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Expert Consensus on Clinical Application of Lateral Lumbar Interbody Fusion: Results From a Modified Delphi Study

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Abstract

Study Design: Modified Delphi study.

Objective: The objective of this study was to establish expert consensus on the application of lateral lumbar interbody fusion (LLIF) by using the modified Delphi study.

Methods: From June 2019 to March 2020, Members of the Chinese Study Group for Lateral Lumbar Spine Surgery were selected to collect expert feedback using the modified Delphi method where 65 spine surgeons from all over China agreed to participate. Four rounds were performed: 1 face-to-face meeting and 3 subsequent survey rounds. The consensus was achieved with $\geq$a 70.0% agreement for each question. The recommendation of grade A was defined as $\geq$90.0% of the agreement for each question. The recommendation of grade B was defined as 80.0-89.9% of the agreement for each question. The recommendation of grade C was defined as 70.0-79.9% of the agreement for each question.

Results: A total of 65 experts formed a panelist group, and the number of questionnaires collected was 63, 59, and 62 in the 3 rounds. In total, 5 sections, 71 questions, and 382 items achieved consensus after the Delphi rounds including summary; preoperative evaluation; application at the lumbar spinal stenosis, lumbar disc herniation, lumbar spondylolisthesis, adult degenerative scoliosis, postoperative adjacent segmental degeneration, and revision surgery; complications; and postoperative follow-up evaluation of LLIF.

Conclusion: The modified Delphi method was utilized to ascertain an expert consensus from the Chinese Study Group for Lateral Lumbar Spine Surgery to inform clinical decision-making in the application of LLIF. The salient grade A recommendations of the survey are enumerated.

Keywords
lateral lumbar interbody fusion, delphi method, expert consensus

Introduction

More recently, a less invasive lateral lumbar interbody fusion (LLIF) technique has been reported using cages inserted through the lateral transpsoas approach.[1-4] This approach reportedly has the advantages of short operative time, less bleeding, large bone graft area, high fusion rate, short hospitalization time, and lower complication rates, which has been widely used in the treatment of various lumbar diseases.[1-4] Lumbar interbody fusion is an established treatment for numerous spinal disorders, such as degenerative, traumatic, infectious, and tumorous pathologies. The anterior lumbar interbody fusion (ALIF) technique, posterior lumbar interbody fusion (PLIF) technique, and transforaminal lumbar interbody

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fusion (TLIF) technique have been well described.[5-8] At present, there are still many controversies on the preoperative evaluation, clinical indications, contraindications, complications, and postoperative follow-up evaluation.[1-4,9-12]

The modified Delphi method.[13] is an anonymous method of soliciting expert opinions through multiple rounds of face-to-face surveys and systematically-designed questionnaires.

The purpose of this study was to establish the consensus of experts on the application of lateral lumbar interbody fusion (LLIF) by using the modified Delphi method.

Methods

Study Design

A modified Delphi survey.[13] was performed with 1 face-to-face meeting (June 2019) and 3 subsequent web-based surveys (June 2019 to March 2020).

Development of Questionnaires

The research team prepared the proposal and was approved by the Chinese Study Group for Lateral Lumbar Spine Surgery (approval number not applicable). The research team searched the databases PubMed, Medline, EMBASE, the Cochrane library, Clinical key, Springer link, Wiley Online Library, CNKI, and Wanfang, of studies reporting LLIF with PRISMA guidelines. Case reports, commentaries, and cadaveric or experimental studies in animals were excluded. 18 comparative studies, 37 cohort studies, and 13 systematic reviews were included and used to build the questionnaire. 3 members of the research team were responsible for reviewing and evaluating the studies using the published evidence rating system.[14] to control specifically for confirmation bias and ensure validity and consistency. The questionnaire contained a summary; preoperative evaluation; application at the lumbar spinal stenosis, lumbar disc herniation, lumbar spondylolisthesis, adult degenerative scoliosis, postoperative adjacent segmental degeneration, and revision surgery; contraindications; complications; and postoperative follow-up evaluation of LLIF. There were 119 survey questions in the questionnaire, including 48 single-choice questions (40.3%), 71 multiple-choice questions (59.7%), and 382 options in total. In single-choice questions, only 1 option can be selected. And in multiple-choice questions, 1 or more options can be selected.

Panelists

Invitation to participate was sent by email to all members of the Chinese Study Group for Lateral Lumbar Spine Surgery (n = 77). A total of 72 members replied and 65 were selected and agreed to participate. Eligibility was based on the number of years in practice (minimum of 5 years in practicing spine surgery and a minimum of 2 years in practicing LLIF surgery) and an estimated number of LLIF cases operated (minimum of 20 patients) per year. The panelists' mean age was 50.7 years, and 95.2% had been practicing spine surgery for more than 10 years, 82.5% had been practicing LLIF surgery for more than 5 years (Table 1).

Table 1. Panelists Characteristics.

	Round			
Characteristic	1 (n = 58)	2 (n = 63)	3 (n = 59)	4 (n = 62)
Age				
30-39	3	3	3	3
40-49	21	22	21	22
50-59	34	38	35	37
University Hospital	56	61	57	60
Years in practicing spine surgery				
5-9	3	3	3	3
10-19	13	15	13	14
≥20	42	45	43	44
Years in practicing LLIF surgery				
2-4	10	11	10	10
5-9	19	21	20	21
≥10	29	31	29	31
Number of LLIF cases operated per year				
20-49	17	19	17	19
50-99	14	16	15	15
≥100	27	28	27	28

Delphi Rounds

The survey consisted of 4 rounds; 1 face-to-face meeting and 3 subsequent survey rounds. If the questions were agreed by 70.0% or more experts, they were reached to a consensus. If the questions were agreed by 30.0% or fewer experts, they were excluded from the consensus. And the questions will go to the next round if they were agreed between 30.0% to 70.0% experts.

In the first round: 58 panelists met face-to-face, discussed, and modified the survey questionnaires.

The second round: The panelists received the modified questionnaires using the online platform https://www.wjx.cn (WenJuanXing, CSX, CHN) and were asked to make their choices according to their experiences.

The third round: Questions that did not reach consensus in the second round were revised for additional clarification. And the panelists received the new survey and were asked to make their choices.

The fourth round: For the questions that did not reach consensus in the third round, the research team changed some multiple-choice questions into single-choice questions, and further clarified the questions and options based on published studies. The panelists received the new survey and were asked to make their choices.

Data Analysis

The research team analyzed the results of every round. A response rate of >70.0% were considered valid for each round of the survey. And the consensus was defined as ≥70.0% of the

agreement for each question. The recommendation of grade A was defined as ≥90.0% of the agreement for each question. The recommendation of grade B was defined as 80.0-89.9% of the agreement for each question. The recommendation of grade C was defined as 70.0-79.9% of the agreement for each question.

Results

Of 77 panelists invited, 65 participated, responses were received from 63, 59, and 62 for each survey, respectively (Table 1).

Sixty-three panelists responded to the first questionnaire (second round) and 176 options achieved consensus. Fifty-nine panelists responded to the second questionnaire (third round) and 37 options achieved consensus. Sixty-two panelists responded to the third questionnaire (fourth round) and 25 options achieved consensus.

In total, 71 questions including 238 options achieved consensus after the Delphi rounds. Grade A consensus was achieved in 34.9% of options, Grade B in 23.7% of options, and grade C in 41.4% of options.

Tables 2, 3, and 4 summarized grade A and B recommendations and percentage of agreement regarding the summary of LLIF including indications, contraindications, advantages, and disadvantages; the preoperative evaluation; the LLIF application at LDH, LSS, lumbar spondylolisthesis, ADS, ASD, and revision surgery; the postoperative follow-up and evaluations; the management of complications, etc.

Discussion

The research team searched several Chinese and English databases and most of the items in the consensus were supported by evidence-based studies.

In this consensus, LLIF includes extreme lumbar interbody fusion (XLIF), oblique lumbar interbody fusion (OLIF), lateral lumbar interbody fusion (LLIF), crenel lumbar interbody fusion (CLIF), and direct lumbar interbody fusion (DLIF). Indications of LLIF include lumbar disc herniation (LDH), lumbar spondylolisthesis of grade I and II, lumbar spinal stenosis (LSS), adult degenerative scoliosis (ADS), revision surgery, and adjacent segmental degeneration (ASD). Contraindications of LLIF include the history of severe retroperitoneal disease or surgery, congenital lumbar spinal stenosis, severe lumbar spinal stenosis, lumbar spondylolisthesis of grade III and IV, the noose of the facet joints, and severe degenerative facet joint lesions. They were consistent with published literature.[1-12,15-22]

Kwon et al.[19] and Xu et al.[20] suggested that LLIF can treat I°/II° lumbar spondylolisthesis. Ozgur et al.[21] also indicated that severe spondylolisthesis was one of the contraindications to LLIF. Chester et al.[22] suggested that almost all LLIF patients needed to undergo second-stage open posterior spinal fusion and segmental pedicle screw fixation. Heo et al.[23] investigated patients with lumbar disc herniation treated by OLIF combined with intervertebral foraminal endoscopy, and the follow-up showed that the postoperative recovery of the patients was good.

Anand et al.[24] used XLIF to treat ADS patients, the Cobb angle, Visual analogue scale (VAS), and Oswestry dysfunction index (ODI) scores were also improved significantly at the 2-year follow-up. Tormenti et al.[25] conducted a comparative study of XLIF combined with open posterior fixation (8 cases) and PLIF (4 cases) for ADS patients, and the results showed that the cobb angle of patients in the XLIF group was corrected significantly better than PLIF group. Acosta et al.[26] investigated that DLIF could effectively restore the coronal and sagittal balance of the lumbar spine.

The advantages of LIIF include more minimally invasive, higher fusion rates, indirect decompression, improved spinal stability, shorter hospital stay, better restoration of coronal balance, and better restoration of sagittal balance in our study. Studies.[15,23,27] have shown that the complication rates of LLIF are lower than that of TLIF and PLIF, but there is a risk of injury of the lumbosacral plexus nerve during psoas muscle dissection. LLIF has greater mechanical stability than PLIF, not only because it uses a larger cage, but also because structures such as the posterior ligaments are well protected.

Pereira et al.[15] and Xu et al.[16] suggested that LLIF was increasingly used in the treatment of lumbar spinal stenosis and degenerative disc diseases. Karikari et al.[17] reported that the average blood loss of patients receiving LLIF in segments L1 to L2 alone was 46 ml, and that of patients receiving LLIF in more than 2 segments was 175 ml. Attenello et al.[18] indicated that open internal fixation had a better correction, but it was also associated with higher complications.

In this study, whether auxiliary lateral or posterior internal fixation is required for LLIF surgery should be determined via the intraoperative stability of the cage, condition of intraoperative/postoperative lumbar spine instability, and integrity of posterior ligament complex. Louie et al.[28] concluded that the LLIF of stand-alone was safe and effective. John et al.[29] demonstrated that the open internal fixation group had a better correction, but it was also associated with higher complications. The advantages of staging surgery reached to consensus in this study include the reduced duration of surgery and anesthesia, reduced risks of complications, reduced the difficulty of correction, and help to further assess the patients' condition and determine the next step of treatment.

Moreover, the consensus indicated that the selected cage could appropriately increase the height of the intervertebral space of the surgical segment and the location of the cage should be placed in the middle of the intervertebral space.

Sembrano et al.[30] and Park et al.[31] indicated that compared with a non-lordosis cage, the cage with lordosis can achieve greater correction of lordosis in surgical segments, but there is no significant difference in the restoration of global lumbar lordosis. They also suggested that place the cage in the front 1/3 of the vertebrae is more conducive to restore lordosis.

As for nerve monitoring in LLIF, most studies.[32-36] reported that nerve monitoring should be performed during LLIF to

Table 2. Summary, Pre-Op Evaluations, and Post-Op Follow-Up of Lateral Lumbar Interbody Fusion (LLIF).

Item	Percentage of agreement (%)	Grade of recommendations
LLIF include		
Extreme lumbar interbody fusion (XLIF)	98.4	A
Oblique lumbar interbody fusion (OLIF)	95.2	A
Lateral lumbar interbody fusion (LLIF)	95.2	A
Direct lumbar interbody fusion (DLIF)	90.0	A
Indications of LLIF		
Adult degenerative scoliosis (ADS)	100.0	A
Adjacent segmental degeneration (ASD)	100.0	A
Lumbar Spondylolisthesis	90.5	A
Revision surgery	87.3	B
Contraindications of LLIF		
History of severe retroperitoneal disease or surgery	94.9	A
III° or IV° spondylolisthesis	91.4	A
Severe lumbar spinal stenosis	85.2	B
Advantages of LLIF		
Indirect decompression	81.0%	B
Disadvantages of LLIF		
Insufficient decompression	85.7	B
Psoas muscle injury	82.4	B
The basic information that needs to be collected before surgery		
Height, weight, and BMI	95.2	A
Age	92.1	A
Smoking history	84.1	B
History of abdominal surgery	93.7	A
Preoperative imaging examination required		
Standing anteroposterior (AP) and lateral lumbar X-ray, over-flexion and over-extension lumbar X-ray	82.5	B
Computerized tomography (CT) of the lumbar spine	84.1	B
Magnetic Resonance Imaging (MRI) of the lumbar spine	100.0	A
Bone mineral density (BMD)	96.6	A
Follow-up time point after LLIF should be:		
Post-op 3 months	95.4	A
Post-op 6 months	90.5	A
Post-op 12 months	93.7	A
Post-op 24 months	87.3	B
Post-op 36 months	81.4	B
The end time point of routine follow-up after LLIF should be:		
Post-op 36 months	81.4	B
The following contents should be evaluated during follow-up:		
Pain relief	100.0	A
Patients' clinical functions	98.4	A
Patients' Quality of life	96.8	A
Imaging examinations	98.1	A
Imaging examinations required during follow-up:		
Standing anteroposterior (AP) and lateral lumbar X-ray	93.7	A
During follow-up, the clinical functions should be evaluated by:		
Visual analogue scale (VAS)	100.0	A
Oswestry disability index score (ODI)	95.2	A
During the follow-up, the following contents should be focused on the X-rays:		
Sagittal spinal-pelvic parameters	95.2	A
The sequence of the lumbar spine	93.7	A
Coronal balance	93.6	A
Intervertebral height	92.1	A
Cage subsidence	90.5	A
Lumbar lordosis	88.9	B
Any motion of fusion segments	88.9	B
Any loosening of screws and fracture of robs	87.3	B
The motion of the lumbar spine	84.1	B
Width of intervertebral foramen	81.0	B

(continued)

Table 2. (continued)

Item	Percentage of agreement (%)	Grade of recommendations
During the follow-up, the following contents should be focused on the CT scan:		
The fusion of surgical levels	98.4	A
Shift of cage	84.1	B
Loosen of screws	82.5	B
During the follow-up, the following contents should be focused on the MRI:		
Compression of nerve roots	95.2	A
Hyperplasia of posterior longitudinal ligament and ligamentum flavum	84.1	B
Condition of lumbar spinal stenosis	84.1	B
The criteria for evaluating the fusion of intervertebral bone grafting after LLIF surgery are:		
The trabecula that connecting the adjacent endplates passes through or surrounds the bone graft	98.4	A
During the follow-up of LLIF, the following conditions require revision surgery:		
Nonunion occurring with the formation of pseudarthrosis and segmental instability	82.5	B
Low back pain and lower limb symptoms due to failure of internal fixations	88.9	B

Table 3. Application at the Lumbar Spinal Stenosis, Lumbar Disc Herniation, Lumbar Spondylolisthesis, Adult Degenerative Scoliosis, Postoperative Adjacent Segmental Degeneration, and Revision Surgery of Lateral Lumbar Interbody Fusion (LLIF).

Item	Percentage of agreement (%)	Grade of recommendations
Which of the following symptoms can be solved better by LLIF?		
Low back pain	90.5	A
What segments of LDH can be treated with LLIF?		
L3/4	93.7	A
L4/5	90.5	A
L2/3	88.9	B
What causes of lumbar spondylolisthesis are most suitable for LLIF?		
Degenerative	96.8	A
For what grade is LLIF suitable for lumbar spondylolisthesis?		
Grade I	96.8	A
Grade II °	93.6	A
Surgical strategies for LLIF in the treatment of spondylolisthesis:		
Simultaneous posterior surgery	90.5	A
What causes of LSS are suitable for LLIF?		
Non-osseous central spinal stenosis	87.3	B
What degrees of LSS are suitable for LLIF?		
Schizas A: intradural cerebrospinal fluid is clear, but uneven distribution is uneven	81.4	B
To what degree of facet joint degeneration is suitable for LIIF?		
Degrees II: narrow joint space or mild osteophyte formation	90.3	A
Which of the following segments are suitable for LLIF for the treatment of LSS?		
L3/4	100.0	A
L4/5	98.4	A
L2/3	95.2	A
How many fusion segments can LLIF treat for LSS?		
3 segments	84.1	B
2 segments	82.5	B
1 segment	81.0	B
When LLIF was used to treat multisegmental LSS, the selection of the responsible segment mainly depended on:		
Patients' manifestations	100.0	A
Imaging examinations (X-ray, CT, MRI)	98.4	A
The advantages of staged surgery include:		
Help to further assess the patients' condition and determine the next step of treatment	98.4	A
Reduced duration of surgery and anesthesia	85.7	B
Which of the following segments are suitable for LLIF for the treatment of ADS?		
L3/4	100.0	A
L4/5	100.0	A

(continued)

Table 3. (continued)

Item	Percentage of agreement (%)	Grade of recommendations
L2/3	98.4	A
L1/2	81.0	B
The main contents should be evaluated before surgery:		
Coronal balance	96.8	A
The degree of stenosis and nerve compression	95.2	A
The flexibility of scoliosis	95.2	A
Patients' characteristics of symptoms	93.7	A
History of surgery	92.1	A
Sagittal spinal-pelvic parameters	88.9	B
Bone mineral density	87.3	B
Sagittal balance	82.5	B
When LLIF was used to treat ADS patients, the following goals could be achieved:		
Restore the coronal balance	100.0	A
Relieve the low back pain	92.1	A
Decompress the nerve and relieve lower limb symptoms	84.1	B
The advantages of the concave approach include:		
More correction	84.1	B
The advantages of the convex approach include:		
Ease of exposure	92.1	A
Ease of proceeding the intervertebral space	88.9	B
The intraoperative nerve monitoring should be:		
Combined multiple nerve monitoring	84.1	B
The advantages of staging surgery include:		
Help to further assess the patients' condition and determine the next step of treatment	96.8	A
Reduced duration of surgery and anesthesia	93.6	A
If posterior internal fixation was assisted, the screw placement methods could be:		
Percutaneous screw placement	86.1	B
Transmuscular space approach	81.4	B
Which of the following segments are suitable for LLIF for the treatment of ASD?		
L2/3	100.0	A
L3/4	100.0	A
L4/5	95.2	A
The main contents should be evaluated before surgery:		
The degree of stenosis and nerve compression	98.4	A
Patients' characteristics of symptoms	95.2	A
Coronal balance	85.7	B
Bone mineral density	85.7	B
Degree of sagittal spondylolisthesis	82.5	B
Sagittal spinal-pelvic parameters	82.5	B
When LLIF was used to treat ASD patients, the following goals could be achieved:		
Relieve the low back pain	93.6	A
Decompress the nerve and relieve lower limb symptoms	90.5	A
The criteria for auxiliary lateral or posterior internal fixation were:		
Condition of intraoperative/postoperative lumbar spine instability	88.9	B

reduce the incidence of nerve injury. However, there is also a study.[37] suggesting that the incidence of nerve injuries has no significant difference between the groups that use or don't use intraoperative nerve monitoring. Multiple nerve monitoring is recommended according to this consensus.

Zhu et al.[38] demonstrated that the operation time, intraoperative blood loss, the hospital stay of the OLIF group was significantly better than that of the PLIF group, while the VAS/ODI score and intervertebral space height restore of the OLIF group was better than that of the PLIF group at 3 months after surgery. The fusion rate of the 2 groups was the same at 12 months after surgery.

The complications of LLIF include nerve injury, vascular injury, abdominal organ injury, vertebral fracture, pseudarthrosis, and cage subsidence in this study. Hijji et al.[39] found that the common complication after LLIF was transient nerve injury, with an incidence of 36.1%, and the permanent injury was only 4.0%. Joseph et al.[40] also concluded that the incidence of revision surgery was about 3.74%, and the reasons for revision surgery after LLIF included incision infection, nerve

Table 4. Management of Complications of Lateral Lumbar Interbody Fusion (LLIF).

Item	Percentage of agreement (%)	Grade of recommendations
Common complications associated with LLIF surgery included:		
Nerve injury	100.0	A
Vascular injury	98.4	A
Cage subsidence	93.7	A
Abdominal organ injury	93.6	A
Vertebral fracture	85.7	B
Which level has the most incidence of nerve injury:		
L4/5	82.5	B
What type of nerve injury was most common after LLIF:		
Transient nerve injury	82.5	B
The common causes of intraoperative nerve injury of LLIF were:		
Exposure injury	96.8	A
Traction injury	96.8	A
If intervention is required, the following treatments could be helpful:		
Neurotrophic drugs	95.2	A
revision surgery	84.1	B
Which of the following methods can reduce the incidence of intraoperative nerve injury?		
Avoiding the psoas approach	81.0	B
Intraoperative blunt separation	82.5	B
Shortening the duration of intraoperative traction	93.7	A
Intraoperative nerve monitoring	88.9	B
Common causes of vascular injury in LLIF surgery are:		
Direct surgical injury	96.8	A
In which case a blood transfusion is required:		
Intraoperative blood loss $>$ 1000ml	92.1	A
Common abdominal organ injuries after LLIF were:		
Ureteral injury	82.5	B
Peritoneal injury	88.9	B
Selection of bone graft materials:		
Autogenous bone + allogeneic bone	88.9	B
Allogeneic bone	81.0	B
What are the common causes of cage subsidence?		
Patients with osteoporosis	100.0	A
Endplate damage	96.8	A
Nonfusion occurrence	89.8	B
Selection of inappropriate size of the cage	85.7	B
The preventive measures for the cage subsidence include:		
Selecting the appropriate size of the cage	96.8	A
Avoiding endplate injury	95.2	A
Adding lateral or posterior fixation	90.5	A
Perioperative anti-osteoporosis treatment	85.1	B

damage, epidural hematoma, psoas hematoma, adjacent segment degeneration, and formation of pseudarthrosis.

In this study, the cage subsidence most often occurs in the upper endplate, and the common causes of cage subsidence include osteoporosis, without lateral or posterior fixation, cage located inappropriately, high BMI, endplate damage, and selection of the inappropriate size of the cage. Le et al.[41] found that greater cage or posterior fixation may be needed to reduce the risk of cage subsidence for patients with osteoporosis. Lang et al.[42] suggested that cage sinking into vertebral body $>$ 2 mm as the evaluation standard for cage subsidence in their study. However, Tohmeh et al.[43] and Bocahut et al.[44] used cage sinking into vertebral body $>$ 4 mm as the evaluation standard for cage subsidence. Marchi et al.[45] suggested that the criteria for the postoperative fusion of LLIF were as follows: 1. The trabecula that connecting the adjacent endplates passes through or surrounds the bone graft; 2. The motion range in the fusion segments $< 5^{\circ}$; 3. The shift of the fusion segment $\leq$3 mm; 4. The transparency line at the upper and lower ends of the intervertebral bone grafting does not exceed 50%.

In the Delphi survey, the selection of panelists is the key to success in the establishment of expert consensus. The improper selection of experts will increase the bias in the investigation and lead to the decline of the response rate in the consultation process. In this study, panelists were selected from the medical systems of more than a dozen provinces, municipalities, and autonomous regions in China to form an expert group. Although their ages, the number of years in practice, and

experience impact beliefs on LLIF are different, they are all members of the Chinese Study Group for LLIF and fulfill the selection criteria which was well represented in terms of age and medical practice. In the process of expert evaluation, the questionnaire recovery rate was more than 90%, and the proportion of experts who proposed modification was high. Most of the treatments in the resulting expert consensus are well supported by evidence-based medicine.

Furthermore, the modified Delphi method is a popular method of soliciting expert opinions through multiple rounds of face-to-face surveys and systematically-designed questionnaires. It has been employed and widely used to help enhance effective decision-making. The method gathers opinions from a diverse panel of experts and anonymity eliminates the risk of biased opinions. Also, there is an opportunity given to participants to further express their views in the face to face round. There are fewer drawbacks of the modified Delphi method such as there are no systematic guidelines and participants are required to be continually involved in answering a similar question in multiple rounds.[13]

There are also some limitations in this study: (1) the selected panelists are all from China, therefore, the expert consensus does not apply to other countries and regions. (2) There is a lack of statistical analyses in the Delphi rounds. No reliability analyses were performed, which may significantly bias the findings of the present study. (3) XLIF, OLIF, LLIF, CLIF, and DLIF are not well distinguished. Although these technologies are typical representatives of lateral intervertebral fusion technologies, there are some differences.[46-47]

Conclusions

The modified Delphi method was utilized to ascertain an expert consensus from the Chinese Study Group for Lateral Lumbar Spine Surgery to inform clinical decision-making in the application of LLIF. LLIF is an minimally invasive, effective and safe approach for treating numerous degenerative lumbar disorders. The best indications for LLIF are ASD, ADS, and lumbar degenerative listhesis grades I and II; The major contraindications are >grade 3 listhesis and retroperitoneal surgery/ disease; Pre-op MRI and DEXA are mandatory; Convex side access is better in ADS; Nerve injury is caused by exposure and traction injuries and is best relieved by neuropathic drugs.

Authors' Note

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. We have permissions for the use of software, questionnaires/(web) surveys, and scales in the studies. We have full control of all primary data and we agree to allow the journal to review their data if requested. We state that we have consented to participate. All authors declared that they have not been exempt from the requirement and they all approved to submit this article to Global Spine Journal.

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Author Contributions

The authors Yong Hai and Jingwei Liu contributed equally to this study and they are co-first authors.

Declaration of Conflicting Interests

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