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SURGERY

Perioperative Complications in 155 Patients Who Underwent Oblique Lateral Interbody Fusion Surgery

Perspectives and Indications From a Retrospective, Multicenter Survey

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Study Design. A retrospective multicenter survey.

Objective. To investigate the perioperative complications of oblique lateral interbody fusion (OLIF) surgery.

Summary of Background Data. OLIF has been widely performed to achieve minimally invasive, rigid lumbar lateral interbody fusion. The associated perioperative complications are not yet well described.

Methods. The participants were patients who underwent OLIF surgery under the diagnosis of degenerative lumbar diseases between April 2013 and May 2015 at 11 affiliated medical institutions. The collected data were classified into intraoperative and early-stage postoperative (≤1 mo) complications. The intraoperative complications were then subcategorized into organ damage (neural, vertebral, vascular, and others) and other complications, mainly related to instrumental failure. The collected data were also divided and analyzed based on whether the surgeon was certified to perform the surgery and the incidence of complications in the early (April 2013–March 2014) and late stages (April 2014–May 2015) of OLIF introduction.

Results. In the 155 included patients, 75 complications were reported (incidence rate, 48.3%). The most common complication was endplate fracture/subsidence (18.7%), followed by transient psoas weakness and thigh numbness (13.5%) and segmental artery injury (2.6%). Almost all these complications were transient, except for three patients who had permanent damage: one had ureteral injury and two had neurological injury. Postoperative complications included surgical site infection (1.9%) and reoperation (1.9%). Whether the primary operator was experienced did not affect the incidence of complications. Regarding the introductory stage, the incidence of complications was 50% in the early stage and 38% in the late stage.

Conclusion. The overall incidence of perioperative complications of OLIF surgery reached 48.3%, of which only 1.9% resulted in permanent damage. Our analysis based on surgeon experience indicated that the OLIF procedure could be performed without increasing incidence of complications, under the guidance of experienced supervisors.

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In treating lower back pain (LBP) and related neurological disorders refractory to conservative care, lumbar interbody fusion (LIF) surgery has been widely used as a viable option. Several open and minimally invasive lumbar fusion approaches are available, including anterior lumbar interbody fusion (ALIF) and posterior/transforaminal lumbar interbody fusion (P/TLIF). Among these interbody fusion procedures, ALIF achieves effective indirect posterior decompression by recovering the intervertebral height followed by enlarging the foramen and spinal canal.[1–3]

Recently, a more minimally invasive ALIF, lumbar lateral interbody fusion (LLIF), is attracting attention with two major approaches: direct/extreme LIF (D/XLIF), which approaches the lateral portion of the intervertebral disc (IVD) directly *via* splitting the psoas muscles, and oblique lateral interbody fusion (OLIF) procedure, which approaches the oblique corridor in front of the psoas muscle without muscle splitting. LLIF allow the surgeons to directly access the IVD space in a minimally invasive manner (Figure 1A, B). Especially some previous anatomical or radiological studies well described the OLIF procedure. Davis *et al*[4] investigated the oblique lateral corridor in front of the psoas muscle using cadavers, concluding that the corridor provides safe and easy access to the L2–S1 IVD with minimal psoas retraction Molinares *et al*[5] showed the safety of oblique corridor using magnetic resonance imaging.

These interbody fusion procedures have inherent risks of perioperative complications; P/TLIF can cause perioperative complications such as musculoligamentous injury, nerve root injury, and durotomy,[6–10] and ALIF can result in damage to major organs and blood vessels.[11–13] Furthermore, D/XLIF can cause distinctive complications such as thigh pain/motor loss after the surgery, mainly owing to its approach of psoas muscle splitting; the incidence of this complication is approximately 60%.[14] Regarding the OLIF procedure, we have already reported a limited number of perioperative complications such as cage subsidence and transient thigh numbness[15]; however, there have been no well-established studies on the perioperative complications of the OLIF procedure. Therefore, the current study aimed to determine the perioperative (intra- and postoperative) complications in patients who underwent the OLIF surgery at our medical facilities.

MATERIALS AND METHODS

Patients and Methods

The present study was conducted as a retrospective review of the operative data collected by 24 spine surgeons at our affiliated 11 medical institutions performed under the approval of the institutional ethics committees.

The participants were LBP patients who were operated on under the diagnosis of degenerative lumbar diseases between April 2013 and May 2015. Each of the institution had $\geq$5 OLIF cases. The collected basic demographic data were as follows: age, sex, diagnosis, lateral instrumented levels, intra- or post- (within 1 month) operative complications, and whether each surgeon was officially certified as a specialized spine surgeon by the Japanese Society for Spine Surgery and Related Research (JSSR) to evaluate their surgical experience: Candidate surgeons are certified as a specialized spine surgeon by JSSR when they have an experience of performing more than 300 spine surgeries as a primary operator.

The perioperative complication data were retrospectively collected. Intraoperative complication data included neurological injury; vertebral injury such as endplate injury and cage subsidence; vascular injury; other injuries; and instrument failure. Postoperative complication data included surgical site infection and reoperation, among others. These items were selected in accordance with the findings of previous reports.[7,10,11,13,16,17]

Surgical Technique

OLIF surgery was performed based on the standard procedure described previously.[18] Briefly, patients were placed in the lateral decubitus position on their right side, and the target IVD space was identified under fluoroscopic guidance. Presence of a scoliosis does not affect the side of surgical approach. A 4-cm skin incision was made 6 to 10 cm anterior to the midportion of the marked disc. The surgical team approached the retroperitoneal space *via* blunt dissection and mobilizing the peritoneum anteriorly to expose the anatomical oblique lateral corridor, followed by intervertebral cage insertion (OLIF25 Clydesdale Spinal System; Medtronic Sofamor Danek, Minneapolis, MN). After anterior fusion, patients were placed in the prone position to undergo posterior fusion with pedicle screws *via* open or percutaneous procedures depending on the pathologies.

Primary Analysis: Incidence of Perioperative Complications

The data were analyzed and classified according to the major categories of intraoperative complications and early-stage postoperative (within 1 month) complications. Intraoperative complications were then subcategorized into organ damage (neural, vertebral, vascular, or others) and other complications, mainly instrument failure. The incidence is indicated in percentage (%).

Secondary Analysis: Distribution of Incidence Depending on the Experience or Learning Curve

The data were divided and analyzed based on whether the surgeon was certified as having the surgical skill, and the incidence of complications in the early stage of the

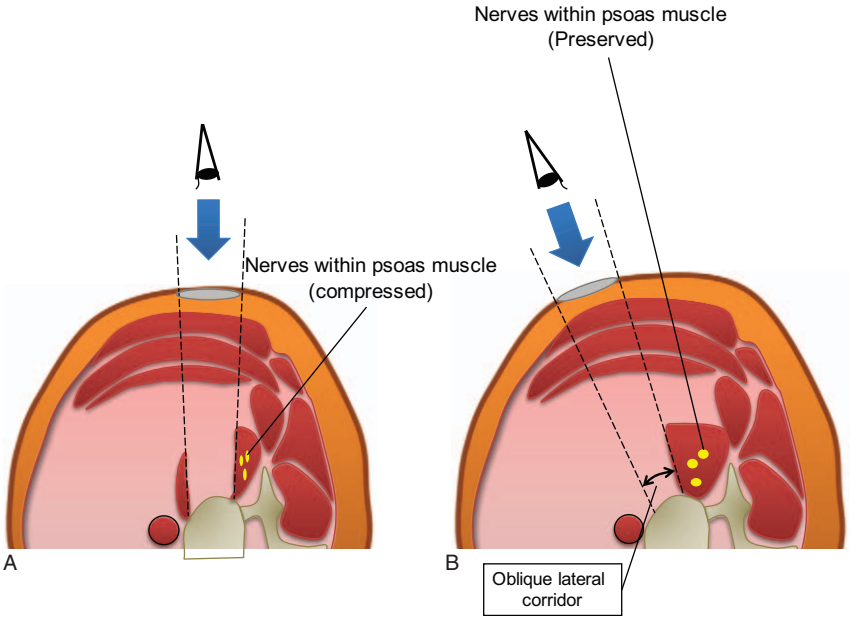

Figure 1. Approaches of two distinct lateral interbody fusion (LIF) surgeries. Notice the opposing view direction of the two procedures (OLIF: anterior to posterior; D/XLIF: posterior to anterior). **A**, Direct/extreme lateral interbody fusion (DLIF/XLIF) approaches the intervertebral disc (IVD) by splitting the psoas muscle, which can sometimes injure or compress the intramuscular nerves. **B**, Oblique lateral interbody fusion (OLIF) approaches the oblique lateral portion of the IVD *via* oblique lateral corridor without psoas splitting, where basically no significant organs or nerves exist. OLIF approach keeps the intrapsoas nerves almost intact with little compression.

introduction of OLIF (April 2013–March 2014), and late stage (April 2014–May 2015).

RESULTS

Table 1 shows the patient demographic data. A total of 155 participants were included (men/women, 69/86; age: mean, 63.5 yr; range, 14–87 yr). The most frequent diagnosis was spondylolisthesis (100 cases, 65.0%), followed by kyphoscoliosis with multilevel fusion (28 cases, 18.1%) and discogenic LBP with intervertebral disk degeneration (16 cases, 10.3%). The most fused level was L4–5 (54 cases, 69.2%), followed by L3–4 (32 cases, 41.0%). Regarding the other levels, there was 1 case of T10–11 (1.3%), 1 case of T12–L1 (1.3%), 6 cases of L1–2 (7.7%), 14 cases of L2–3 (17.9%), and 6 cases L5–S (7.7%).

Complications

Table 2 shows the reported perioperative complications. A total of 75 complications were reported, with an incidence of 48.3%. Intraoperative complications accounted for 69 cases (44.5%) and postoperative for 7 cases (4.7%). The most reported complication was endplate fracture (18.7%), followed by transient psoas weakness and transient neurological disorder (13.5%), segmental artery injury (2.6%), and surface layer infection (1.9%), among others. Almost all the complications were transient or mild, but three of them were revealed to be permanent: one case each of ureteral injury, nerve root injury, and cauda equina damage. The first ureteral injury occurred during the installation of the retractor, and the latter two major injuries occurred during the intervertebral preparation in an inappropriate position just at the early introductory stage of the OLIF procedure. In detail, the ureteral injury occurred when the surgeon inserted a thread pin to fix the retractor to the vertebral body. Regarding the two nerve injuries, the surgeon of the first case violated spinal canal *via* IVD space to injure intradural cauda equina due to disorientation (case 1). The other nerve injury occurred in the contralateral spinal nerve when the surgeon was penetrating the annulus fibrosus (case 2).

One patient died of a cerebrovascular event 1 week after the surgery; the association of the complication with the surgery is not clear.

Secondary Analysis: Distribution of Incidence Depending on the Experience or Learning Curve

The incidence of complications between certified spine surgeons and other fellow surgeons was equal: 60 cases of 124 (48.3%) and 15 cases of 31 (48.3%), respectively.

The incidence of complications in the early period and the later period was 50% and 38%, respectively, showing temporal improvement after the introduction. Among the permanent complications, the two neurological injuries described above occurred in the early stage by certified surgeons. The remaining ureteral injury was due to a clinical fellow in the late stage. Figure 2 shows the complication rate after the introduction of OLIF surgery every 10 cases. The complication rate (black) showed bimodal-like distribution. Two severe neurological injuries occurred at the early phase, whereas ureter injury occurred at the mid phase.

Whether the primary operator was a certified spine surgeon did not affect the incidence of complications, indicating that a trainee can perform OLIF surgery without increasing the risk of complications, under the supervision of a certified trainer.

DISCUSSION

We have reviewed the incidence of perioperative complications in patients who underwent OLIF surgery. In the 155 patients, 75 complications were reported (incidence rate,

TABLE 1. Patient Demographic Data (n = 155)

Characteristic	
Mean age, yr (range)	63.5 (14–82)
Sex (M/F)	69/86
Diagnosis, n (%)	
Spondylolisthesis	100 (65.0)
Kyphoscoliosis	28 (18.1)
Discogenic lower back pain (LBP)	16 (10.3)
Others	10 (6.6)
Fused levels*, n (%)	
T10-11	1 (1.3)
T11-12	0 (0)
T12-L1	1 (1.3)
L1–2	6 (7.7)
L2–3	14 (17.9)
L3–4	32 (41.0)
L4–5	54 (69.2)
L5-S	6 (7.7)

*Subtracted from clearly notified 77 cases.

48.3%) with predominance in the intraoperative period, among which only 3 cases of permanent damage in ureter and nerves were reported. The most common complication was subsidence/endplate fracture (18.7%), followed mainly by transient thigh pain/numbness and/or psoas weakness (13.5%) and segmental artery injury (2.6%). The incidence of complications was equal when OLIF was performed by clinical fellows (trainees) and certified spine surgeons (trainers), indicating that trainees under the supervision of a certified trainer can perform OLIF surgery without increasing the risk of complications. The perioperative incidence of complications was 50% at the early stage after OLIF introduction and 38% in the late stage, indicating the existence of a learning curve.

Previous studies have reviewed LLIF procedure-related incidence of complications, mainly for D/XLIF surgery and few for OLIF. One of the known and major complications of LLIF surgery is lumbar plexopathies, encompassing transient hip flexion weakness and transient sensory deficits.[19] We have previously reported some OLIF-related complications such as cage subsidence and transient thigh pain/numbness in a limited number of patients.[15] Joseph *et al*[20] systematically reviewed 42 LLIF complication-related studies comparing them with those after performing the posterior counterpart, minimally invasive TLIF surgery. The complication data are helpful to compare and understand OLIF complications. Table 3 shows the comparison of complications between psoas-splitting LLIF (D/XLIF), extracted from the article, and those of OLIF, in which the items were matched to the maximum extent possible.

As shown in Table 3, the incidence of complications after OLIF surgery seems relatively high (48.3%) compared with that after D/XLIF (31.4%), but with less incidence of permanent complications (only 1.2%), which is half of that after D/XLIF.[20] Herein, we may not be able to directly compare these incidences because there are possible preteritions such as segmental arterial injury, peritoneal injury, and neural injury that will be hidden in the limited exposures in D/XLIF, that is, D/XLIF can directly approach the lateral side of the spinal column without causing any other organ injuries with their highly specified dilators and retractors involving some potential risk such as bowel injury, and vascular injury, such as aortic perforation.[21–23]

TABLE 2. Perioperative Complications

Intraoperative (69 Cases, 44.5%)		
Neurological injury	Spinal nerve injury	1 (0.6)
	Cauda equina injury	1 (0.6)
	Transient thigh pain/numbness, psoas weakness	21 (13.5)
Vertebral injury	Endplate injury (including cage subsidence)	29 (18.7)
Vascular injury	Segmental artery	4 (2.6)
	Other vessels	2 (1.3)
Other injuries	Ureteral injury	1 (0.6)
	Pleural laceration	2 (1.3)
	Peritoneal laceration	3 (1.9)
Instrument failure	Breakage of the LIF cage	2 (1.3)
	Surgical instrument failure	2 (1.3)
Postoperative (within 1 month after the surgery, six cases, 3.9%)		
	Surgical site infection	3 (1.9)
	Reoperation	3 (1.9)
	Postoperative death	1 (0.6)

LIF indicates lumbar interbody fusion.

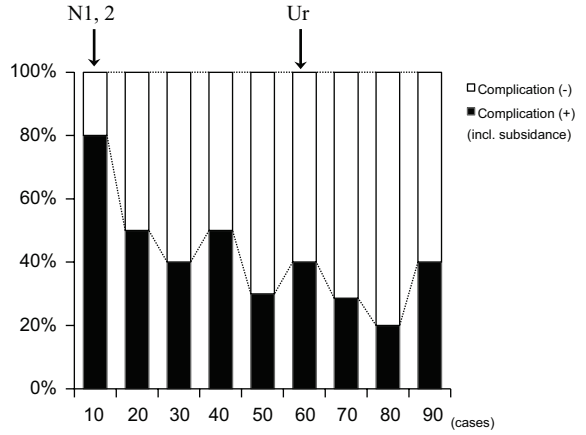

Figure 2. Complication rate after the introduction of oblique lateral interbody fusion (OLIF) surgery every 10 cases. The complication rate (black) showed bimodal-like distribution. N1 indicates the point where permanent nerve injury occurred (defined as case 1 in the text), and N2 case 2. Ur indicates the point where permanent ureter injury occurred. Note that two severe neurological injuries occurred at the early phase, whereas ureter injury occurred at the mid phase.

On the contrary, OLIF achieves a mini-open approach of direct psoas and retroperitoneal visualization, which can reduce the risk for severe procedural complications. The OLIF procedure avoids the incidence of postoperative transient sensory deficit, as is seen in the incidence of 13.5% in OLIF and 27.1% in D/XLIF. Furthermore, neural injuries between D/XLIF and OLIF can differ in their characteristics: D/XLIF tends to be more traumatic compared to OLIF. Anatomically, the psoas muscle includes the complicated nerve plexus,[19] which can be damaged during the transpsoas approach. The risk of injury to the intrinsic muscular branches to the psoas muscle exists at all zones at the L3–4 and L4–5 levels.[24] Regarding these complications, neurologic complications such as sensory disturbance, temporary neurological deficit including transient postoperative motor weakness, and permanent neurological deficits, should be investigated in detail. Table 4 implies a literature review of neurological complications compared with TLIF and D/XLIF.[20,25–33] The review indicates that OLIF has the least possible incidence in postoperative sensory and temporary motor weakness (13.5%), and permanent neurological deficit (1.2%). Considering the permanent neurological deficit in the present study was due to irregular manipulation in the early phase after the introduction of OLIF surgery, which can be considered to be the safer procedure compared with other interbody fusion procedures. Thus, D/XLIF mandatory requires intraoperative real-time electromyography monitoring to avoid such neuronal damage; however, it is not enough to avoid neurological complication. Uribe *et al*[34,35] discussed possible injury to the retroperitoneal sensory nerves such as the ilioinguinal, iliohypogastric, lateral femoral cutaneous, and genitofemoral nerves, as intraoperative real-time electromyography monitoring used in D/XLIF does not monitor these sensory nerves, concluding that the complete detection of nerve injuries including sensory nerves are quite difficult. They also suggest some intraoperative notifications to avoid neural injuries, by proper patient positioning, gentle dissection, and shorter operative duration,[35] which can be more easily achieved in the OLIF procedure.

Another major complication was cage subsidence, including endplate injury with an incidence of 13.5%. The reason for the postoperative subsidence is multifactorial such as overdistraction, aggressive reaming of endplates, or

TABLE 3. Comparison of Total and Specific Complications Between Direct/Extreme Lumbar Interbody Fusion and Oblique Lateral Interbody Fusion

Complication	D/XLIF*		OLIF	
	No. Patients	Incidence (%)	No. Patients	Incidence (%)
Total complications	4260	31.4	155	48.3
Transient sensory deficit	2160	27.08		13.5
Neurological deficit				
Temporary	2957	9.40		0
Permanent	2525	2.46		1.2
Intraoperative complication†	2181	1.93		6.5
Wound complication	1254	0.80		1.9
Instrument failure				2.6
Subsidence	1900	10.84–58.2‡		18.7
Reoperation	2193	3.74		1.9

Adopted from the study by Joseph et al.[18]

†*Includes durotomies, instrument fractures, anterior longitudinal ligament rupture, abdominal wall paresis, vertebral body fractures, bower injuries, and vascular injuries.*

‡*Depends on the study: the value is higher if minor subsidence is included.*

D/XLIF indicates direct/extreme lumbar interbody fusion; OLIF, oblique lateral interbody fusion.

TABLE 4. Literature Review of Neurological Complications

	Authors and Year	No. of Pts	Neurological Deficit Incidents (%) [Cases]		
			Sensory	Temporary (Including Motor Weakness)	Permanent
TLIF	Joseph *et al*, 2015	–	20.2 [380/1885]	2.22 [30/1349]	1.01[14/1382]
	Wang and Zhou, 2014	204	11.8 [24]	2.94 [6]	1.96 [4]
	Wong *et al*, 2014	144	8.33 [12]	8.33 [12]	–
	Villavicencio *et al*, 2010	76	–	3.95 [3]	6.58 [5]
	Avg. (%)		13.4 (8.33–20.2)	4.36 (2.22–8.33)	3.18 (1.96–6.58)
D/XLIF	Joseph *et al*, 2015	–	13.7 [585/2160]	6.5[278/2957]	1.46[62/2525]
	Lykissas *et al*, 2013	454	21.4 [97]	3.96 [18]	6.6 [30]
	Aichmair *et al*, 2013	293	78.8 [231]	21.8 [64]	2.04 [6]
	Rodgers *et al*, 2011	600	Almost all*	0.7 [4]	–
	Cahill *et al*, 2012	118	–	27.5 [28]	–
	Tohmeh *et al*, 2011	102	17.6 [18]	–	–
	Pimenta *et al*, 2011	36	–	25 [9]	–
	Avg. (%)		32.8 (13.7–78.8)	16.95 (3.96–27.5)	3.36 (1.46–6.6)
OLIF	Abe *et al*, 2016 (present study)	155	13.5 [21]		1.2 [2]

*Thigh pain and hip flexor weakness were nearly universal.

D/XLIF indicates direct/extreme lumbar interbody fusion; OLIF, oblique lateral interbody fusion; TLIF, transforaminal lumbar interbody fusion.

distraction of a severely narrowed disc is a major topic in the recent study on LLIF. The real incidence of cage subsidence in LLIF is unknown, as the criteria are mixed depending on the studies; the range of incidence of cage subsidence is 10.84% to 58.2% as an LLIF complication (Table 3). Whether cage subsidence itself can be an absolute negative complication still remains to be discussed, as it can provide future intervertebral stability with efficient bony fusion, making better contact with the cage opening and the vertebral body.[36] As is described in Figure 3, the average perioperative complication rate without the incidence for subsidence kept around 20% except just after the introductory phase, meaning that incidence for complications other than subsidence is stable. At this point, most part of the subsidence may not be accepted as a complication except for endplate injury resulting in adjacent vertebral body fracture, which was not investigated in detail in the present study. Anyhow, the surgeons should be more cautious in preparing the endplates to avoid excess preparation.[34] To avoid breaching the endplate, some other instruments such as angled curettes or rasps, and more precise image guidance such as O-arm and navigation systems, can be helpful.

The reoperation rate was relatively high in D/XLIF cases; this is because the involved articles for D/XLIF cases include stand-alone surgery (anterior cage insertion only without posterior fusion), which can lead to postoperative backing out of the cage due to persistent radiculopathy and symptomatic implant subsidence[37]; the incidence was high at 10.3%.

The present study reported three permanent perioperative complications, two of which were spinal nerve injury and cauda equina injury. Generally, durotomy and neurological injury tends to occur during posterior decompression and fusion surgery.[38] These were due to the disorientation of the surgeons during the surgery, who tried to achieve meticulous resection of the IVD. This could have been avoided by appropriate intraoperative fluoroscopic guidance, which can be applied to D/XLIF surgery. The two permanent nerve injuries in the present study are rare, but include suggestive information. Generally as OLIF procedure is approached *via* vacant and safe oblique lateral window just in front of psoas muscle, intraoperative neuromonitoring is not indispensable such as in transpsoas XLIF surgery. The two neural injury cases were rare in their

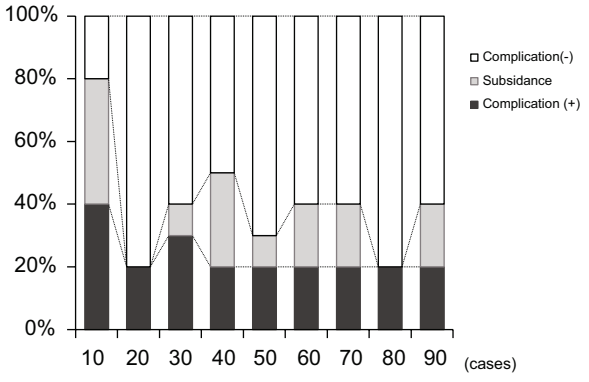

Figure 3. Complication rate after the introduction of oblique lateral interbody fusion (OLIF) surgery every 10 case with separated incidence for subsidence. The complication rate (black) showed significantly high at the introductory period, whereas it keeps around 20% every 10 cases when the incidence for subsidence (gray) was put aside.

occurrence mechanism and unavoidable whether neural monitoring was used or not. These cases should have been avoided by acquiring exact and correct intraoperative orientation under fluoroscopic guidance, especially with great care at the introductory stage of the procedure. Furthermore, gentle penetration of the contralateral annulus fibrosus should also be needed.

The remaining permanent complication, ureteral injury, is generally rare because a ureter falls aside with peritoneum to the ventral direction. The currently reported injury occurred when installing the retractor with a fixating device, which could have been avoided by careful retroperitoneal exposure. Enough sweeping and mobilizing the peritoneum are effective for avoiding to left the ureter behind and for well-exposed surgical site. Sometimes a preoperative ureteral catheter should be helpful to identify a ureter and also to avoid ureter injury.

An interesting fact is that the incidence rates of complications were equal between the trainers and trainees, indicating that trainees can perform OLIF surgery without further increased complications when they were under the supervision of the trainers. In detail, Figure 2 tells us that the two of the latter three complications occurred within 10 cases after the introduction of OLIF procedure. Furthermore, the more the amount of surgeries, the less the occurrence of complications. Comparing with other spinal surgery technique, experienced surgeons have less complication rate in pedicle screw insertion,[39–41] which is the same tendency in the OLIF surgery. These facts support the previous study that LLIF is a relatively safe alternative to traditional open anterior approaches, but there is a learning curve to be overcome to minimize the risk of iatrogenic complications such as those in the posterior surgery.[14] The result also indicates that trainees without sufficient training and experiences should perform OLIF surgery under the supervision of experienced trainers.

The present study has some limitations. First, it is a retrospective study. Other complications might not have been given in the survey, and surgical indication criteria for some degenerative diseases such as spondylolisthesis, scoliosis, and lateral listhesis should be strictly defined in the future prospective study. Also it should have involved some ''leakage,'' that is, missed patients or complications as the survey is based on the self-reported data and surgical charts; thus, a prospective study with defined evaluations should be performed to acquire more accuracy. For instance, postoperative subsidence is worth investigating; however, detailed evaluation is beyond the scope of the current retrospective multicenter survey, as it was unable to evaluate the status at the exactly same moment after the surgery. Furthermore, other factors, such as facet joints, the degree of disc degeneration, and intervertebral mobility, should be investigated more in detail in future prospective study. Intraoperative complications such as segmental artery injuries should be also investigated in prospective manner. Second, detailed data of the patients, such as comorbidities, operative parameters (duration and bleeding), bone mineral density, and physique, were not acquired in the present study, whereas these factors can affect the incidence and efficacies during surgery.[42] In the future prospective study, it should be important to define more precise surgical indication and exclusion criteria for OLIF surgery. Lastly more patients should be included to evaluate more accurate incidence of perioperative complications. Future survey with more subjects will also provide us some suggestion on the appropriate learning curve in performing OLIF surgery.

In conclusion, the overall incidence of perioperative complications of OLIF surgery was 48.3%, of which only 1.9% resulted in permanent damage; these were lower compared to another counterpart, D/XLIF. Our analysis based on surgeon experience showed no significant difference between experienced and inexperienced surgeons, indicating that the OLIF procedure can be safely performed under the guidance of experienced supervisors. Severe complications should be avoided by acquiring exact intraoperative orientation using fluoroscope, gentle penetration of contralateral annulus fibrosus, and sufficient exposure of retroperitoneal space by meticulous peritoneal mobilization.

➢ Key Points

- ❑ In the current retrospective investigation of perioperative complications of OLIF surgery in 155 patients, the overall complication rate was 48.3%; almost all these complications were transient, but three patients had permanent damage (1.9%): one had ureteral injury and two had neurological injury.
- ❑ The most common complication was endplate fracture/subsidence (18.7%), followed by transient psoas weakness and thigh numbness (13.5%) and segmental artery injury (2.6%).
- ❑ Our analysis based on surgeon experience indicated that the OLIF procedure could be performed without increasing incidence of complications, under the guidance of experienced supervisors.

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