Finally, an inherent subjective bias occurred in data interpretation while the program completed the analysis objectively. However, this study may still be utilized to explain the overall position and general direction in this sector.

5. Conclusions

Over time, research on geriatric spine surgery and allied topics has grown in importance and scope, indicating a tendency toward globalization. The most productive country and institution were the United States and the University of California, respectively. The most influential and core journal was *Spine*. H. Hassanzadeh and A. Jain were the most productive authors, while R. A. Deyo was the most co-cited author. Since 2005, "osteoporosis" has been a topic of attention and focal point in the field of geriatric spine surgery, including its derivative topics such as "vertebroplasty" and "kyphoplasty." The main topics of concern for researchers in the field of geriatric spine surgery are clinical outcomes (including surgical safety and efficacy), complications, and perioperative and postoperative management of elderly patients.

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Author contributions

Conceptualization: Ming-Tao Zhu.
Software: Ming-Tao Zhu.
Supervision: Chien-Min Chen, Hong-Qi Liu.
Writing – original draft: Guang-Xun Lin.
Writing – review & editing: Chien-Min Chen.

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