



Worldwide research productivity in the field of full-endoscopic spine surgery: a bibliometric study

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Abstract

Purpose To investigate the quantity and quality of articles in the field of full-endoscopic spine surgery (FESS) from different countries and assess characteristics of worldwide research productivity.

Methods Articles published from 1997 to July 23, 2018, were screened using the Web of Science database. All studies were assessed for the following parameters: the number of total publications, h-index, contribution of countries, authors, journals, and institutions.

Results A total of 408 articles were identified between 1997 and 2018. Between 1997 and 2017, the number of published articles tended to increase by 41 times. The largest number of articles was from China (30.15%), followed by South Korea (28.68%), the USA (13.97%), Germany (9.31%), and Japan (4.90%). The highest h-index was found for articles from South Korea (23), followed by the USA (18), Germany (16), China (11), and Japan (7). The highest number of articles was published in *World Neurosurgery* (12.50%), followed by *Pain Physician* (10.29%), *Spine* (6.62%), *European Spine Journal* (4.66%), and *Journal of Neurosurgery: Spine* (4.17%). Wooridul Spine Hospital published the largest number of articles (10.29%), followed by Tongji University (5.88%), University of Witten/Herdecke (5.39%), Brown University (5.15%), and Third Military Medical University (3.43%).

Conclusions The number of articles published in the field of FESS has increased rapidly in the past 20 years. In terms of quantity, China is the most contributive country based on the number of publications. High-quality papers as measured by h-index and the large quantity is from South Korea (second only to China).

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.

Key points

1. Spine
2. Full-endoscopic spine surgery
3. Research productivity
4. Bibliometric analysis

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Figure: Map of worldwide research productivity from 1997 to 2018 (July 23)

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Take Home Messages

1. The number of articles published in the field of full endoscopic spine surgery has increased rapidly in the past 20 years.
2. China is the most productive country in terms of total publications while South Korea is the highest productive country measured by h-index.
3. High-quality papers as measured by h-index and the large quantity is from South Korea (second only to China).

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Keywords Spine · Endoscopic spine surgery · Research productivity · Bibliometric analysis

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Extended author information available on the last page of the article

Introduction

Full-endoscopic spine surgery (FESS) has very limited surgical space, constantly irrigation, maintaining visibility and working channel which allows the passage of endoscopic armamentarium for bleeding control, radiofrequency, laser, endoscopic burr, and small forceps. With groundwork built over half a century, FESS has emerged as a new alternative surgical technique for open surgery, based on its background knowledge, safety and efficacy, cost-effectiveness, and advanced surgical tools to treat a myriad of spine pathologies, including prominent lumbar disk herniation, spinal stenosis, and fusion surgery [1–4]. Research in the field of FESS has made great progress in recent years. However, scientific contribution to the field of FESS is different for various countries [5].

Bibliometric analysis can be used to study the growth, development, and dissemination of any area of research. It also provides various quantitative and qualitative indicators of scientific achievement and authors' influence. The volume of publications and the number of citations are important indicators of research contributions. They can be used as core parts of scientific research. In recent years, this method for assessing the productivity of worldwide research has been increasingly carried out in various medical fields [5–10]. However, bibliometric study in the field of FESS research has not been reported yet. Therefore, the purpose of this study was to determine characteristics of national productivity in the field of FESS research. This study may try to study the relative frequency of its practice with regard to geography and come out with possible reasons and speculation for the present distribution and trends. Results of this study can provide surgeons and researchers with insights into the state of worldwide research. Concurrently, the continuing study may establish the reasons for the current patterns.

Materials and methods

A computerized literature search against database of Web of Science (WoS) (Thomson Reuters, New York, USA) was conducted on July 23, 2018. WoS platform is the world's leading database for collecting citations and other academic impacts. It has been used in previous similar studies [7, 11]. Articles published in WoS-cited journals from 1997 to July 23, 2018, were collected. Only original articles and reviews were included while letter, editorial material, and correction were excluded. If multiple institutional affiliations were listed, the source nation would be considered the country of the corresponding author. This

study collected articles on full-endoscopic spine surgery only. Microendoscopic spine surgery and thoracoscopic spine surgery were excluded. The database was searched using the following terms: “percutaneous endoscopic spine surgery,” “endoscopic cervical discectomy,” “endoscopic cervical foraminotomy,” “endoscopic thoracic discectomy,” “endoscopic lumbar discectomy,” and “endoscopic lumbar laminotomy.” “Microendoscopic spine surgery” or “thoracoscopic spine surgery” were excluded.

We collected the following information for analysis: total publications and trends contributed by worldwide FESS research from 1997 to July 23, 2018, countries' contribution and h-index, top five productive authors, top five journals, top five institutions, and top ten cited articles.

Primary outcomes were the number of articles and h-index contributed by each country. To reveal contributions of different countries, these countries were ranked according to their productivities. The quantity of research productivity was based on the number of articles published by different countries, while the quality of research productivity was evaluated based on h-index and citations. The h-index is the number of articles (n) in a country that have been cited at least n times up to date [10, 12].

Statistical analysis

For significant changes in trends between 1997 and 2018 (July 23), regression analysis was performed. All statistical analyses were performed using SPSS version 23.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was considered at $P < 0.05$.

Results

A total of 504 articles on FESS were identified in WoS database as the result of search. With an additional manual screening according to the inclusion criteria, a total of 408 articles were identified finally. The total number of annual articles was increased significantly (41-fold) from 1997 ($n = 2$) to 2017 ($n = 82$) ($P < 0.05$). The number of articles published in each year has increased. In 2016, the number of articles published was 3.8 times that of 2015 (Fig. 1). A total of 28 countries contributed to the field of FESS research. China published the largest number of articles (30.15%; 123/408), followed by South Korea (28.68%; 117/408), the USA (13.97%; 57/408), Germany (9.31%; 38/408), and Japan (4.90%; 20/408) (Fig. 2). Among the 28 countries that published papers in the field of FESS research, South Korea had the highest h-index (23), followed by the USA (18), Germany (16), China (11), and Japan (7) (Table 1).

Figure 3 shows a map of worldwide research productivity.

Fig. 1 Publications in the field of full-endoscopic spine surgery from 1997 to 2018 (July 23)

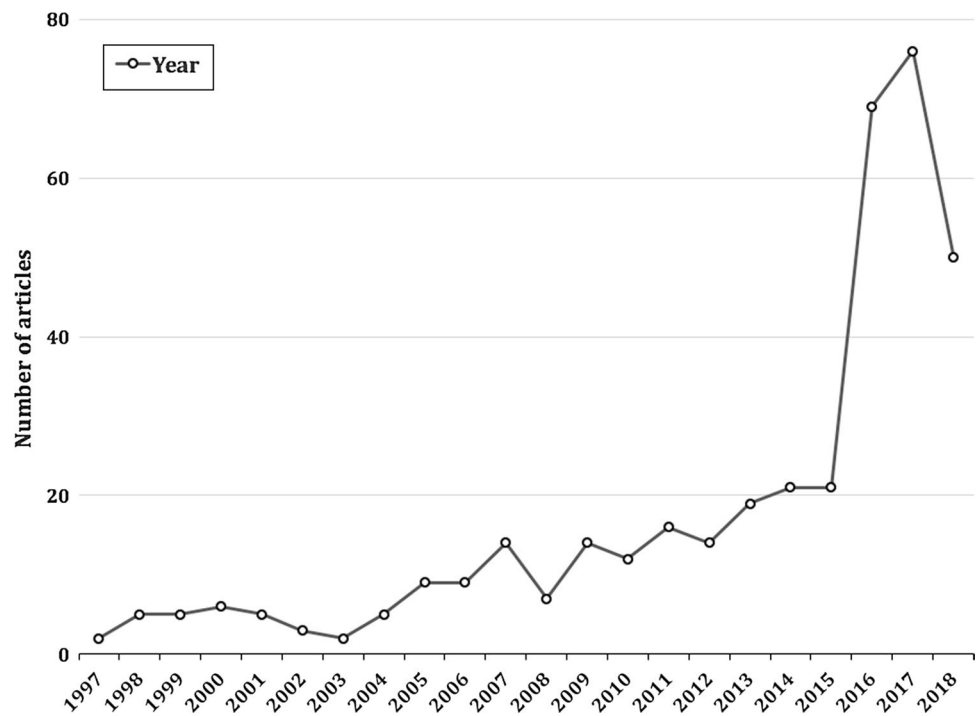


Fig. 2 Time trend for the number of articles from top five countries from 1997 to 2018 (July 23)

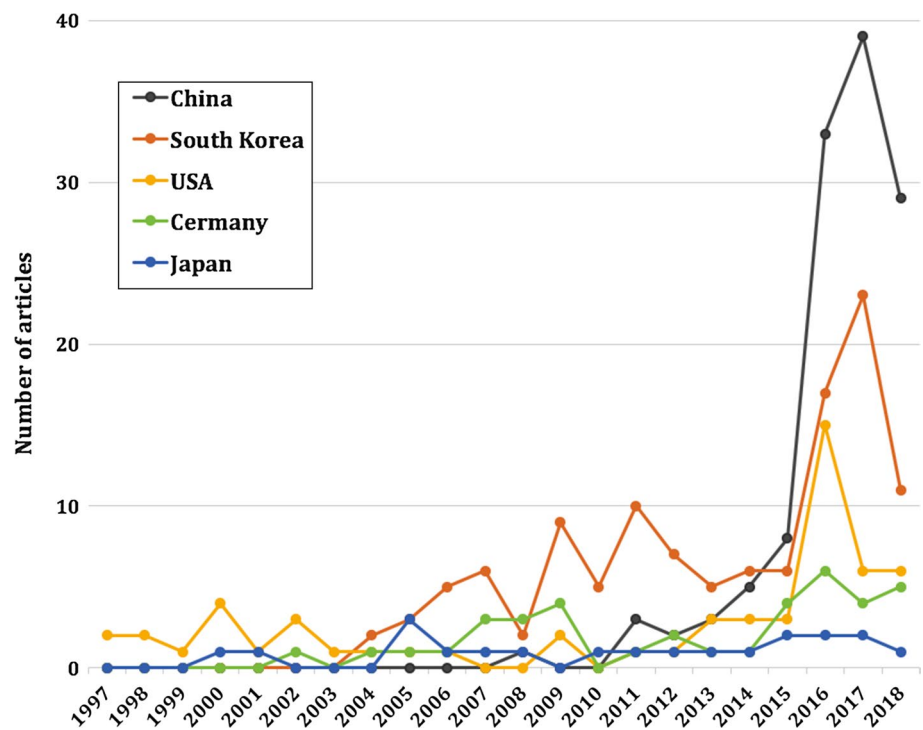


Table 2 shows publication ranking of the top five journals. *World Neurosurgery* (12.50%; 51/408) published the largest number of articles in the field of FESS research, followed by *Pain Physician* (10.29%; 42/408), *Spine* (6.62%; 27/408), *European Spine Journal* (4.66%; 19/408), and *Journal of Neurosurgery: Spine* (4.17%; 17/408).

The top five most productive institutions in the field of FESS are summarized in Table 3. A total of 123 publications were from these institutions. Wooridul Spine Hospital published the largest number of articles (10.29%; 42/408), followed by Tongji University (5.88%; 24/408), University of Witten/Herdecke (5.39%; 22/408), Brown University

Table 1 Top five countries contributed to research publications in full-endoscopic spine surgery field

Rank	Country	Number	%	h-index
1	China	123	30.15	11
2	South Korea	117	28.68	23
3	The USA	57	13.97	18
4	Germany	38	9.31	16
5	Japan	20	4.90	7

(5.15%; 21/408), and Third Military Medical University (3.43%; 14/408).

The top five most productive authors in FESS research field are shown in Table 4. Three of them were from South Korea, one was from Germany, and the other one was from the USA.

The top ten cited articles are shown in Table 5. The highest number of citations for an article in the field of FESS research was 229. Six of these top ten cited articles were published in the journal of *Spine*, while the remaining four articles were each published in *Journal of Neurosurgery: Spine*, *Mount Sinai Journal of Medicine*, *Journal of Neurosurgery*, and *European Spine Journal*.

Discussion

Scientific publications provide new knowledge in certain area. They can also be used as indicators of research productivity to assess the contribution of countries to research in certain area around the world. The method of using bibliometric to assess worldwide research productivity has been

Table 2 Top five journals in full-endoscopic spine surgery field

Rank	Journals	Number	%
1	World neurosurgery	51	12.50
2	Pain physician	42	10.29
3	Spine	27	6.62
4	European spine journal	19	4.66
5	Journal of neurosurgery: spine	17	4.17

Table 3 Top five productive institutions in full-endoscopic spine surgery field

Rank	Institution (Country)	Number	%
1	Wooridul Spine Hospital (South Korea)	42	10.29
3	Tongji University (China)	24	5.88
2	University of Witten/Herdecke (Germany)	22	5.39
4	Brown University (USA)	21	5.15
5	Third Military Medical University (China)	14	3.43

used in many areas of biomedical research [6–12]. FESS research has made great progress in recent years. To the best of our knowledge, the current study is the first bibliometric assessment of worldwide productivity in the field of FESS research.

Results of the present study showed that the number of FESS publications was increased significantly from 1997 to 2018. This indicates that the development of FESS research has a rapid stage of progress in recent years. The overall publication trends from different countries are different. The authors found that 87.01% of total articles were published by the top five countries, suggesting that worldwide research results of FESS were concentrated in some

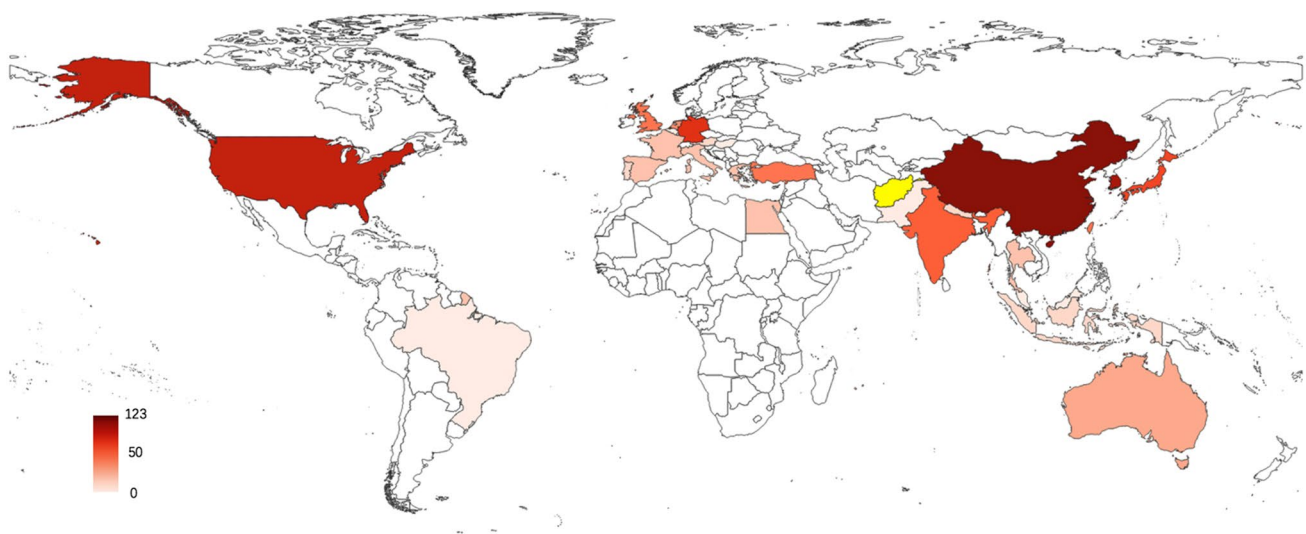
**Fig. 3** Map of worldwide research productivity from 1997 to 2018 (July 23)

Table 4 Top five productive authors in full-endoscopic spine surgery field

Rank	Authors	Number	%	Affiliation
1	Lee SH	48	11.65	Department of Neurosurgery, Wooridul Spine Hospital, Seoul, South Korea
2	Ahn Y	24	5.83	Department of Neurosurgery, Gil Medical Center, Gachon University, Incheon, South Korea
3	Ruetten S	22	5.34	Department of Spine Surgery and Pain Therapy, St. Anna Hospital Herne, University of Witten/Herdecke, Herne, Germany
4	Telfeian AE	21	5.09	Department of Neurosurgery, Rhode Island Hospital, The Warren Alpert Medical School of Brown University, Rhode Island, USA
5	Kim JS	19	4.61	Department of Neurosurgery, Seoul St. Mary's Hospital, The Catholic University of Korea, Seoul, South Korea

Table 5 Top ten cited articles in full-endoscopic spine surgery field

Rank	Title (year)	Author	Journal	Citations
1	Posterolateral endoscopic excision for lumbar disk herniation—Surgical technique, outcome, and complications in 307 consecutive cases (2002)	Yeung AT et al.	Spine	229
2	Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique—A prospective, randomized, controlled study (2008)	Ruetten S et al.	Spine	187
3	Percutaneous endoscopic lumbar discectomy for recurrent disk herniation: Surgical technique, outcome, and prognostic factors of 43 consecutive cases (2004)	Ahn Y et al.	Spine	97
4	Use of newly developed instruments and endoscopes: full-endoscopic resection of lumbar disk herniations via the interlaminar and lateral transforaminal approach (2007)	Ruetten S et al.	Journal of Neurosurgery: Spine	92
5	Full-endoscopic cervical posterior foraminotomy for the operation of lateral disk herniations using 5.9-mm endoscopes—A prospective, randomized, controlled study (2008)	Ruetten S et al.	Spine	84
6	The evolution of percutaneous spinal endoscopy and discectomy: State of the art (2000)	Yeung AT et al.	Mount Sinai Journal of Medicine	79
7	Transforaminal percutaneous endoscopic discectomy in the treatment of far-lateral and foraminal lumbar disk herniations (2001)	Lew SM et al.	Journal of Neurosurgery	77
8	Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: A prospective randomized study in 280 consecutive cases (2006)	Hoogland T et al.	Spine	76
9	Transforaminal endoscopic surgery for symptomatic lumbar disk herniations: a systematic review of the literature (2001)	Nellensteijn J et al.	European Spine Journal	75
10	Operative failure of percutaneous endoscopic lumbar discectomy: A radiologic analysis of 55 cases (2006)	Lee SH et al.	Spine	75

countries. The top research institutions were all from the top five productive countries in the field of FESS, and two of them were from China. A small number of major countries have released most of major research results, similar to other medical fields. Within these countries, a single or a couple of institutions provide the “national-endoscopic-publication-output.” Also, within these institutions, whenever you have enjoyed the opportunity to visit one or a couple of them, only a single or a couple of surgeons out of the team practice high-volume spinal endoscopy. The main reasons for differences in scientific output among countries are differences in population size, socioeconomic status, and overall research capacity [6, 11, 13]. Additionally, differences in structural

training in endoscopic spinal surgery in different countries have also played an important role in the development of FESS. In North America and Europe, formal accredited Endoscopic Spine Surgery fellowship programs are lacking, and only a few mentorship programs exist that are the centers of clinical expertise. The authors of this publication were interested in better understanding what distinguishes endoscopic spine surgeons in Asian countries with respect to training background, practice patterns, and motivators from surgeons residing in other countries and whether or not they performed endoscopic spine surgery at a higher degree of sophistication and innovation. Spinal endoscopy is more frequently adopted by Asian surgeons residing in

China, Japan, and South Korea, who also seem to perform it at a higher self-reported skill level and employ it to a more significant percentage of their clinical practice. Endoscopic spine surgery training in Asia seems better formalized, while surgeons in North America and Europe are still left to wonder where and under whose mentorship to train for these advanced endoscopic procedures as industry-sponsored weekend cadaver workshops rarely can go beyond introducing the endoscopic instrumentation, and basic surgical technique, and offer little in the way of teaching appropriate diagnostic workup, surgical indications, management of complications, and procedural steps commensurate with the clinical context of the various common lumbar degenerative conditions.

The results showed that China and South Korea have far more research studies in the field of FESS than other countries. Particularly, the number of publications in China has soared in the past 2 years. China has an advantage in recruiting patients with spinal diseases for high participation based on its large population [14, 15]. The spine unit has become an independent department in many general hospitals in China. China also has the largest number of spine surgeons. Their ability of conducting and writing their works has also improved [16–19]. On the other hand, the rapid growth of economy has promoted the increase in funds in the medical field, correspondingly improving research results, as well as incentives and perks at academic practices may have driven publications in South Korea and China. [20, 21]. In South Korea, due to aging of the population and development of endoscopic surgical tools, development of FESS has become more and more obvious in recent years. The national medical insurance system has also played an important role in the development of FESS [22, 23]. Such development of FESS is directly reflected in the quantity and quality of publications. The number of publications from South Korea is only second to China. However, the h-index of publications from South Korea is twice as high as China. South Korea has the highest h-index, much higher than any other countries. This indicates that the quality of FESS research originating from South Korea is the highest. South Korea is the country with the most productivity, not only in quantity, but also in quality. On the contrary, China had the largest quantity, but not the highest quality. Interestingly, as with any new surgical instrument and method gaining prevalence and becoming standard as an accepted tool to treat lumbar spinal diseases, academic training has been initiated by key opinion leaders (KOL) in North American Spine Society (NASS) and AOSpine by organizing workshops under the umbrella of endoscopic experts in South Korea, Germany, the USA and China. In Asia, National and International Organizations such as the Korean Minimally Invasive Spine Society (KOMISS), World Congress of Minimally Invasive Spinal Surgery and Technology (WCMISS), and the Pacific and

Asian Minimally Invasive Spine Society (PASMIS) have also begun to integrate cadaver workshops and symposia on spinal endoscopy as well into the core curriculum. Those academic and practical activities above seem to be the main reason why South Korea, China, and other Asian countries have prevailed the academic works of endoscopic spine surgery as well.

Although the USA has been a leader in many biomedical fields, it is not a leader in the field of FESS. At least the number of publications from the USA is less than that from China or South Korea. In addition, quality of publications from the USA is lower than that from South Korea. This may be related to reimbursement and other economic considerations, the USA the code for endoscopic spine procedures came in 2017, and most of the insurance does not reimburse optimally for endoscopic spine surgeries. In addition, the publication may in itself be a poor indicator of the increase in the number of endoscopic procedures. The country like India, there is a surge in the endoscopic spine procedures, but publications are poor as there are no incentives for publications. At the same time, the government needs to get coverage for citizens with the National Health Service Fund, which is related to why it has not shown many publications in the field of FESS in Canada, Britain, and Australia. Then we can notice by the same logic why there are not many publications from India and Brazil.

The number of citations is further used to identify hot spots and trends in the field of FESS, as shown in the top ten articles cited. Interestingly, there was no article from China in the top ten cited articles. The USA published three of ten top cited articles. This might demonstrate that the USA also plays an important role in the field of FESS. In addition, Germany published four of ten top cited articles with middle-quantity publications. This finding further proves that the influence of FESS research from Germany cannot be ignored. Regarding the top five productive authors in the field of FESS, this study found that three of the five top productive authors were from South Korea. This study also found that most articles were published by multiple authors. Among the top five productive authors, three authors from South Korea were related to each other. They appeared as co-authors in many articles. Such kind of correlation has also been observed in other articles. This could be considered a strategic mutual beneficial approach.

Spine has published six of ten top cited articles. However, no articles have been published in *World Neurosurgery* which has the largest number of articles published in the field of FESS research. This indirectly suggests that articles published in *Spine* may be more influential.

The present study has some limitations. First, we used WoS database to search for FESS research. Therefore, articles published in non-WoS-cited journals were not included. Second, despite our additional manual screening, selection

bias was inevitable. Third, although widely used, citation numbers do not fully reflect the quality of an article. Fourth, although search methods in this study attempted to include all subject terms associated with FESS, some high-impact articles might have been missed.

Conclusion

This study is the first survey report on the quantity and quality of publications in the field of FESS. The current study proves that the number of publications in the field of FESS has increased rapidly in recent years. Most of endoscopic spine publications are limited to a few countries and institutions. China and South Korea have made rapid progress in FESS research. They have significantly increased their contribution to the field of FESS. China is the most productive country in terms of total publications, while South Korea is the highest productive country measured by h-index. South Korea is the country with the highest productivity, not only in quality, but also in quantity. However, contributions of the USA and Germany cannot be underestimated. For gaining prevalence worldwide, the insurance models and their effects on the practice of endoscopic spine surgery should be investigated.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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