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SPINE RESEARCH

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The 20 most important core concerns for novices in endoscopic spinal surgery among Chinese doctors

An exploratory sequential mixed-methods study

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Abstract

Background: Spinal endoscopic surgery has been the most rapidly developing subspecialty in the field of spinal surgery in the past decade, with explosive growth in the number of operations. The learning curve of spinal endoscopic surgery is steep, and the issues of concern at the beginning of training are not clear.

Materials and methods: This study utilized an exploratory sequential mixed-methods design in 2 stages. In phase 1, concerns were collected by openly and qualitatively listing questions from their stance among 110 novices in endoscopic spinal surgery and were analyzed by using the content analysis approach with the assistance of Nvivo software. In phase 2, qualitative results were sequentially transformed into constructs and items for the Delphi survey questionnaire. Two rounds of e-Delphi were conducted among Chinese experts in endoscopic spinal surgery to identify the 20 most important core concerns of novices.

Results: The 20 most important core questions were mainly focused on facet arthroplasty (2 items), structural identification under a microscope (2 items), lateral treatment of spinal stenosis (6 items), and judgment of nucleus pulposus removal (4 items). The average score of the importance of each question ranged from 8.57 to 8.93 points.

Conclusions: The 20 most important core questions in the early stage of endoscopic spinal surgery were identified by a panel of spinal endoscopic surgery doctors with rich surgical experience and a stellar reputation in China, including surgical procedures and details, as well as the indications of spinal endoscopy, perioperative management, retreatment of postoperative symptoms, and even the treatment of cervical spondylosis and degenerative spinal diseases such as lumbar spinal stenosis.

Abbreviation: CV = coefficient of variation.

Keywords: Delphi method, endoscopic spinal surgery, novice

1. Introduction

Minimally invasive and endoscopic surgery is the inevitable trend of development. Spinal endoscopic surgery has been the most rapidly developing subspecialty in the field of spinal surgery in the past decade, with explosive growth in the number of operations. The indications for such surgery have gradually expanded from lumbar disc herniation to cervical, thoracic, and lumbar degenerative diseases. The annual volume and depth of spinal endoscopic surgery performed by Chinese doctors far surpasses that in other countries worldwide.[1,2]

However, in the process of rapid development, many problems such as the following need to be addressed:

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Supplemental Digital Content is available for this article.

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Spine Research (2025) 1:2;90–98

Received: 20 April 2025 / Accepted: 28 July 2025

http://dx.doi.org/10.1097/br9.0000000000000009

Key Points

1 An exploratory sequential mixed-methods study was performed to identify the core concerns for novices in endoscopic spinal surgery among Chinese doctors.
2 The 20 core concerns for the early development of spinal endoscopic surgery consist of surgical procedures and details, the indications of spinal endoscopy, perioperative management, retreatment of postoperative symptoms, and even the treatment of cervical spondylosis and degenerative spinal diseases.
3 These concepts are beneficial for novices ascending the learning curve and can provide guidance for training in endoscopic spinal surgery techniques, at least in China.
4 This exploratory sequential mixed-methods design offers a feasible model for the promotion of other new technologies.

(1) Orthopedic,neurosurgery, pain medicine, interventional medicine, and other disciplines perform such surgeries individually, which causes the understanding of technology and training methods to vary greatly; (2) the single-person operation mode of spinal endoscopic surgery and the lack of an ideal teaching and training model makes the learning curve uniquely "steep"; and (3) in the period of rapid development of the discipline, top experts focus on new technologies and methods and pay less attention to the core problems and "traps" in the initial stage of technology development.[3–8]

To address this situation, we organized experts who had experience comprising many years and a large number of spinal endoscopic surgeries in the Chinese mainland to carry out a survey integrating qualitative listing and quantitative 2 rounds of E-Delphi letter consultation to identify the 20 most important questions for the early development of spinal endoscopic surgery that would be beneficial for "novices" to smoothly cross the curve and provide direction for the follow-up education and training courses of experts.

2. Methods

An exploratory sequential mixed-methods design was utilized in this study to reach consensus on the 20 most important core questions in the early stage of endoscopic spinal surgery.[9] As mentioned in the published protocol, in phase 1, the concerns for novices in endoscopic spinal surgery were collected by openly and qualitatively listing questions from their stance and then analyzed by using an inductive content analysis approach. In phase 2, qualitative results were sequentially transformed into survey components, constructs, and items for the Delphi survey questionnaire. Two rounds of e-Delphi were conducted among Chinese experts who had performed endoscopic spinal surgery for a long period comprising a large number of surgeries to identify the 20 most core concerns from novices. Detailed methods, including the participants, sample size, data collection, and analysis, were conducted following the previously published protocol.[9]

2.1. Qualitative data collection and analysis

Qualitative data were collected by openly listing the participants' concerns regarding full-endoscopic spinal surgery from 110 spinal endoscopic surgery novices working at Peking University Third Hospital and other areas in Chinese mainland. Qualitative data were analyzed using content analysis approach to develop a categorized database with assistant of NVivo software[10] (NVivo 11 pro). Each question was classified into the same category by key nodes, and then merged into 1 question item according to the same meaning of each one. Themes and questions were constructed to form the questionnaire for sequentially Delphi survey in stage 2.

2.2. Quantitative data collection and analysis

In the first-round survey, 115 experts and 210 junior spinal endoscopic doctors (introduced by 115 experts. They have been able to perform spinal endoscopic surgery independently, but not very much.) were invited to participate. A total of 83 experts representatively distributed throughout Chinese mainland were invited to participate in the second-round survey.

Expert selection criteria (first round)

1. Engaged in spinal endoscopy for more than 5 years and with a certain reputation in the field of spinal endoscopy.
2. More than 100 endoscopic operations performed in 1 year.
3. Support and willingness to participate in this research.
4. Completion of multiple rounds of correspondence.

Expert selection criteria (second round)

1. More than 200 endoscopic operations were performed in 1 year.
2. The rest of the criteria are the same as in the first round.

2.3. First-round survey

The first-round instrument comprised the invitation letter and the questionnaire. The invitation letter extended a warm invitation to the consultation panelists and briefly introduced the significance, scheme, and matters for attention in this consultation project. The questionnaire was composed of 2 sections. The first section included basic information and professional discipline of the participant. The second section consists of refined questions from qualitative data.

The panelists were asked to assess the importance of each question using a 9-point Likert scale, with 0 indicating definitely not important and 9 indicating definitely important.[11] Blank areas were left for participants to suggest other necessary question items. We clearly defined the meaning of the "most important core" as follows: a higher score meant that the evidence-based answer to this

question would be crucial for novices of Full Endoscopic Spine Surgery to successfully complete the learning curve and avoid risks in the actual operation. The working group sent and recycled questionnaires by e-mail. In both rounds, we sent up to 3 reminders in cases of nonresponse.

The first-round survey was conducted from March 15 to May 20 in 2021.

2.4. Second-round survey

The second-round survey took place between June 10, 2021, and August 15, 2021. Participants who completed the first round were invited to the second-round survey. The questionnaire consisted of 50 questions chosen by at least 20% of panelists in the first round.

The items were sorted from highest to lowest by frequency of the full score (9 points) for each round. Kendall's coefficient (*W*) was calculated by SPSS 25.0 to analyze the agreement among the panelists in terms of the most important questions.[9]

3. Results

3.1. Demographics of experts in each phase of this study

A total of 110 participants in phase 1 were novices in spinal endoscopic surgery, and all decided to pursue a career in spinal endoscopy. They had a certain understanding and concept of endoscopic spine surgery. Two-thirds of them had participated in the surgery, very few of them could operate independently, but with number of operation less than 20. There are 115 experts, 210 junior spinal endoscopy doctors participated in the first-round consultation, and 83 experts participated in the second round. The basic information included demographic data, professional information, practice status and practice environment (Table 1). The average age of experts in 2 rounds was 45.5 and 45.2 years, and the average years of working in spinal endoscopy were more than 8.22 and 8.47 years, respectively. The effective response rates in the 2 rounds of expert evaluation were 93.91% and 80.72%, respectively, and the average authority level was 0.96.

3.2. Qualitative result

In total, 591 questions were collected from open lists among 110 spinal endoscopic surgery novices. Twenty-seven themes (Table 2) and 145 questions were refined by using content analysis approach to sequentially form the Delphi survey questionnaire.

3.3. Quantitative result from Delphi survey

3.3.1. Active degree of experts. The effective response rates of expert questionnaires in 2 rounds were 93.91% and 80.72%, respectively. In the first round, 210 junior physicians' questionnaires were collected, with 204 valid questionnaires. Invalid questionnaires were referred to be with no outline, large areas of the same outline or missing outlines. In addition, self-filled information from experts that did not meet the selection criteria, such as insufficient annual surgical volume, has also been deemed invalid (Table 1). Overall, the invited experts were highly motivated.

3.3.2. Degree of expert authority. The average authority coefficients of experts in the 2 rounds were 0.96 ± 0.104 and 0.96 ± 0.052, respectively, and that of junior physicians was 0.83 ± 0.063, indicating that participants in this study had a high degree of authority and high credibility (Table 1).

3.3.3. Degree of expert coordination. Kendall's coefficients were 0.22 ($p < 0.05$, Table, Supplemental Digital Content, https://links.lww.com/SPRES/A2) and 0.17 ($p < 0.05$, Table, Supplemental Digital Content, https://links.lww.com/SPRES/A2) in the first round of expert and junior physician letter consultation, and the coefficient of variation (CV) of each item was 0.15 to 0.34 (Table 3) and 0.2 to 0.31 (Table 4), respectively. Kendall's coefficient and CV for each item were 0.45 ($p < 0.05$, Table, Supplemental Digital Content, https://links.lww.com/SPRES/A2) and 0.04 to 0.11 (Table 5) in the second round.

3.3.4. Result of consultation on the relevant provisions. The highest frequency of the top 20 questions in the first round of expert correspondence results (9 points) was 51, while the main high-frequency items were concentrated in categories 1 (2 items), 6 (5 items), 8 (5 items), and 14 (2 items) (Table 4). The highest frequency of the top 20 questions in the first round of low seniority physician correspondence results (9 points) was 95, and the main high-frequency items were concentrated in categories 2 (2 items), 6 (4 items), 8 (5 items), 12 (2 items), 14 (2 items), and 25 (2 items) (Table 4). The highest frequency of the top 20 questions in the second round of expert correspondence results (9 points) was 63, while the main high-frequency items were concentrated in categories 1 (2 items), 6 (4 items), 8 (6 items), and 17 (2 items) (Table 5).

4. Discussion

As the most promising and fastest-growing minimally invasive spine technology,[12,13] percutaneous endoscopic spine surgery has witnessed a blowout growth in the number of operations after decades of development, from Yeung Endoscopic Spine System[14] technology and Transforaminal Endoscopic Spine System[15] technology to Full Endoscopic Spine Surgery technique,[16] and its indications also range from simple lumbar disc herniation to the treatment of spinal degenerative diseases such as spinal canal stenosis, lumbar instability and cervical spondylosis.[17–19] Although hospitals at all levels in China carry out such operations,[20] the volume and scale are small. As seen from the statistical data of this study, a large number of surgeries in China are still concentrated

Table 1

Demographic characteristics of the participants.

	Round 1		Round 2
Panelist characteristics	**Expert**	**Junior physician**	**Expert**
Total number (person)	115	210	83
Valid response (copies)	108	204	67
Valid response rate (%)	93.91	97.14	80.72
Age, y	45.5	36.6	45.2
Gender			
Male (*n*)	115	210	83
Female (*n*)	0	0	0
Professional title			
Chief physician (*n*)	59 (54.62%)	9 (4.41%)	35 (52.24%)
Associate chief physician (*n*)	42 (38.89%)	68 (33.33%)	28 (41.79%)
Attending physician (*n*)	7 (6.48%)	127 (62.25%)	4 (5.97%)
Clinical experience (years)	21.19	10.93	20.76
Clinical experience in spinal endoscopy (years)	8.22	4.09	8.47
The service department			
Spine surgery	79 (73.15%)	125 (61.27%)	52 (77.61%)
Orthopedic surgery	15 (13.89%)	43 (21.08%)	6 (8.96%)
Pain	13 (12.04%)	32 (16.66%)	9 (13.43%)
Neurosurgery	1 (0.92%)	3 (14.70%)	
Others		1 (0.49)	
Hospital Level			
Tertiary hospitals	107 (99.07%)	183 (89.71%)	66 (98.51%)
Secondary hospital	1 (0.93%)	19 (9.31%)	1 (1.49%)
Rest		2 (0.98%)	
Annual operations (case)			
< 100	0	146 (71.57%)	0
100–200	25(23.15%)	58 (28.43%)	0
200–300	27 (25%)	0	25 (37.31%)
300–400	20 (18.52%)	0	18 (26.87%)
400–500	10 (9.26%)	0	8 (11.94%)
> 500	26 (24.07%)	0	16 (23.88%)
Expert authority coefficient	0.96 ± 0.10	0.83 ± 0.10	0.96 ± 0.05

Table 2

Summary diagram of the question themes (27 Themes)

Serial number	Definition	Serial number	Definition
1	The problem of facet formation (9 items)	15	About the position of spinal endoscopic surgery (4 items)
2	About intraoperative hemostasis (10 items)	16	About the treatment of the posterior longitudinal ligament (4 items)
3	About intraoperative anesthesia (8 items)	17	About organizational structure under the microscope (3 items)
4	About the intraoperative puncture (6 items)	18	About cervical endoscopy (7 items)
5	About the ligamentum flavum (6 items)	19	About infection and antibiotic use (5 items)
6	About the end of surgery criteria (8 items)	20	About postoperative residual symptoms (3 items)
7	About postoperative rehabilitation (6 items)	21	About endoscopic fusion and internal fixation (5 items)
8	About spinal stenosis (10 items)	22	About the question of intraoperative rinse fluid (2 items)
9	About annulus fibrous treatment (6 items)	23	About inconsistencies between images and symptoms (2 items)
10	About the of approach and indication (5 items)	24	About endoscopic multilevel spinal surgery (4 items)
11	About the problem of spinal hypertension (6 items)	25	About spinal endoscopic revision (4 items)
12	About intraoperative dural sac injury (5 items)	26	About medication after spinal endoscopy (3 items)
13	About recurrence after spinal endoscopy (7 items)	27	About basic diseases of patients undergoing spinal endoscopic surgery (2 items)
14	About nerve root injury during surgery (5 items)		

in some departments of large tertiary hospitals, accounting for more than 90% of all endoscopic spine surgeries (Table 2). Therefore, for more specialists in small and medium-sized hospitals, there are still technical bottlenecks encountered when carrying out a large number of surgeries, especially regarding the technical specifications, training system and access system that are not perfect,[21,22] which makes it more difficult to complete the learning curve.

We define novices of spinal endoscopy as those who are still on the learning curve, that is, between the initial 20 to 60 surgeries.[5,23] This study discussed the technology from 2

Table 3

The top 20 full marks with frequency of results in round 1 (experts).

Serial number (full marks frequency, ranking)	Problem description	Mean (ranking)	CV
1-1 (34, 11th)	How much of the articular process should be removed? (tip, body, basis)	6.73 (46th)	0.34
1-2 (51, 1st)	What skills does joint process take shape to have?	7.79 (4th)	0.21
2-4 (33, 13th)	What are the hemostatic techniques during the operation?	6.59 (58th)	0.34
4-1 (32, 17th)	How to determine puncture points for different approaches?	7.21 (18th)	0.28
6-3 (49, 2nd)	What are the skills for picking nucleus pulposus?	7.82 (3rd)	0.18
6-4 (44, 3rd)	How to determine whether there is residual nucleus pulposus?	7.70 (5th)	0.20
6-5 (33, 13th)	Does increase the laceration or break the disc if the annulus fibrosus is larger than the nucleus pulposus?	6.93 (36th)	0.20
6-7 (37, 8th)	To what extent do the intervertebral disc, posterior longitudinal ligament, ligamentum flavum, etc., need to be treated?	7.41 (12th)	0.23
6-8 (41, 5th)	To what extent do nerve roots and dural sacs decompress?	7.63 (6th)	0.21
8-2 (33, 13th)	How to choose surgical approach for spinal stenosis?	7.27 (15th)	0.25
8-3 (42, 4th)	How to determine the scope of decompression for spinal stenosis?	7.84 (2nd)	0.16
8-5 (33, 13th)	What are the indications of spinal endoscopy for spinal stenosis?	7.54 (8th)	0.20
8-7 (35, 9th)	What are the skills for decompression of spinal stenosis?	7.86 (1st)	0.15
8-8 (35, 9th)	What are the indications and skills for ULBD?	7.51 (9th)	0.20
12-5 (32, 17th)	How to deal with cerebrospinal fluid leakage after dural sac injury?	6.71 (48th)	0.34
13-7 (32, 17th)	How long is the peak of recurrence after surgery? Associated with what factors?	7.00 (34th)	0.29
14-1 (32, 17th)	How to deal with intraoperative nerve root injury?	6.89 (39th)	0.33
14-5 (34, 11th)	What are the operational skills and precautions for the removal of extreme lateral protrusion?	7.82 (11th)	0.22
17-3 (38, 7th)	How to identify nerve root and dural sac during operation? Ligamentum flavum and intervertebral space? Vertebral body and pedicle?	7.15 (24th)	0.29
19-5 (41, 5th)	How to deal with infection after spinal endoscopy?	6.73 (10th)	0.26

CV = coefficient of variation.

Table 4

The top 20 of full marks frequency of results in round 1 (junior physician).

Serial number (full marks frequency, ranking)	Problem description	Mean (ranking)	CV
1-2 (90, 2nd)	What skills does joint process take shape to have?	7.54 (2nd)	0.24
4-1 (75, 5th)	How to determine puncture points for different approaches?	7.42 (5th)	0.24
4-4 (77, 3rd)	What should be noted at the puncture site in special cases,such as fat or extreme lateral protrusion?	7.44 (3rd)	0.24
5-2 (67, 15th)	How to deal with ligamentum flavum and nerve root, dural sac adhesion?	7.22 (15th)	0.26
6-3 (95, 1st)	What are the skills for picking nucleus pulposus?	7.69 (1st)	0.22
6-4 (76, 4th)	How to determine whether there is residual nucleus pulposus?	7.44 (4th)	0.26
6-7 (70, 12th)	To what extent do the intervertebral disc, posterior longitudinal ligament, ligamentum flavum, etc., need to be treated?	7.29 (12th)	0.24
6-8 (72, 7th)	To what extent do nerve roots and dural sacs decompress?	7.39 (8th)	0.29
8-3 (72, 7th)	How to determine the scope of decompression for spinal stenosis?	7.40 (7th)	0.25
8-5 (69, 13th)	What are the indications of spinal endoscopy for spinal stenosis?	7.27 (13th)	0.26
8-6 (71, 9th)	What are the management steps for central spinal canal stenosis and nerve root canal stenosis?	7.37 (9th)	0.24
8-7 (73, 6th)	What are the skills for decompression of spinal stenosis?	7.42 (5th)	0.27
8-8 (64, 19th)	What are the indications and skills for ULBD?	7.16 (19th)	0.24
12-4 (66, 16th)	How to prevent dural sac injury?	7.22 (16th)	0.31
12-5 (66, 16th)	How to deal with cerebrospinal fluid leakage after dural sac injury?	7.21 (17th)	0.25
14-1 (71, 9th)	How to deal with intraoperative nerve root injury?	7.37 (10th)	0.27
14-5 (71, 9th)	What are the operational skills and precautions for the removal of extreme lateral protrusion?	7.37 (10th)	0.31
19-5 (66, 16th)	How to deal with infection after spinal endoscopy?	7.18 (18th)	0.28
25-1 (68, 14th)	What are the skills for spinal endoscopic revision separation of adhesions?	7.25 (14th)	0.24
25-2 (64, 19th)	What are the indications for revision of spinal endoscopy?	7.16 (20th)	0.24

CV = coefficient of variation.

angles combined with the practical problems of novices and experienced surgeons to reach a more objective, real, and clinically meaningful understanding of Chinese endoscopic spinal surgeons. The findings can not only promote the improvement of the novices' learning curve but also provide a foundation for the construction of spinal endoscopic

Table 5

The top 20 of full marks frequency of results in round 2 (experts).

Serial number (full marks frequency, ranking)	Problem description	Mean (ranking)	CV
1-1 (58, 7th)	How much of the articular process should be removed? (tip, body, basis)	8.79 (6th)	0.07
1-2 (65, 1st)	What skills does joint process take shape to have?	8.93 (1st)	0.04
4-4 (54, 12th)	What should be noted at the puncture site in special cases,such as fat or extreme lateral protrusion?	8.73 (12th)	0.07
6-3 (59, 3rd)	What are the skills for picking nucleus pulposus?	8.84 (5th)	0.06
6-4 (59, 3rd)	How to determine whether there is residual nucleus pulposus?	8.87 (2nd)	0.04
6-7 (58, 7th)	To what extent do the intervertebral disc, posterior longitudinal ligament, ligamentum flavum, etc., need to be treated?	8.69 (13th)	0.11
6-8 (60, 2nd)	To what extent do nerve roots and dural sacs decompress?	8.79 (6th)	0.08
8-2 (54, 12th)	How to choose surgical approach for spinal stenosis?	8.78 (10th)	0.06
8-3 (59, 3rd)	How to determine the scope of decompression for spinal stenosis?	8.85 (4th)	0.05
8-5 (54, 12th)	What are the indications of spinal endoscopy for spinal stenosis?	8.67 (15th)	0.09
8-6 (51, 18th)	What are the management steps for central spinal canal stenosis and nerve root canal stenosis?	8.60 (19th)	0.10
8-7 (59, 3rd)	What are the skills for decompression of spinal stenosis?	8.87 (2nd)	0.04
8-8 (56, 9th)	What are the indications and skills for ULBD?	8.79 (6th)	0.06
11-1 (51, 18th)	How to prevent and manage myeloid hypotension-like syndrome during operation?	8.57 (20th)	0.10
12-4 (52, 16th)	How to prevent dural sac injury?	8.66 (17th)	0.08
17-1 (52, 16th)	How to manage when get lost after forming in surgery?	8.67 (15th)	0.08
17-3 (56, 9th)	How to identify nerve root and dural sac during operation, ligamentum flavum and intervertebral space, vertebral body and pedicle?	8.79 (6th)	0.06
18-1 (55, 11th)	What are the indications for endoscopic treatment of cervical spondylosis?	8.78 (10th)	0.06
19-5 (54, 12th)	How to deal with infection after spinal endoscopy?	8.69 (13th)	0.08
21-3 (50, 20th)	What are the principles and skills of endoscopic endplate treatment?	8.63 (18th)	0.09

CV = coefficient of variation.

surgery training and access systems, thereby promoting the development of minimally invasive spinal surgery.

The Delphi method is an anonymous method to widely solicit experts' opinions. After the application of many questionnaire surveys, it was utilized, modified and gradually summarized to form a basically consistent view of experts to develop a predictive and evaluative method combining qualitative and quantitative analyses for the evaluated problems.[24,25] In this study, correspondence experts were selected according to the specific operation volume, highlighting the professional authority and representativeness of experts in this field to ensure the authenticity and reliability of the correspondence results. The valid response rates of the 2 rounds of expert correspondence were 93.91% and 80.72%, and both authority coefficients were 0.9, which reflected a high level of expert enthusiasm and professionalism, indicating that the experts' judgment and opinions were based on rich theory and practice and had high reliability. The expert coordination coefficient of the second round was significantly higher than that of the first round, and the CV each item was at a relatively low level, which indicated that there was considerable consistency in the results, especially with so many experts consulted by letter.[26] The average score of the 20 most important questions in the 2 rounds of results was the lowest at 6.73, and especially all the average scores in the second round were above 8, which also showed the high level of consistency of expert opinions. It should be noted that during the first round of correspondence in this study, each expert introduced 2 junior physicians engaged in spinal endoscopy to complete the same questionnaire to compare the importance of the same problem and different problems between junior physicians and experienced surgeons. Due to the large number of expert correspondence teams, the same design was not used in the second round of correspondence.

In the results of the first round of correspondence, 14 of the 20 most important questions determined by experts and junior physicians were the same (Table 3): up to 70%, including "6. about the end of surgery criteria" (4 in total) and "8. about spinal stenosis" (4 in total). The most prominent was the question "1-2. What skills are involved in the joint process?" (Table 4). The full score frequency and ranking were 51, 1st and 90, 2nd, respectively. Experts and junior physicians both believed that it was very important to improve the learning curve. Other issues that were considered to be very important included "How to determine puncture points for different approaches?," "How to deal with intraoperative nerve root injury?" and " How to deal with infection after spinal endoscopy?." The full frequency division and ranking are relatively high (Table 3), suggesting that these issues were important and needed more consideration, speculation, and practice by novices and even their participation in some standardized training because orderly and targeted training was very meaningful for novices.[22,23] For example, the proper level of force between the instrument and the tissue was always difficult to measure in microsurgery[27] and could only be learned by the

surgeon. In particular, the operation of minimally invasive devices in the spinal canal requires more practical training.

The difference was that, for example, "the problem of the puncture point" was the initial key step of the operation[28,29]; the ranking of the 2 parts of the correspondence results was different, ranking relatively lower in the expert results (17th), while the ranking of the correspondence results of junior physicians was higher (6th). That is, the degree of emphasis was different. However, for the whole operation, whether the puncture is correct or not, it directly affects the steps of catheterization, shaping and decompression.[30] If the imaging data can be read in detail and measured carefully before the operation to fully understand the prominent position of the nucleus pulposus, whether the patient is obese or thin, the height of the iliac crest and other factors, this can facilitate successful completion of the puncture step.[7,30,31] Of course, the experience of the surgeon was also very important. After the completion of the second round of expert correspondence, among the 20 most important questions identified (Table 4), question "1-2" related to articular process shaping still ranked the highest, while the above 2 major aspects of "6." and "8." still ranked as the most important. Four items belonging to "6. about the end of surgery criteria," including the release of nerve roots, the removal of the ligamentum flavum and the removal of the nucleus pulposus, were finally selected as the most important among the 20, which should also indicate a more basic, detailed but truly important problem in the novices' learning curve. Six items belonging to "8. "Spinal stenosis" were listed as the most important among the 20 patients, which should pertain to the relatively high-level stage or the later stage of the learning curve. In addition, there were certain details and steps such as "How to prevent and manage myeloid hypotension-like syndrome during the operation," "How to prevent dural sac injury," and "How to manage getting lost after initiating surgery?" and "How can the nerve root and dural sac be identified during the operation, and how can the ligamentum flavum and intervertebral space, vertebral body and pedicle be identified?," which need to be improved through a certain amount of case training and experience involving a considerable amount of surgery.[32] Superb surgical techniques and reasonable perioperative management were also the keys to reducing the complications of spinal endoscopic surgery.[33] The questions "What are the indications for endoscopic treatment of cervical spondylosis?" and "What are the principles and skills of endoscopic endplate treatment?" ranked 11th and 20th, respectively, which were also relatively high-level problems. Surgery involving endoscopic fusion and internal fixation should not be problematic for novices in the spine endoscopy learning-curve stage but may be challenging for practitioners at a more skilled stage.[34] However, this was indeed the direction of everyone's attention and efforts. On the one hand, the development of spinal endoscopy expands the indications. On the other hand, this also suggests the application of spinal endoscopy in the treatment of cervical spondylosis and lumbar spinal stenosis in the current field of spinal surgery.[35,36] This kind of spinal degenerative disease has been routine, and it is also part of the higher level learning curve that spinal endoscopists should improve. Especially in the elderly population, there is an increasing number of patients with lumbar spinal stenosis, and the demand for minimally invasive spinal endoscopy to treat lumbar spinal stenosis will be increasingly greater, especially for patients with complications.[37,38]

5. Conclusions

In general, through the results of 2 rounds of expert letters, 20 core concerns for the early development of spinal endoscopic surgery were finally identified, including surgical procedures and details, as well as the indications of spinal endoscopy, perioperative management, retreatment of postoperative symptoms, and even the treatment of cervical spondylosis and degenerative spinal diseases such as lumbar spinal stenosis. Very clear and specific questions indicated the importance of improving the learning curve and the necessity of training during the learning curve.[23,39,40] Therefore, the findings also provided a framework and content direction for training in spinal endoscopic surgery. This is also a reminder that these important issues should become the focus of assessment when a spinal endoscopy access system is established. Of course, the more important work is that in the next step, we will organize experienced experts and scholars to systematically and carefully answer and discuss these questions to more specifically and practically solve the technical difficulties and doubts of novices. Providing a feasible model for the promotion of other new technologies will be an additional benefit.

Acknowledgments

The authors are deeply grateful to all those who participated in this project, including experienced spinal endoscopy experts and novices who will be committed to spinal endoscopy in the future.

Ethical statement

This study aims to identify the 20 most critical concerns faced by Chinese novice surgeons during early stages of endoscopic spinal surgery. Participants were provided with detailed written informed consent, outlining the purpose, procedures, risks, benefits, and data usage. Researchers strictly adhered to professional standards, ensuring ethical practices throughout the study. Data were collected scientifically, and analyzed using validated methods, while participant information remained confidential. All participants retained full rights to withdraw from the study without penalties or inconveniences.

Findings will be used solely for academic purposes, with explicit consent required before publication.

Conflict of interest

The authors have no conflicts of interest to disclose.

Funding source

This work was supported by the Capital's Funds for Health Improvement and Research (2020-2-4091) and Key Clinical Projects of Peking University Third Hospital (BYSYZD2019001 and BYSYZD2019017).

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

CL and HC had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: All authors. Acquisition, analysis or interpretation of data: CL, HC, and BH. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: CL, HC, and BH. Administrative, technical or coordinate support: BZ. Study supervision: BH and BZ.

References

[1] Xiu P, Zhang X. Endoscopic spine surgery in China: its evolution, flourishment, and future opportunity for advances. J Spine Surg. 2020;6(Suppl 1):S49–53.
[2] Lin GX, Kotheeranurak V, Mahatthanatrakul A, et al. Worldwide research productivity in the field of full-endoscopic spine surgery: a bibliometric study. Eur Spine J. 2020;29:153–60.
[3] Ahn Y, Lee S, Son S, Kim H, Kim JE. Learning curve for transforaminal percutaneous endoscopic lumbar discectomy: a systematic review. World Neurosurg. 2020;143:471–9.
[4] Hsu HT, Chang SJ, Yang SS, Chai CL. Learning curve of full-endoscopic lumbar discectomy. Eur Spine J. 2013;22:727–33.
[5] Sclafani JA, Kim CW. Complications associated with the initial learning curve of minimally invasive spine surgery: a systematic review. Clin Orthop Relat Res. 2014;472:1711–7.
[6] Jaikumar S, Kim DH, Kam AC. History of minimally invasive spine surgery. Neurosurgery. 2002;51(5 Suppl):S1–14.
[7] Ao S, Wu J, Zheng W, Zhou Y. A novel targeted foraminoplasty device improves the efficacy and safety of foraminoplasty in percutaneous endoscopic lumbar discectomy: preliminary clinical application of 70 cases. World Neurosurg. 2018;115:e263–71.
[8] Yang J, Guo C, Kong Q, et al. Learning curve and clinical outcomes of percutaneous endoscopic transforaminal decompression for lumbar spinal stenosis. Int Orthop. 2020;44:309–17.
[9] Liu C, Chu HL, Li G, et al. The 20 most important questions for novices of full-endoscopic spinal surgery in China: a mixed-method study protocol. BMJ Open. 2021;11:e049902.
[10] Dornan T, Bundy C. What can experience add to early medical education? Consensus survey. BMJ. 2004;329:834.
[11] O'Leary DP, Lynch N, Clancy C, Winter DC, Myers E. International, expert-based, consensus statement regarding the management of acute diverticulitis. JAMA Surg. 2015;150:899–904.
[12] Gokaslan ZL, Telfeian AE, Wang MY. Introduction: endoscopic spine surgery. Neurosurg Focus. 2016;40:E1.
[13] Ahn Y. Current techniques of endoscopic decompression in spine surgery. Ann Transl Med. 2019;7(Suppl 5):S169.
[14] Yeung AT. Minimally invasive disc surgery with the yeung endoscopic spine system (YESS). Surg Technol Int. 1999;8:267–77.
[15] Hoogland T, Schubert M, Miklitz B, Ramirez A. Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280 consecutive cases. Spine (Phila Pa 1976). 2006;31:E890–7.
[16] Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: a prospective, randomized, controlled study. Spine (Phila Pa 1976). 2008;33:931–9.
[17] Pan M, Li Q, Li S, et al. Percutaneous endoscopic lumbar discectomy: indications and complications. Pain Physician. 2020;23:49–56.
[18] Kim M, Kim HS, Oh SW, et al. Evolution of spinal endoscopic surgery. Neurospine. 2019;16:6–14.
[19] Wu PH, Kim HS, Jang IT. A narrative review of development of full-endoscopic lumbar spine surgery. Neurospine. 2020;17(Suppl 1):S20–33.
[20] Zhang XF, Du J, Yeung AT. Development of percutaneous endoscopic lumbar discectomy (PELD) technology in China. J Spine. 2017;06:374–6.
[21] Ahn Y, Oh HK, Kim H, Lee SH, Lee HN. Percutaneous endoscopic lumbar foraminotomy: an advanced surgical technique and clinical outcomes. Neurosurgery. 2014;75:124–33; discussion 132.
[22] Epstein S, Tran BN, Capone AC, et al. The current state of surgical ergonomics education in U.S. surgical training: a survey study. Ann Surg. 2019;269:778–84.
[23] Wang H, Huang B, Li C, et al. Learning curve for percutaneous endoscopic lumbar discectomy depending on the surgeon's training level of minimally invasive spine surgery. Clin Neurol Neurosurg. 2013;115:1987–91.
[24] Benning A, Ghaleb M, Suokas A, et al. Large scale organisational intervention to improve patient safety in four UK hospitals: mixed method evaluation. BMJ. 2011;342:d195.
[25] Odland ML, Nepogodiev D, Morton D, et al. Identifying a basket of surgical procedures to standardize global surgical metrics: an international Delphi study. Ann Surg. 2021;274:1107–14.
[26] Jorm AF. Using the Delphi expert consensus method in mental health research. Aust N Z J Psychiatry. 2015;49:887–97.
[27] Sugiyama T, Lama S, Gan LS. Forces of tool-tissue interaction to assess surgical skill level. JAMA Surg. 2018;153:234–42.
[28] Fan G, Wang T, Hu S, Guan X, Gu X, He S. Isocentric navigation of percutaneous endoscopic transforaminal discectomy at the L5/S1 level in difficult puncture cases: a technical note. Pain Physician. 2017;20:E531–40.
[29] Choi KC, Lee JH, Kim JS, et al. Unsuccessful percutaneous endoscopic lumbar discectomy: a single-center experience of 10,228 cases. Neurosurgery. 2015;76:372–80; discussion 380.
[30] Hu Z, Li X, Cui J, et al. Significance of preoperative planning software for puncture and channel establishment in percutaneous endoscopic lumbar DISCECTOMY: a study of 40 cases. Int J Surg. 2017;41:97–103.
[31] Zeng Y, Bao J, Su J, et al. Novel targeted puncture technique for percutaneous transforaminal endoscopic lumbar discectomy reduces X-ray exposure. Exp Ther Med. 2017;14:2960–8.

[32] Elkheshin SE, Soliman AY. Endoscopic interlaminar lumbar discectomy: how to decrease the learning curve. Surg Neurol Int. 2020;11:401.
[33] Xie TH, Zeng JC, Li ZH, et al. Complications of lumbar disc herniation following full-endoscopic interlaminar lumbar discectomy: a large, single-center, retrospective study. Pain Physician. 2017;20:E379–87.
[34] Yue JJ, Long W. Full endoscopic spinal surgery techniques: advancements, indications, and outcomes. Int J Spine Surg. 2015;9:17.
[35] Lee CH, Choi M, Ryu DS, et al. Efficacy and safety of full-endoscopic decompression via interlaminar approach for central or lateral recess spinal stenosis of the lumbar spine: a meta-analysis. Spine (Phila Pa 1976). 2018;43:1756–64.
[36] Yang JS, Chu L, Chen CM, et al. Foraminoplasty at the tip or base of the superior articular process for lateral recess stenosis in percutaneous endoscopic lumbar discectomy: a multicenter, retrospective, controlled study with 2-year follow-up. Biomed Res Int. 2018;2018:7692794.
[37] Yang F, Chen R, Gu D, et al. Clinical comparison of full-endoscopic and microscopic unilateral laminotomy for bilateral decompression in the treatment of elderly lumbar spinal stenosis: a retrospective study with 12-month follow-up. J Pain Res. 2020;13:1377–84.
[38] Chung AS, McKnight B, Wang JC. Scientific view on endoscopic spine surgery: can spinal endoscopy become a mainstream surgical tool? World Neurosurg. 2021;145:708–11.
[39] Mayer HM. A history of endoscopic lumbar spine surgery: what have we learnt? Biomed Res Int. 2019;2019:4583943.
[40] Pinto A, Faiz O, Bicknell C, Vincent C. Surgical complications and their implications for surgeons' well-being. Br J Surg. 2013;100:1748–55.