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Equipoise for Lateral Access Surgery

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■ OBJECTIVE: **To investigate the use of lateral access surgery among surgeons from the Asia-Pacific region to determine equipoise for areas of contentious use.**

■ METHODS: **A questionnaire was distributed to members of the Asia Pacific Spine Society. Surgeons were asked about their past experiences with lateral access surgery, including their advantages and disadvantages, specific surgical strategies, choices in implant-related factors, order of levels to operate on in multilevel reconstruction surgery, and postoperative complications.**

■ RESULTS: **A total of 69 of 102 surgeons (67.6%) had performed lateral access surgery previously. In total, 56 participating surgeons (54.9%) agreed that anterior column reconstruction via lateral access is most of time superior to transforaminal lumbar interbody fusion and other techniques. Surgeons would consider laminectomy instead of indirect decompression in the presence of severe central or lateral recess stenosis, thickened ligamentum flavum, and facet joint hypertrophy. For the order of levels to operate on in multiple level reconstruction for deformity, where 1 stands for L3—L4 or higher, 2 stands for L4—L5, and 3 stands for L5—S1, 2-1-3 (28/95, 29.5%) was most common, followed by 1-2-3 (26/95, 27.4%), and 3-2-1 (21/95, 22.1%).**

■ CONCLUSIONS: **Lateral access surgery is seeing greater use in the Asia-Pacific region, especially in upper middle- to high-income countries, whereas keenness of surgeons who practice in lower middle- to low-income countries can be improved by more training, resources, and reasonable cost. A high percentage of surgeons do not consider indirect decompression for spinal stenosis. There was no consensus on the order of levels in multiple level reconstruction for deformity.**

INTRODUCTION

Lumbar interbody fusion is an established surgical procedure to treat various spinal pathologies, including degenerative disc disease, spinal deformities, trauma, infections, and neoplasia.[1,2] In the recent years, different minimally invasive retroperitoneal surgical approaches, including extreme lateral interbody fusion (XLIF), direct lateral interbody fusion (DLIF), and oblique lateral interbody fixation (OLIF), have been developed to avoid the intraoperative concerns and complications of the traditional anterior lumbar interbody fusion to the lumbar spine.[3-6]

Although lateral access surgery has been shown to minimize soft-tissue injury, decrease blood loss, and shorten hospital stay while maintaining equivalent or improved clinical and radiographic outcomes as compared to open procedures,[7,8] its indications and contraindications may require further refinement. For example, it has been suggested that lateral access surgery may not be suitable for severe central canal stenosis, bony lateral recess stenosis, and high-grade

Key words
- Interbody fusion
- Questionnaire
- lateral access surgery

Abbreviations and Acronyms
ALL: Anterior longitudinal ligament
APSS: Asia Pacific Spine Society
DLIF: Direct lateral interbody fusion
LL: Lumbar lordosis
LLIF: Lateral lumbar interbody fusion
MRI: Magnetic resonance imaging
OLIF: Oblique lateral interbody fusion
PEEK: Polyether ether ketone
PI: Pelvic incidence
TLIF: Transforaminal lumbar interbody fusion
XLIF: Extreme lateral interbody fusion

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spondylolisthesis.[9] In addition, the lateral approach may be risky in patients with previous retroperitoneal surgery, retroperitoneal abscess, or abnormal vascular anatomy.[10]

As a relatively novel technique, several aspects of the surgical strategies and implant-related decisions in lateral access surgery vary among surgeons. For example, although indirect decompression procedures have been reported to restore disc height and provide adequate symptom relief, some patients experience poor postoperative radiographic outcomes and inadequate symptom relief that may require reoperations through laminectomy.[11-13] Furthermore, stand-alone lateral access surgery without additional posterior pedicle screw fixation is seeing wider use except for conditions with high biomechanical stress such as facet arthropathy, instability, and multilevel reconstruction surgery.[14,15] In addition, the order of levels to operate on in multilevel reconstruction surgery for deformity is scarcely discussed in the literature and is worth investigating.

To summarize the surgeons' perspective regarding the aforementioned controversies, the present questionnaire-based study aimed to 1) investigate the current use of lateral access surgery among surgeons from the Asia-Pacific region; 2) investigate the surgeons' views regarding the advantage and disadvantage of lateral-access surgery compared with transforaminal lumbar interbody fusion (TLIF) and other techniques; and 3) investigate the surgeons' views regarding the surgical strategies of lateral access surgery, including indirect decompression, order of levels to operate on in multilevel surgery, and implant-related factors.

METHODS

Questionnaire Development

A questionnaire was created to assess the current use of lateral access surgery among Asia Pacific Spine Society (APSS) surgeons by the APSS anterior column reconstruction focus group. Several discussions were conducted between the members before finalizing on this questionnaire with the purpose of collecting APSS surgeons' experience and decision-making principles (**Supplementary Table 1**). The questionnaires were distributed in bulk to the APSS membership during the months of July to November 2021 via the REDcap system (Vanderbilt University, Nashville, Tennessee, USA).

The questionnaire consisted of several themes. First, the surgeons were asked about their past experiences with lateral access surgery. A series of demographic background questions were asked, including country of practice, age of surgeon, years in spine surgery, and sector of practice. In addition, surgeons were then asked if they performed lateral access surgery before, their background knowledge (taken a course or served as a lecturer), their starting and current practice (open technique, anterior to psoas, or transpsoas), and the factors that can potentially increase their keenness to perform lateral access surgery.

Second, a series of questions were asked regarding the advantage and disadvantage of lateral access surgery. Specifically, the participants were asked if they think anterior column reconstruction via lateral access is most of the time superior to TLIF or other techniques. The reasons behind their views were recorded. One or more of the following answers can be selected: 1) better disc height improvement, 2) allows indirect decompression, 3) better slip correction/coronal correction, 4) better generation of lordosis, 5) increases fusion rate, 6) earlier mobilization, and 7) reduced hospital stay. Selectable answers against lateral access surgery included 1) technical difficulty, 2) surgical risk, 3) can do the same with TLIF, 4) I have done TLIF without any problem, and 5) longer operation time duration. Further, the surgeons were asked in what situations they would or would not consider performing anterior longitudinal ligament (ALL) release.

Third, the participating surgeons were asked about their specific surgical strategies for lateral access surgery. Regarding indirect decompression, the participants were asked when they would consider laminectomy and if they would consider stand-alone surgery without posterior instrumentation. Further, the surgeons' choices in implant-related factors, including bone graft (autograft, allograft, demineralized bone matrix, or bone morphogenetic protein), cage material (polyetheretherketone [PEEK], titanium, or expandable cages) and screw type for posterior fixation (percutaneous pedicle screws, open pedicle screws, or cortical bone trajectory screws) also were recorded. To investigate the order of level surgeons would operate on in multiple level reconstruction for deformity, 3 choices were provided (1 stands for L3–L4 or higher; 2 stands for L4–L5; 3 stands for L5–S1), and surgeons were asked to put them in order based on their practice. Further questions were asked to investigate the surgeons preoperative imaging choices (flexion–extension radiographs, traction radiographs, fulcrum radiographs, whole-spine standing/scoliosis series, computed tomography, magnetic resonance imaging [MRI]), whether they work with vascular-access surgeons, whether they use intraoperative neuromonitoring, side of operation (left- or right-side approaches), whether they use anterior drains, and whether they use corset use after the operation. Finally, surgeons were asked to describe the postoperative complications they have encountered.

Statistical Analysis

A power analysis was conducted to determine the appropriate response sample size for the APSS spine surgeon population. To achieve an effect size of 0.8 in χ^2 test or in independent *t*-test for the anticipated response types, a minimum sample size of 12.3 or 25.5 would be required, respectively. The current use of lateral access surgery was summarized based on surgeon's answers for the number of lateral access surgery they have performed. The association with surgeons' age and years in spine surgery were compared using Kruskal–Wallis one-way analysis of variance with post-hoc pairwise comparisons. Surgeons' view regarding the advantage and disadvantage of lateral access surgery versus other techniques was compared with their surgical experience using the χ^2 test. In addition, the reasons for or against the superiority of lateral access surgery was compared with different surgical experiences using χ^2 test or the Fisher exact test. Post-hoc Bonferroni adjusted *z*-tests were applied for reasons that contain a cell count less than 5. The surgeons' written responses to questions investigating their surgical strategies were summarized into different categories and were described quantitatively. To investigate the effect of country of practice, countries were divided into upper middle- to high-income (Australia, China, Hong Kong, Japan, Malaysia, New Zealand, South Korea, Singapore, Taiwan, Thailand, Turkey) and lower middle- to low-income (Bangladesh,

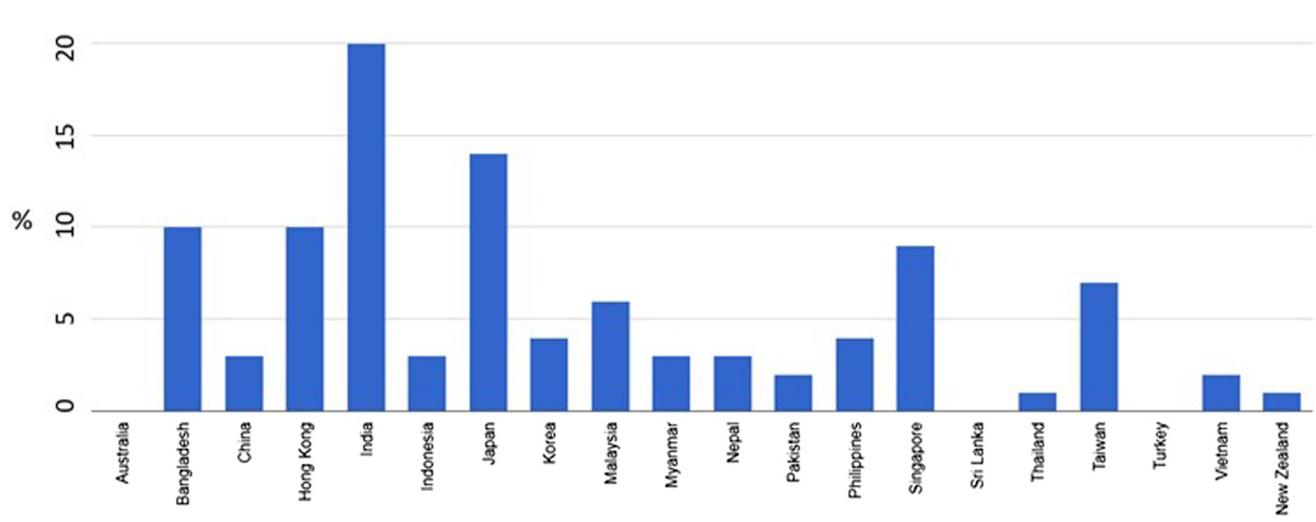

Figure 1. Distribution of surgeons participated according to countries.

Table 1. Demographic Data and Spine Surgery Practice of Participating Surgeons

Parameters	Mean (SD, Range) or Frequency, *n* (%)
Age, years	46.3 (10.4, 28.0—80.0)
Years in spine surgery	13.7 (10.0, 1.0—50.0)
Sector of practice	
Private	16 (15.7%)
Government	26 (25.5%)
Academic institution	38 (37.3%)
Mixed	22 (21.6%)
Perform lateral access surgery?	
Yes	69 (67.6%)
Number of cases done (percentage among "yes"):	
≤10	22 (31.9%)
11—50	25 (36.2%)
>50	22 (31.9%)
No	33 (32.4%)
Taken a course for this type of surgery	
Yes	64 (62.7%)
No	38 (37.3%)
A lecturer for this type of surgery	
Yes	32 (31.4%)
No	70 (68.6%)

SD, standard deviation.

India, Indonesia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam) groups based on the World Bank classification 2021.[16] For continuous variables including surgeons' age and years of experience in spine surgery, normality tests were performed, followed by Mann—Whitney U tests for comparison between country groups. For categorical variables, including preoperative imaging tools, side of operation, bone graft options, and cage material, χ^2 test/Fisher exact tests were used with post-hoc Bonferroni-adjusted *z*-tests for comparison. Statistical testing was performed using SPSS (version 28; IBM Corp., Armonk, New York, USA). The normality of data collected was tested by Shapiro—Wilk tests. A P value <0.05 was considered statistically significant.

RESULTS

Current Use of Lateral Access Surgery

A total of 102 surgeons from 17 cities/countries responded. The response rate to our questionnaire was 19.4% (102/525). All surgeons who responded were spine surgeons. 6 questionnaires had incomplete entries but were still included in the study for analysis. The region distribution of surgeons who participated in the study is summarized in Figure 1. The average age of the surgeons was 46.3 ± 10.4 years. The average years in spine surgery was 13.7 ± 10.0 years. Among the 102 participants, 69 surgeons (67.6%) had performed lateral access surgery before (Table 1). Surgeons who were more experienced in lateral access surgery tended to have practiced spine surgery longer (0 case: 10.4 ± 6.5 years, <10 cases: 8.9 ± 7.6 years, 11—50 cases: 16.2 ± 10.4 years, >50 cases: 20.8 ± 11.7 years; P < 0.001), whereas no significant association was found between the experience in lateral access surgery and surgeons' age (0 case: 44.8 ± 8.1 years, <10 cases: 42.3 ± 7.6 years, 11—50 cases: 48.0 ± 10.5 years, >50 cases: 50.6 ± 13.9 years; P < 0.001; P = 0.124) (Figure 2). Lack of experience (20/33, 60.6%) and being

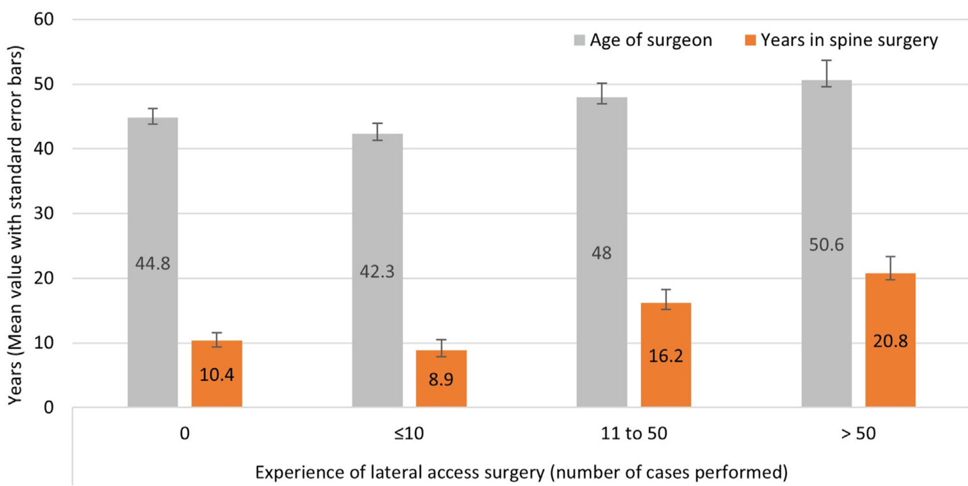

Figure 2. Mean age of surgeon and years in spine surgery for each group of various experience in lateral access surgery.

at the starting stage of their career (9/22, 40.9%) were the most common reasons for not performing more lateral access surgery in 0 case and <10 cases categories, respectively.

Among 96 surgeons who answered the questions regarding their starting and current practices, 51 surgeons (53.1%) started their practices with open technique; 35 surgeons (36.5%) started with anterior to psoas technique (OLIF); 19 surgeons (19.8%) started with the transpsoas technique (DLIF or XLIF). Training had a major effect deciding the starting techniques, as 23 surgeons (24.0%) stated that they performed their starting techniques as they were first taught. Currently, anterior to psoas is the most popular approach (43/96, 44.8%), followed by open (34/96, 35.4%), mini-open (32/96, 33.3%), and transpsoas techniques (25/96, 26.0%).

Surgeons who practiced in upper middle- to high-income countries ($n = 55$) were significantly older in age (48.4 ± 11.3 vs. 43.8 ± 8.8, $P = 0.03$), had more years of spine surgery practice (16.9 ± 11.0 vs. 10.0 ± 7.3, $P < 0.001$), and were more experienced in lateral access surgery (46/55, 83.6% vs. 23/47, 48.9%, $P < 0.001$) compared with surgeons who practiced in lower middle- to low-income countries ($n = 47$). A comparison of surgeon profile between upper middle- to high-income countries and lower middle- to low-income countries is shown in Table 2.

Comparison Between Lateral Access Surgery and TLIF or Other Techniques

Participating surgeons were asked whether they thought anterior column reconstruction via lateral access is most of time superior to TLIF and other techniques. In total, 56 surgeons agreed and 46 disagreed with this statement (Table 3). No association was found between the answer to this statement and number of lateral access surgery cases performed ($P = 0.765$). Although 33 surgeons have not performed lateral access surgery before, a similar percentage of them agreed that anterior column reconstruction via lateral access is most of the time superior to TLIF/other techniques (37/69 vs. 19/33, $P = 0.871$). Significantly fewer surgeons who practiced in upper middle- to high-income countries agreed with the superiority of lateral access surgery (23/55, 41.8% vs. 33/47, 70.2%, $P = 0.004$). In the 7 reasons provided for potential advantages of lateral access surgery, "better disc height restoration" (45/56, 80.3%), "allows indirect decompression" (42/56, 75.0%), and "better generation of lordosis" (42/56, 75.0%) were most common choices. For surgeons who disagreed with the statement, "I have done TLIF without any problems" (20/46, 43.4%) and "can do the same with TLIF" (20/46, 43.4%) were the most common reasons. Further, among contraindications for lateral access surgery, vessel situation (73/102, 71.6%), prominent/high iliac crest (51/102, 50.0%), severe osteoporosis (>4 standard deviation) (48/102, 47.1%), prominent psoas (31/102, 30.4%), facet osteophytes (27/102, 26.5%), and lack of dynamic movement on radiographs (19/102, 18.6%) received different levels of attention.

The surgeons were then asked about the suitable situations for ALL release (Table 4). In total, 45 surgeons (44.1%) emphasized lordosis restoration in alignment issues, including kyphosis, sagittal imbalance, kyphoscoliosis with sagittal imbalance, and pelvic incidence—lumbar lordosis mismatch. A total of 14 surgeons (12.7%) stated they would choose ALL release to achieve anterior column support for spine infection or trauma. Regarding the conditions unsuitable for ALL release, vascular concerns (20/102, 19.6%), severe osteoporosis (16/102, 15.7%), previous abdominal surgery (15/102, 14.7%), and significant comorbidities including smoking, old age, and tumor (11/102, 10.8%) were the main concerns (Table 4).

Surgical Thinking and Technical Concerns

The participating surgeons provided various reasons on when they would consider laminectomy instead of relying on indirect decompression (Table 5). Severe central and lateral recess

Table 2. A Comparison of Surgeon Profile Between Regions/Countries

Parameters*	Countries: Upper Middle- to High-Income Countries ($n = 55$)	Countries: Lower Middle- to Low-Income Countries ($n = 47$)	*P* Value†
Age, years, mean (SD); median (IQR)	48.4 (11.3); 46.5 (12.0)	43.8 (8.8); 42.0 (13.0)	0.030‡
Years in spine surgery, mean (SD); median (IQR)	16.9 (11.0); 15.0 (13.3)	10.0 (7.3); 8.0 (9.3)	<0.001‡
Type of practice, *n* (column%)			
Orthopedic surgery	54 (98.2%)	47 (100%)	1.000
Neurosurgery	1 (1.8%)	0	
Sector of practice			
Private	9 (16.4%)	7 (14.9%)	0.001‡
Government	19 (34.5%)[a]	7 (14.9%)[b]	
Academic institution	23 (41.8%)	15 (31.9%)	
Mixed	4 (7.3%)[a]	18 (38.3%)[b]	
Perform lateral access surgery?			
Yes	46 (83.6%)[a]	23 (48.9%)[b]	<0.001‡
No	9 (16.4%)[a]	24 (51.1%)[b]	
Number of cases performed			
<10 cases	8 (14.5%)	14 (29.8%)	<0.001‡
11—50 cases	18 (32.7%)[a]	7 (14.9%)[b]	
>50 cases	20 (36.4%)[a]	2 (4.3%)[b]	
0 cases	9 (16.4%)[a]	24 (51.1%)[b]	
A course for this type of surgery			
Yes	47 (85.5%)[a]	17 (36.2%)[b]	<0.001‡
No	8 (14.5%)[a]	30 (63.8%)[b]	
Served as a lecturer for this type of surgery			
Yes	27 (49.1%)[a]	5 (10.6%)[b]	<0.001‡
No	28 (50.9%)[a]	42 (89.4%)[b]	
What aspect may increase your keenness?			
More training			<0.001‡
Yes	11 (20.0%)[a]	31 (66.0%)[b]	
No	44 (80.0%)[a]	16 (34.0%)[b]	
More support/resources			0.042‡
Yes	12 (21.8%)[a]	19 (40.4%)[b]	
No	43 (78.2%)[a]	28 (59.6%)[b]	
Better evidence for its role			0.008‡
Yes	24 (43.6%)[a]	9 (19.1%)[b]	
No	31 (56.4%)[a]	38 (80.9%)[b]	

SD, standard deviation; IQR, interquartile range.

*Regions/countries were divided into upper middle- to high-income (Australia, China, Hong Kong, Japan, Malaysia, New Zealand, South Korea, Singapore, Taiwan, Thailand, Turkey) and lower middle- to low-income (Bangladesh, India, Indonesia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam) groups based on the World Bank classification 2021.

†For categorical variables, χ^2 tests/Fisher exact tests were used with post-hoc Bonferroni adjusted *z*-tests for comparison of column proportions; superscript a and b indicate the percentages were significantly different from each other in the same row.

‡Statistically significant.

Continues

Table 2. Continued

Parameters*	Countries: Upper Middle- to High-Income Countries ($n = 55$)	Countries: Lower Middle- to Low-Income Countries ($n = 47$)	*P* Value†
Reasonable cost			0.037‡
Yes	18 (32.7%)[a]	25 (53.2%)[b]	
No	37 (67.3%)[a]	22 (46.8%)[b]	
Understanding management of complications			0.930
Yes	18 (32.7%)	15 (31.9%)	
No	37 (67.3%)	32 (68.1%)	

SD, standard deviation; IQR, interquartile range.

*Regions/countries were divided into upper middle- to high-income (Australia, China, Hong Kong, Japan, Malaysia, New Zealand, South Korea, Singapore, Taiwan, Thailand, Turkey) and lower middle- to low-income (Bangladesh, India, Indonesia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam) groups based on the World Bank classification 2021.

†For categorical variables, χ^2 tests/Fisher exact tests were used with post-hoc Bonferroni adjusted *z*-tests for comparison of column proportions; superscript a and b indicate the percentages were significantly different from each other in the same row.

‡Statistically significant.

stenosis (41/102, 40.2%), thickened ligamentum flavum (10/102, 9.8%), facet joint hypertrophy (9/102, 8.8%), and inadequate symptoms relief from indirect decompression (9/102, 8.8%) were the main concerns. In a subsequent question, surgeons were asked when they would consider stand-alone surgery without posterior instrumentation. Among 96 valid entries, 59 surgeons (61.5%) selected "never"; 31 surgeons (32.3%) selected 1 level; 4 surgeons (4.2%) selected 2 levels; and 2 surgeons (2.1%) selected 3 levels or more. Regarding the order of level in multiple level reconstruction for deformity, 3 major orders were provided: 2-1-3 (28/95, 29.5%), 1-2-3 (26/95, 27.4%), and 3-2-1 (21/95, 22.1%). Other uncommon orders included 2-3-1 (6/95, 6.3%) and 3-1-2 (2/95, 2.1%). The thoughts on order of levels to operate on showed no difference between surgeons with different previous experience (P = 0.128).

The surgeons' choices in implant-related factors, including bone graft, cage material, and screw type for posterior fixation, showed varieties in their practice (Table 6). Regarding bone graft, the common choices included autograft (55/97, 56.7%), demineralized bone matrix (36/97, 37.1%), bone morphogenetic protein (22/97, 22.7%), and allograft (20/97, 20.6%). Regarding cage material, PEEK cage (61/95, 64.2%) was the most frequently used cage type, followed by titanium cage (29/91, 31.9%), expandable PEEK cage (4/89, 4.5%), and expandable titanium cage (4/90, 4.4%). Regarding screw type for 1 or 2 level posterior fixation, 66 surgeons (68.0%) used percutaneous

Table 3. Views of Surgeons on Comparing Lateral Access with TLIF or Other Techniques*

True (56, 54.9%): Reasons	True: Number and Percentage	False (46, 45.1%): Reasons	False: Number and Percentage
Better disc height restoration	45/56, 80.4%	Technical difficulty	8/46, 17.4%
Allows indirect decompression	42/56, 75.0%	Surgical risk	15/46, 32.6%
Better slip correction/coronal correction	38/56, 67.9%	Can do the same with TLIF	20/46, 43.5%
Better generation of lordosis	42/56, 75.0%	I have done TLIF without any problems	20/46, 43.5%
Increases fusion rate	32/56, 57.1%	Longer operation time duration	10/46, 21.7%
Earlier mobilization	24/56, 42.9%	Others	9/46, 19.6%
Reduced hospital stay	24/56, 42.9%		
Others	2/56, 3.6%		

TLIF, Transforaminal lumbar interbody fusion.

*Based on the question "Anterior column reconstruction via lateral access is most of the time superior to TLIF/other techniques?"

Table 4. A Summary of the Surgeons' Views on When to Perform ALL Release

Reasons to Use ALL Release		Characteristics of Unsuitable Candidates	
Conditions	**Number and Percentage**	**Conditions**	**Number and Percentage**
Alignment issues: lumbar kyphosis, sagittal imbalance, kyphoscoliosis with sagittal imbalance, or PI-LL mismatch	45/102, 44.1%	Vascular concerns: vascular aneurysms, abnormal vascular anatomy, or extensive aortic calcification	20/102, 19.6%
Indication-related: direct surgery, corpectomy, avoiding osteotomy, draining of abscess	13/102, 12.7%	Severe osteoporosis	16/102, 15.7%
Revision surgery, failed previous posterior surgery, or adjacent level disease	11/102, 10.8%	Previous abdominal/retroperitoneal surgery	15/102, 14.7%
Infection-related issues: tuberculous spondylitis/Pott disease, infectious spondylodiscitis, or second-stage surgery in spine infection	9/102, 8.8%	Significant comorbidities: smoking, old age, obesity, renal anomalies, tumor or metastasis, fused discs, neuromuscular disease, or being immunocompromised	11/102, 10.8%
Dynamic instability or spondylolisthesis	9/102, 8.8%	Prominent psoas or mickey mouse sign	2/102, 2.0%
Coronal plane deformity or Degenerative scoliosis	6/102, 5.9%	No experience, no adequate training, not available in the country	19/102, 18.7%
Deficient anterior column due to trauma	5/102, 4.9%		

ALL, anterior longitudinal ligament; PI-LL, pelvic incidence—lumbar lordosis.

pedicle screws; 45 surgeons (46.4%) used open pedicle screws; 2 surgeons (2.1%) selected cortical bone trajectory screws.

For preoperative imaging, MRI (89/96, 92.7%), flexion—extension radiographs (88/96, 91.7%), whole-spine standing/scoliosis series (63/96, 65.6%), and computed tomography (57/96, 59.4%) were common choices. In addition, some surgeons chose to obtain traction radiographs (14/96, 14.6%) and fulcrum radiographs (19/96, 19.8%) before the surgery. Surgeons who have performed lateral access surgery before are more willing to obtain preoperative whole-spine standing/scoliosis series and MRI scans (whole-spine standing/scoliosis series: 51/69 vs. 13/33, $P = 0.002$; MRI: 65/69 vs. 24/33, $P = 0.004$). Regarding the assist needed from vascular access surgeons, 5 surgeons (5.0%) selected "yes, always"; 34 surgeons (33.7%) selected "yes, sometimes"; and 62 surgeons (61.4%) selected "no." According to the response from 97 surgeons, 53 surgeons (55.2%) used intraoperative neuromonitoring and 43 surgeons (44.8%) did not. Regarding the side of body that they usually operate on, the majority of surgeons (86/97, 88.7%) selected the left side, citing reasons including safer access as it is easier to avoid inferior vena cava from the left side. In addition, when asked if they use anterior drain during the surgery, 48 surgeons (50%) answered "yes, always" and 36 surgeons (37.5%) answered "no." In total, 12 surgeons (12.5%) selected "depending on cases," mentioning bleeding during the surgery, multilevel surgery, infection, and abscess cases as reasons for anterior drain. In the final question, 70 surgeons stated that they use corset postoperatively (70/97, 72.2%). Surgeon's answers showed a wide range of potential complications after lateral access surgery (Table 7). Endplate fracture was only mentioned by surgeons who have performed more than 50 lateral access surgeries, whereas other complications such as arterial injury and quadriceps weakness were mentioned by both groups.

Table 5. A Summary of the Surgeons' Views on When to Perform Laminectomy Instead of Indirect Decompression

Conditions	Number and Percentage
Severe canal stenosis or lateral recess stenosis	41/102, 40.2%
Thickened ligamentum flavum	10/102, 9.8%
Persistent compressive symptoms or poor disc height restoration after anterior decompression	9/102, 8.8%
Facet joint hypertrophy, ankylosis, arthropathy, big facet tropism, or Baastrup's features	9/102, 8.8%
Significant disc extrusion	2/102, 2.0%
Multilevel surgery	2/102, 2.0%
High-grade spondylolisthesis	1/102, 1.0%

Surgeons who practiced in countries with different levels of income showed different surgical preferences during lateral access surgery. Significantly more surgeons who practiced in lower middle- to low-income countries stated that they used a vascular access surgeon (25/47, 52.2% vs. 14/55, 25.5%, $P = 0.002$). Further, traction radiographs (11/55, 20.0% vs. 2/47, 4.3%, $P = 0.017$), fulcrum radiographs (15/55, 27.3% vs. 4/47, 8.5%, $P = 0.017$), and whole-spine series (40/55, 72.7% vs. 24/47, 51.5%, 0.024) were used more frequently by surgeons who practiced in upper middle- to high-income countries. Surgeons who practiced in upper middle- to high-income countries were more likely to use neuromonitoring (33/53, 62.3%) than surgeons who practiced in lower middle- to low-income countries (20/43, 46.5%), although the

Table 6. Implant-Related Choices Including Bone Graft, Screw Types for Posterior Fixation, and Cage Types

Frequently Used Bone Graft Options ($n = 97$)

Bone Graft Types	Autograft	Demineralized Bone Matrix	Bone Morphogenetic Protein	Allograft	Others (Beta TCP, Synthetic HA graft, bone substitute, porous titanium)
Frequency and percentage	55 (56.7%)	36 (37.1%)	22 (22.7%)	20 (20.6%)	10 (10.3%)

Screw Types for 1- or 2-level Posterior Instrumentation ($n = 97$)

Screw Types	Percutaneous Pedicle Screws	Open Pedicle Screws	Cortical Bone Trajectory Screws
Frequency and percentage	66, 68.0%	45, 46.4%	2, 2.1%

Frequently Used Cage Types

Cage Types	PEEK ($n = 95$)	Titanium ($n = 91$)	Expandable PEEK ($n = 89$)	Expandable Titanium ($n = 90$)
Most frequently used	61 (64.2%)	29 (31.9%)	4 (4.5%)	4 (4.4%)
Second most frequently used	20 (21.1%)	34 (37.4%)	2 (2.2%)	13 (14.4%)
Third most frequently used	7 (7.4%)	2 (2.2%)	17 (19.1%)	18 (20.0%)
fourth most frequently used	7 (7.4%)	26 (28.6%)	66 (74.2%)	55 (61.1%)

TCP, tricalcium phosphate; PEEK, polyetheretherketone.

difference here was not statistically significant (P = 0.123). When deciding the operating side of lateral access surgery, more surgeons who practiced in upper middle- to high-income countries preferred performing the surgery from the left side (52/53, 98.1% vs. 34/44, 77.3%, P = 0.001). In addition, regarding bone graft options, surgeons who practiced in upper middle- to high-income countries tended to use less autograft (22/55, 40.0% vs. 33/47, 70.2%) thereby opting for demineralized bone matrix more often (25/55, 45.5% vs. 11/47, 23.4%, P = 0.02).

Table 7. Complications after Lateral Access Surgery Mentioned by Participating Surgeons

Complication	Number and Percentage
Hip flexor and psoas weakness	20/102, 19.6%
Vascular injury or bleeding	12/102, 11.2%
Nerve issues including nerve kinking or entrapment, temporary paresis, and sympathetic denervation	9/102, 8.8%
Cage subsidence	6/102, 5.9%
Temperature difference in legs	4/102, 3.9%
Wound infection	4/102, 3.9%
Abdominal pain	3/102, 2.9%
Quadriceps weakness	3/102, 2.9%
Ureter injury	3/102, 2.9%

DISCUSSION

Lateral access surgery is seeing wider use in the Asia-Pacific region due to its advantages in disc height restoration, accommodating indirect decompression, and powerful generation of lordosis. This questionnaire-based study was conducted to assess the experience with lateral access surgery among APSS surgeons. Based on the responses, ALL release for anterior column reconstruction is considered suitable by participating surgeons to restore lordosis when treating alignment issues while avoiding osteotomy procedures. Severe central or lateral recess stenosis, thickened ligamentum flavum, and facet joint hypertrophy were the common reasons why surgeons would consider adding a laminectomy instead of relying on indirect decompression. Stand-alone surgery seemed to be accepted by more spine surgeons in recent years. Moreover, surgeons showed a relatively even distribution of preferences when deciding the order of levels to operate on in multilevel reconstruction for deformities.

Currently, lateral access approaches including anterior to psoas and transpsoas techniques are commonly adopted by 67.6% of participating surgeons. Lateral access surgery is seeing wider use in Asia-Pacific region, especially in upper middle- to high-income countries, while keenness of surgeons who practice in lower middle to low-income countries can be improved by more training, resources, and reasonable cost. Surgeons with different levels of background knowledge and expertise in lateral access surgery participated in this study. More than 20% of participants responded in each category of number of lateral access surgery performed (0 case, 1–10 cases, 11–50 cases, and >50 cases), demonstrating diversity in surgical strategies for anterior column reconstruction. In another UK-based questionnaire study conducted in 2018 with 32 participating spine surgeons, 58.1% of the surgeons performed lateral access surgery in the last year, while TLIF remains their primary practice (27/31, 87.1%).[17] Surgeons who participated in our study showed greater expertise in lateral access surgery, demonstrating a greater preference for lateral access surgery in the Asia-Pacific region with the many options of DLIF, XLIF, and OLIF techniques popularized in the recent years.

In total, 54.9% of participating surgeons believed that anterior column reconstruction via lateral access is most of time superior to TLIF or other techniques, mostly due to its advantages in disc height restoration, allowing for indirect decompression and generation of lordosis. However, the application of the lateral access surgery may be limited by vessel, psoas, and iliac crest anatomy. According to previous studies, the oblique corridor through which the intervertebral disc can be accessed using the anterior to psoas approach may be obstructed by the bifurcation of the aortoiliac vessel and bulky or high-rising psoas.[18,19] A study conducted by Ng et al.[19] reported that 25.2% of patients aged 18 years and older do not have an accessible oblique corridor during the OLIF approach, whereas 35.0% of their cases had a small oblique corridor of <1.0 cm in length, which requires increased operative expertise. Furthermore, patients with prominent/high iliac crests were considered unsuitable for lateral access surgery especially at the L5/S1 level as the surgical access is obstructed.[10] By identifying the contraindications of lateral access surgery, surgeons can better select cases in which lateral access surgery can be an appropriate treatment to limit the risks faced by patients. More education and training opportunities should be advocated in terms of patient selection and technical limitations. Sagittal correction in lateral access surgery can sometimes be limited by anterior longitudinal ligament tethering, which can be dissected to achieve more aggressive correction. ALL release for anterior column reconstruction was considered suitable by participating surgeons when treating alignment issues including kyphosis, sagittal imbalance, and pelvic incidence—lumbar lordosis mismatch while trying to avoid osteotomy and corpectomy. Sectioning of the ALL allows hypermobility of lumbar segments to allow for aggressive lordosis restoration while maintaining the benefits of indirect decompression and minimally invasive access.[20]

Among the diversities in the surgical strategies for lateral access surgery, choices on indirect decompression versus laminectomy, stand-alone surgery versus posterior fixation, and the order of levels to operate on in multi-level operation received opinions that are worth further examination. First, a high percentage of surgeons considers laminectomy instead of indirect decompression in the presence of severe central or lateral recess stenosis, thickened ligamentum flavum, and facet joint hypertrophy. This result is in accordance with the consensus from a modified Delphi study conducted by Hai et al.,[21] which suggests that nonosseous central spinal stenosis and facet joint with mild osteophyte formation are suitable conditions for lateral lumbar interbody fusion (LLIF), while severe lumbar spinal stenosis, facet joint hypertrophy, and severe degenerative facet joint lesions may be beyond the scope of indirect decompression. Second, stand-alone surgery seemed to be accepted by more spine surgeons in recent years, as approximately 40% of the participants admit that they would consider stand-alone surgery without posterior instrumentation for construct length of at least 1 level, in contrast to a 4% rate of responses in favor of stand-alone cages reported in a UK-based study in 2018.[17] In a decision-making pathway for using stand-alone LLIF, Adl Amini et al. reported that endplate sclerosis associated with Modic changes type II and the presence of foraminal stenosis are potential favorable factors for stand-alone lateral fusion.[22,23] In contrast, Hai et al. recommended simultaneous posterior surgery when treating spondylolisthesis with LLIF, suggesting that stand-alone surgery might not be suitable for patients with isthmic lysis and grade I or II spondylolisthesis.[21,22,24] Third, surgeons showed a relatively even distribution of preferences when deciding the order of levels to operate on in multiple level reconstruction for deformity. The difficulty of exposure and thus the expertise required to achieve satisfactory results are different for each level mentioned above. Lateral interbody fusion at L4—L5 is associated with a greater risk of vessel and nerve injury compared with L3—L4 and above. The safe-working zone in the transpsoas approach (a section of the psoas muscle that is free of retroperitoneal vessels anteriorly and lumbar plexus posteriorly) and the oblique corridor in the anterior to psoas approach (the unobstructed space between the left psoas muscle and the aortoiliac vessels) tend to get narrower at L4—L5 compared with L3—L 4 and above. This is due to the more anteriorly placed lumbar plexus within the psoas muscle and bifurcation of iliac vessels at L4—L5.[18,19,25] At L5—S1, conversely, the iliac crest blocks the surgical access for a transpsoas approach, whereas the anterior-to-psoas approach can still be applied to L5—S1 through the oblique corridor by staying medial to the left psoas and left common iliac vein, with the help from specially designed retractors.[4,26-28] From the authors' perspective, the rationale for performing the lower levels first is the importance of creating more lordosis while performing the higher levels first is technically easier to perform before too much height is gained from the lower levels leading to exposure difficulties under the ribs. The even distribution of the order preference in this study suggests that this surgical detail depends heavily on individual training and pattern, whereas the surgical results associated with each specific order may require further study.

This study has several limitations. First, 6 entries of the questionnaire responses provided incomplete answers, while the valid answers in these incomplete questionnaires were extracted for the analysis. Second, although this study is a questionnaire-based study that lacks clinical evidence, we aimed to summarize the surgeons' view regarding some controversies in lateral access surgery while proposing future research that could be conducted to address these issues. Third, nearly all participating surgeons were spine surgeons, which limit analysis between spine surgeons of orthopedic and neurosurgery backgrounds. Fourth, although some of the participating surgeons claimed to have not performed lateral access surgery before, their opinions are still included in the analysis, since this study focused on the experience and perspectives of APSS members with mixed backgrounds, instead of a smaller group of experts who are specialized in lateral access surgery. Fifth, the complication rates of lateral access surgery among different surgeons were not collected in this study. Comparing the complication rate between surgeons who commonly perform lateral access surgery with those who refrain from doing so may provide valuable insights to the use of lateral access surgery.

CONCLUSIONS

Lateral access surgery is seeing wider use in Asia-Pacific region, especially in upper middle- to high-income countries, while keenness of surgeons who practice in lower middle- to low-income countries can be improved by more training, resources, and reasonable cost. Surgical strategies including preoperative imaging, side of operation, bone graft, and cage material were associated with the socioeconomic status of the country. Severe central or lateral recess stenosis, thickened ligamentum flavum, and facet joint hypertrophy were the common reasons why surgeons consider adding a laminectomy instead of relying on indirect decompression. Stand-alone surgery seems to be accepted by more spine surgeons in recent years. Participating surgeons showed a relatively even distribution of preferences when deciding the order of levels to operate on in multilevel reconstruction for deformity.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Hao Wu: Writing – original draft. **Prudence Wing Hang Cheung:** Methodology, Formal analysis, Writing – review & editing. **Reuben Chee Cheong Soh:** Conceptualization, Writing – review & editing. **Jacob Yoong Leong Oh:** Conceptualization, Writing – review & editing. **Jason Pui Yin Cheung:** Conceptualization, Methodology, Supervision, Project administration, Formal analysis, Funding acquisition, Writing – review & editing.

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