Neurospine 2019;16(1):72-81.
https://doi.org/10.14245/ns.1938024.012

Neurospine
pISSN 2586-6583 eISSN 2586-6591

Original Article

Minimally Invasive Endoscopic-Assisted Lateral Lumbar Interbody Fusion: Technical Report and Preliminary Results

Yoshinori Kyoh

Kyoh Orthopaedics & Neurosurgery Clinic, Amagasaki, Japan

Corresponding Author
Yoshinori Kyoh
https://orcid.org/0000-0002-4699-785X

Kyoh Orthopaedics & Neurosurgery Clinic, 54 Misono-cho, Amagasaki-city, Hyogo 660-0861, Japan
Tel: +81-6-6411-0714
Fax: +81-6-6411-5476
E-mail: yhkang@kyoh-clinic.com

Received: January 16, 2019
Revised: March 5, 2019
Accepted: March 8, 2019

Objective: Lateral lumbar interbody fusion (LLIF) is a highly useful lumbar fusion surgical technique for degenerative spinal disease. However, many complications have already been reported. The purpose of this study is to report the concept, surgical technique, and clinical results of the first 70 consecutive cases treated with a safer and minimally invasive endoscopic-assisted LLIF (ELLIF).
Methods: This retrospective study included 70 cases involving 106 segments in which ELLIF was used to treat degenerative spinal disease. We examined the clinical progress, complications and analyzed radiographic images. Regarding the fusion rate, 49 cases involving 72 segments whose follow-up period was more than 7 months were evaluated.
Results: The mean of preoperative Numerical Rating Scale (NRS) was 7.0 and postoperative NRS was 1.4. Postoperative NRS had a significant correlation with the number of fusion segments ($p = 0.028$). The mean of preoperative disc space height, foraminal height, sagittal rotation angle, whole lumbar lordosis and sagittal translation distance were 3.3 mm, 14.3 mm, 2.4°, 9.7°, and 3.2 mm, respectively. Postoperative values were 9.4 mm, 17.9 mm, -4.9°, 36.3°, and 0.7 mm. The fusion rate was 79.2%. Complications included, transient psoas muscle weakness 1, sensory disturbance in the thigh 2, retroperitoneal injury 1, postoperative ileus possibly involving a retroperitoneal injury 1, and cage migration 4.
Conclusion: Using the ELLIF in the degenerative spinal disease, we obtained good radiological reduction and good clinical results. Our study confirms that ELLIF is safer and provides better results for degenerative spinal disease. However, the issue of cage migration remains to be resolved.

Keywords: Lateral lumbar interbody fusion, Endoscopy, Discectomy, Degenerative scoliosis, Stenosis, Spondylolisthesis

INTRODUCTION

Recently, several techniques of interbody fusion using a full endoscopic system have been reported. Posterior approach including the transforaminal approach[1,2] is invasive to the spinal canal and nerves and is invasive to the facet joints. In these procedures, the insertion of a large cage requires significant joint destruction and the reduction efficiency is not as high as that of the anterior approach. In contrast, lumbar fusion using the retroperitoneal approach is able to preserve the posterior elements and has good reduction efficiency.

In the past, there had been progress in the innovation and development of endoscopic lumbar interbody fusion surgery via retroperitoneal space using laparoscopy,[3] however further improvement in laparoscopic fusion techniques is necessary utilizing more advanced medical and surgical devices.

Lateral lumbar interbody fusion (LLIF) enables indirect decompression while preserving the posterior elements and has good reduction efficiency. However, serious complications that are not seen under the posterior approach have also been reported.[4-6] These complications may include direct injury caused by direct contact between surgical equipment and important tissues, indirect injury caused by traction and involution where connective tissues in the surgical area tug adjacent important tissues, and compression injuries to the surrounding muscles and nerves caused by retractors under the nonvisualized operation. Utilization of endoscope under the visualized view allows for safety key field surgery which avoids such dangerous anatomical structures and therefore provides opportunities for safer surgery.

Here we report on our experience of endoscopic-assisted LLIF (ELLIF) in the treatment of the first 106 spinal segments.

MATERIALS AND METHODS

1. Patient Characteristics

This retrospective study targeted 70 cases (37 men, 33 women; mean age 66.1 ± 13.4 years [22–84 years]) involving 106 spinal segments from L1/2 to L5/S1 treated with ELLIF between February 2017 and August 2018. The mean follow-up period of these 70 cases was 11.2 ± 5.5 months (3–23 months).

All study participants provided written informed consent, and the study design was approved by the appropriate Ethics Review Board in Kyoh Orthopaedics & Neurosurgery Clinic (approval number: 2017-001). The clinical trial registration number related to this study is "UMIN000034229". The indications of surgery were degenerative spondylolisthesis, isthmic spondylolisthesis, degenerative scoliosis and lumbar instability. Contraindications in this study were as follows: tumorous condition, infection, visceral disease that blocked the operation field and serious abdominal aortic disease.

Regarding the fusion rate, the cases in which the follow-up period was 6 months or less were excluded from the evaluation. The mean follow-up period of 49 cases involving 72 segments subject to evaluation of the fusion rate was 13.7 ± 4.6 months (7–23 months).

2. Evaluation

We evaluated the preoperative and postoperative pain using Numerical Rating Scale (NRS), peri- and postoperative complications, and the following factors on lateral X-rays and computed tomography (CT): disc space height (DH), foraminal height (FH), sagittal rotation angle (SRA), whole lumbar lordosis (WLL), and sagittal translation distance (STD) (Fig. 1). The fusion rate

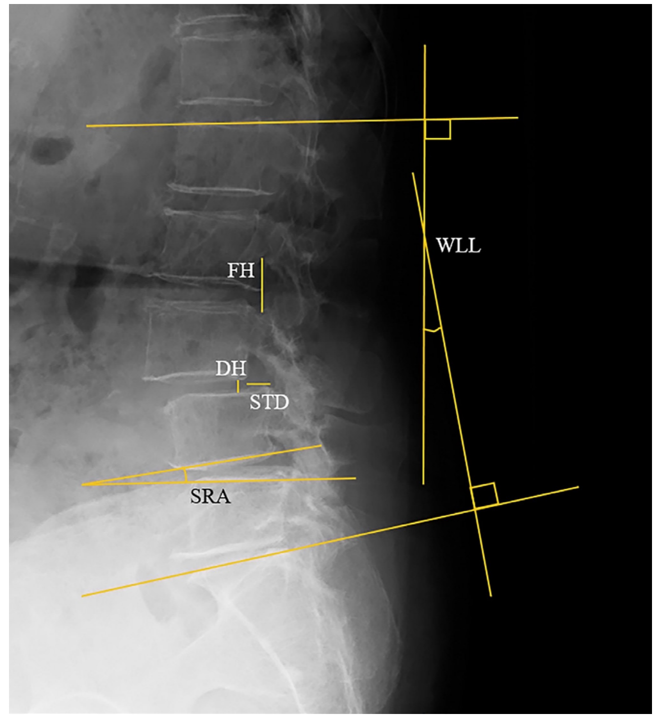

Fig. 1. Radiological evaluation items. DH (mm), disc space height: FH (mm), foraminal height: SRA (°), sagittal rotation angle: WLL (°), whole lumbar lordosis; STD (mm), sagittal translation distance.

was evaluated based on classification of interbody fusion success: Brantigan, Steffee, Fraser (BSF) and the union was determined as BSF-3.[7] We also performed a multiple linear regression analysis considering postoperative NRS and WLL correction (Post WLL - Pre WLL) as dependent variables. Paired t-test was used to calculate p-value of each radiographical correction. Statistical software used for this study was GraphPad Prism 8.0.2 (GraphPad Prism Software Inc., San Diego, CA, USA).

3. Surgical Instrument

1) Lock-arm system and adaptor

We developed and attached an original FESS (full endoscopic spine surgery) adaptor to the Lock-arm system (System JP Inc., Shizuoka, Japan), which is a holder arm system initially developed for laparoscopy (Fig. 2). The Lock-arm is a system that can move freely up to 360° and can firmly fix the surgical field simply using a foot switch. This new system can freely grasp sheaths of any size.

2) Dilator working channel system

An original dilator working channel system developed for ELLIF is then used (Fig. 3). The first long dilator facilitates pro-

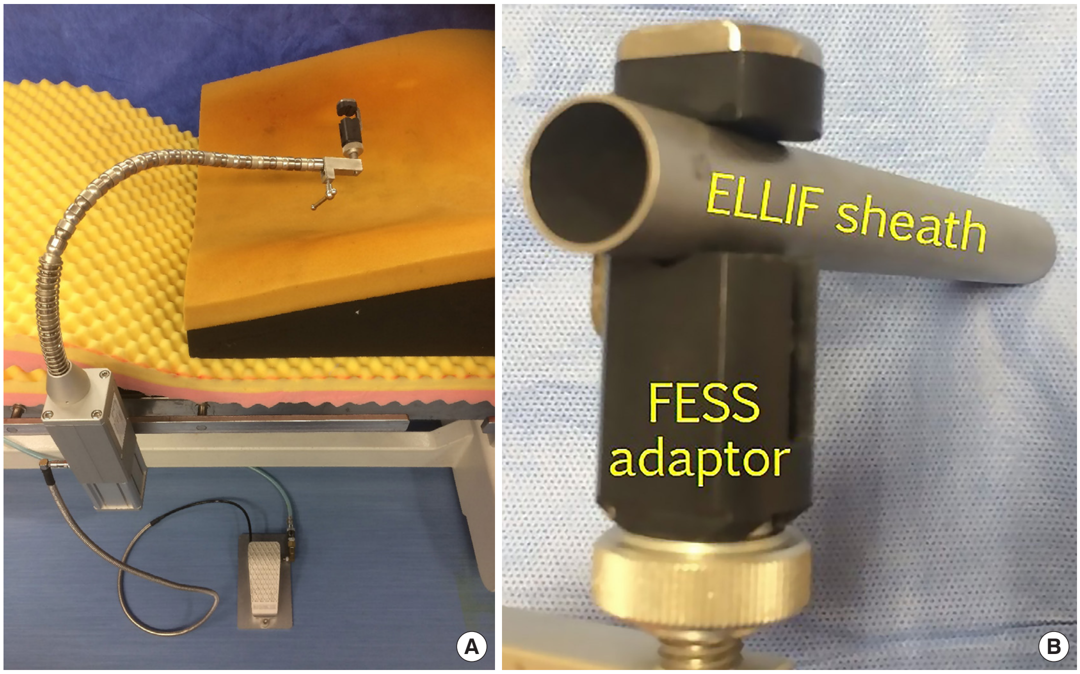

Fig. 2. (A) Lock-arm system. (B) Original full endoscopic spine surgery (FESS) adaptor. ELLIF, endoscopic-assisted lateral lumbar interbody fusion.

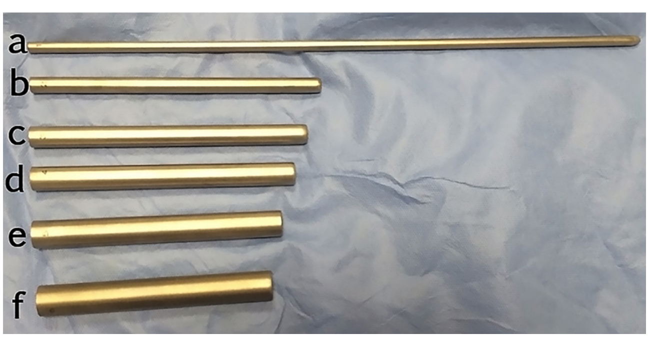

Fig. 3. An original dilator working channel system. First long dilator (a), second sheath (b), third sheath (c), fourth sheath (d), fifth sheath (e), and final sheath (f).

ceeding into the psoas muscle. We can feel the disc bulging shape easily via this long dilator. Additionally, this long dilator works as a core for changing the size of the sheath and is very useful as a lever for changing the direction of the sheath by insertion into the intervertebral disc. The second sheath fits perfectly into the 7.0 diameter full endoscopic system. We start the disc surface resection endoscopically through this sheath. The third sheath is for serial dilation. The fourth sheath is for resection of disc material and endplate preparation by curette under X-ray imaging. Furthermore, we can resect disc material and perform endplate preparation endoscopically by this working channel. We can resect deep into the site visually and safely by full endoscopy. The fifth sheath is for the purpose of setting the 12-mm width cage. We can set the 7- to 10-mm height cage through the fifth sheath. The final sheath is for setting the 11- to 13-mm height cage.

3) Cage

Following intervertebral disc curettage and endplate preparation, a MectaLIF-TiPEEK Oblique cage is positioned and fixed with a dedicated device manufactured by Medacta (Medacta International, Castel San Pietro, Switzerland).

4) Spinal endoscopic instrument

Equipment used for the procedure included a 205-mm spinal endoscopic system (Richard Wolf GmbH, Knittlingen, Germany), PED drill (NAKANISHI Inc., Tochigi, Japan), radio frequency waves (Elliquence, Baldwin, NY, USA), cameras and light source (Stryker Corp., Kalamazoo, MI, USA).

4. Surgical Techniques

Each patient was positioned in the right lateral recumbent position without lateral bending. This absence of bending means that no excessive tension was placed on tissues such as the muscles and the lumbar plexus (Fig. 4).

https://doi.org/10.14245/ns.1938024.012

1) Step. 1: skin incision

The level is checked by X-ray imaging, and a 2-cm incision is made in the skin at the anterior edge of the vertebral body. The subcutaneous tissue is separated from this single portal towards the iliac crest or entry point of external oblique muscle which is the route to the upper intervertebral space.

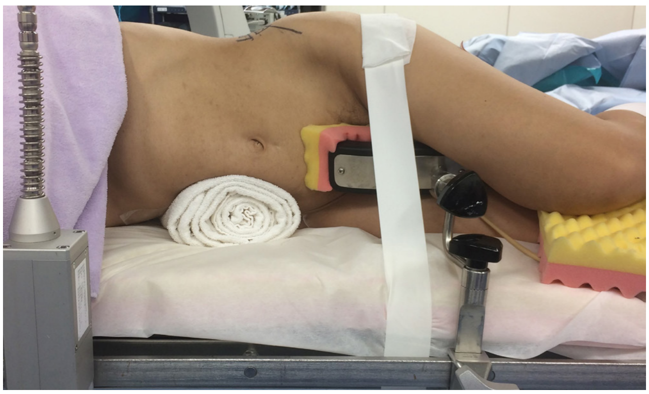

Fig. 4. Operative position.

2) Step. 2: graft bone harvesting

We harvested only a small amount of iliac bone. The cage is filled with the iliac bone mixed with artificial bone. There is no need to make another skin incision for harvesting iliac bone.

3) Step. 3: working channel insertion into the retroperitoneal space

The external obliques, internal obliques, and transverse abdominal muscles are only split with the muscle hook (Fig. 5A). Following this, the intermuscular crevice will be formed (Fig. 5B). From this intermuscular crevice, the endoscopic working channel enters the retroperitoneal space and approaches the target area of L1/2, 2/3, and 3/4 (Fig. 6A). When the target intervertebral space is L4/5 or L5/S1, after harvesting of the ilium, the iliac crest margin is separated. The surgeon can immediately confirm the retroperitoneal area and the dilator directly enters the psoas. This space is sufficient for ELLIF sheath insertion. The psoas major, which is directly visible, can then be easily checked. In this approach, laterocοnal fascia which is the retroperitoneum

Fig. 5. (A, B) Splitting the external oblique muscle, internal oblique muscle, transverse muscle. (C) Skin closure and Penrose drain.

Fig. 6. (A) Single incision allows access up to multiple levels via intermuscular approach or iliac approach. (B, C) A 77-year-old female, endoscopic-assisted lateral lumbar interbody fusion for 4 spinal segments.

of this part is sometimes visible[8] (Supplementary video clip 1). Because the intestinal tract is present in the abdominal side of this very thin membrane, extreme care must be taken.

In case of multilevel LLIF, surgeons require wide exposure.[9] In contrast, it is possible to perform the multilevel treatment with a single 2 cm incision in ELLIF (Fig. 6B, C).

4) Step. 4: fixing the dilator

The psoas major is checked endoscopically without sheath from the retroperitoneal space, and the intervertebral disc is reached through the psoas major muscles (Supplementary video clip 2). Subsequently fix the first dilator and the second sheath and confirm the position under X-ray imaging.

5) Step. 5: annulus opening

The annulus fibrosis and nucleus pulposus are partially resected endoscopically through the second sheath (Supplementary video clip 3).

6) Step. 6: endplate preparation

The sheath is changed to the fourth sheath and the intervertebral disc is resected endoscopically or via X-ray fluoroscopy and the endplates are freshened (Supplementary video clip 4). Resected material floating inside the sheath can be removed immediately by suction.

7) Step. 7: cage insertion

The sheath is changed to the fifth sheath or the final sheath and the cage is fixed (Supplementary video clip 4).

8) Step. 8: wound closure

The muscles naturally close again when the sheath is removed. At this point, a Penrose drain is put in place and only the subcutaneous tissue and skin require suturing (Fig. 5C).

Application for multilevel segments: In cases with multilevel segments requiring treatment, the discs are approached by changing direction as shown in the figures (Fig. 7). For L4/5, L5/S1, the author's original iliac approach facilitates parallel entry into

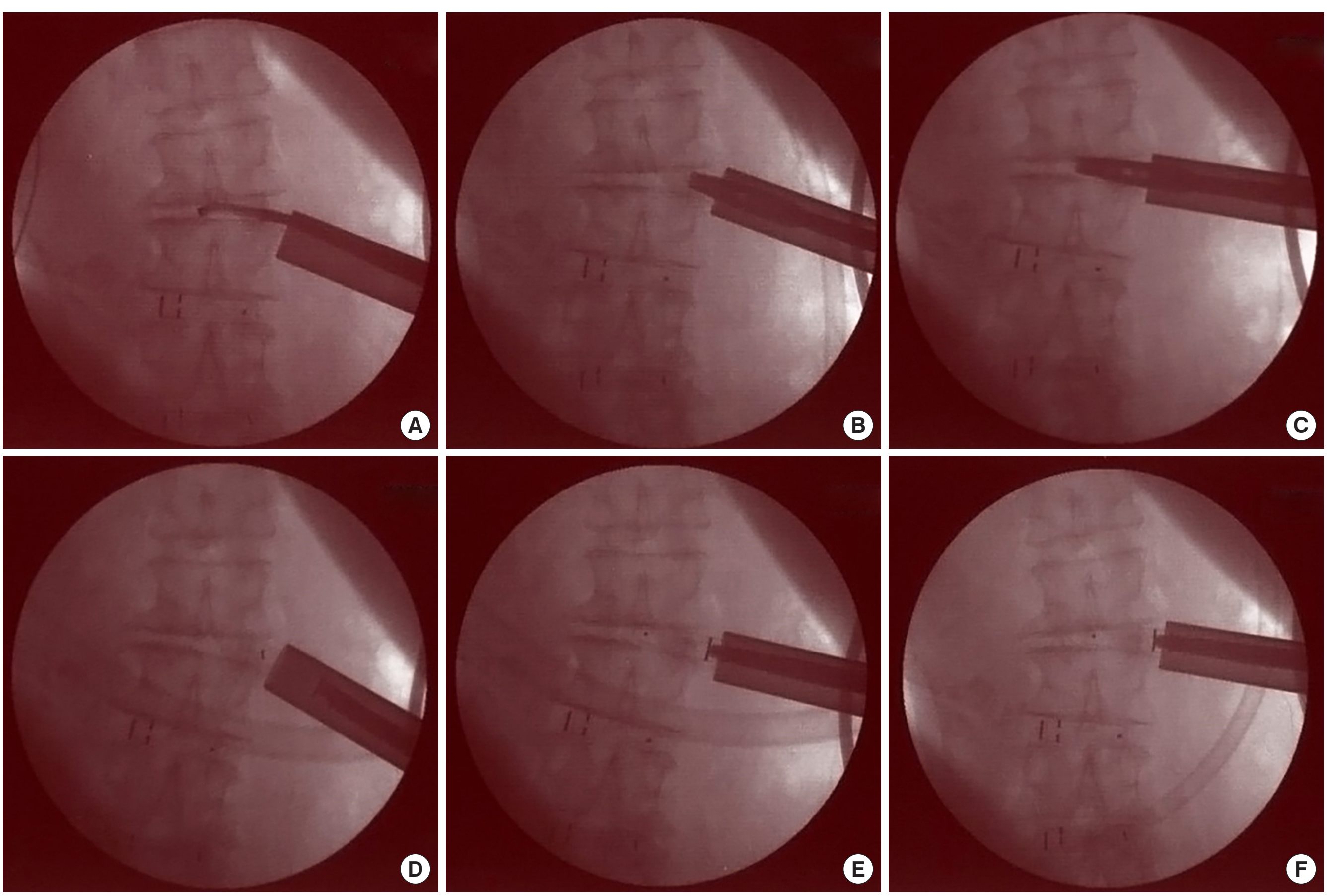

Fig. 7. (A-F) In cases with multilevel discs requiring treatment, the discs are approached by changing direction as shown in the figures.

 https://doi.org/10.14245/ns.1938024.012

the disc. For L3/4 the intermuscular approach facilitates parallel entry into the disc. From the skin incision to L1/2, L2/3, the approach angle is not parallel to the disc. However, using an angled curette, the surgeon can resect disc material deep into the disc space. Additionally, we insert the first long dilator to mid depth. Here, this long dilator is very useful as a lever for changing the direction of the sheath reaching parallel to the disc. After lifting the first dilator, we can reach deeply into the disc space. Finally, similar to the long dilator, the cage inserter is effective in altering the direction of cage fixation. However, if the rib is too low, the procedure is technically difficult. The rib will block lifting of the first dilator. In such cases, fractional rib resection may be necessary.

Application for the osteophytes covered segment: A drilling approach with full endoscopy is used for cases with osteophytes (Fig. 8).

RESULTS

1. Operation Time

The average operation time per one segment was 103.2 minutes in these 70 cases. In the latest 20 cases in this series, the average operation time per one segment was reduced to 82.6 minutes.

2. Intraoperative Bleeding

Regarding bleeding, in fact, there is potential for minor bleeding. However, bleeding volume during surgery was below zero in measurements. Due to accumulation of the irrigation fluid in the retroperitoneal space, the measured value of out-volume liquid (including in gauze and removed by suction) was lower than the in-volume value (the irrigation fluid) in all cases.

3. Clinical Outcomes

The mean of preoperative NRS was 7.0 ± 1.9 and postoperative NRS was 1.4 ± 1.7. No association of postoperative NRS had been seen with age and sex. However, there was a significant correlation ($p = 0.028$) between the postoperative NRS and the number of fusion segments (Table 1).

Complications included: transient psoas muscle weakness 1, sensory disturbance in the thigh 2, retroperitoneal injury 1, post-

Table 1. Multiple linear regression analysis based on postoperative Numerical Rating Scale as dependent variable

Variable	SE	p-value	95% CI
Age	0.015	0.140	-0.007–0.052
Sex	0.395	0.857	-0.860–0.717
No. of fusion segments	0.241	0.028*	0.062–1.024

SE, standard error; CI, confidence interval.
*Significant.

Fig. 8. (A, B) A drilling approach with full endoscopy is used for cases with osteophytes.

https://doi.org/10.14245/ns.1938024.012

Table 2. Comparison of radiographic parameters of 106 spinal segments between preoperative images and postoperative images

Variable	Pre	Post	p-value	Change pre to post
Disc space height: DH (mm)	3.3 ± 2.4	9.4 ± 1.5	< 0.001*	6.1 ± 2.1
Foraminal height: FH (mm)	14.3 ± 3.8	17.9 ± 3.1	< 0.001*	3.6 ± 2.7
Sagittal rotation angle: SRA (°)	2.4 ± 5.9	-4.9 ± 4.7	< 0.001*	7.3 ± 5.6
Whole lumbar lordosis: WLL (°)	9.7 ± 13.0	36.3 ± 10.0	< 0.001*	26.6 ± 8.3
Sagittal translation distance: STD (mm)	3.2 ± 4.5	0.7 ± 1.9	< 0.001*	2.5 ± 3.5

Values are presented as mean ± standard deviation.
*Significant; Student t-test.

Table 3. Multiple linear regression analysis based on WLL correction (post WLL - pre WLL) as dependent variable

Variable	SE	p-value	95% CI
Age	0.074	0.214	-0.055–0.239
Sex	1.965	0.191	-6.515–1.330
Number of fusion segments	1.200	0.099	-0.390–4.399

WLL, whole lumbar lordosis; SE, standard error; CI, confidence interval.

operative ileus possibly involving a retroperitoneal injury 1, cage migration 4. These 4 cages migrated patients required replacement with different cages.

4. Radiological Outcomes

The mean of preoperative DH, FH, SRA, WLL, and STD were 3.3 ± 2.4 mm, 14.3 ± 3.8 mm, 2.4° ± 5.9°, 9.7° ± 13.0°, and 3.2 ± 4.5 mm. Postoperative values were 9.4 ± 1.5, 17.9 ± 3.1, -4.9 ± 4.7, 36.3 ± 10.0, and 0.7 ± 1.9. The mean reduction value (postoperative – preoperative) was DH 6.1 mm, FH 3.6 mm, SRA 7.3°, WLL 26.6°, and STD 2.5 mm. Radiological data are summarized in Table 2. Among the 72 segments, 57 segments were BSF-3 and hence the fusion rate was 79.2%. No association of WLL correction had been seen with age and sex and the number of fusion segments (Table 3).

DISCUSSION

There are many reports of various complications involved in lumbar lateral interbody fusion surgery,[4-6] including death.[6] Here we aimed to facilitate a safe, minimally invasive, and highly therapeutically effective LLIF based on the fundamental concept that tissues which may cause complications should not be included in the surgical field. Clearly, surgeons should be familiar with basic anatomy, while considering that carefully ascertaining the individual patient's anatomy preoperatively ensures the confirmation of a safe surgical field. In consideration of this necessity, we advanced development with Konica Minolta Japan Inc. in order to apply the Plissimo2000 surgical assistance 3-dimensional computed tomography/magnetic resonance imaging (3D CT/MRI) fusion imaging device (Konica Minolta, Tokyo, Japan) to spine surgery. As a result, we achieved visualization of arteries, veins, urinary tract, kidney, lumbar nerve plexus, muscles, and bones by 3D imaging and confirmation of the individual safety key field. In addition, Plissimo2000 does not require a contrast medium (Fig. 9). Even without this system, it is certainly possible to visualize the ureter and blood vessels with contrast-enhanced CT, however contrast use is invasive, and contrast-enhanced CT cannot visualize the lumbar plexus.

The surgical site must be visually checked and confirmed. We used the full endoscopic system to achieve safety key field surgery. Using the full endoscopic system, it is possible to perform the multilevel treatment with a single 2-cm incision. The full endoscopic system is used to check the retroperitoneum and ensure that no abdominal organs are within the field, the position of the psoas major is checked, and the dilator is inserted into the psoas major. Our original working channel system makes it possible to perform surgical interventions in the space between multiple discs by freely changing the angle of insertion of the dilator from only 1 portal. This original working channel system has the following 3 functions: a dilator, a retractor, and as an endoscopic sheath. An essential element of this original technique is the Lock-arm system which can freely move 360° and can firmly fix the surgical field simply using a foot switch. We attached an original adaptor to the Lock Arm for this technique. Endplate preparation is performed under endoscopic view or via X-ray fluoroscopy after confirming that only safe tissue was within the channel.

We successfully achieved a safe, minimally invasive, and highly therapeutically effective LLIF surgery as described above. In this study, the author's initial clinical experience demonstrated that this technique had good reduction efficiency and only a

https://doi.org/10.14245/ns.1938024.012

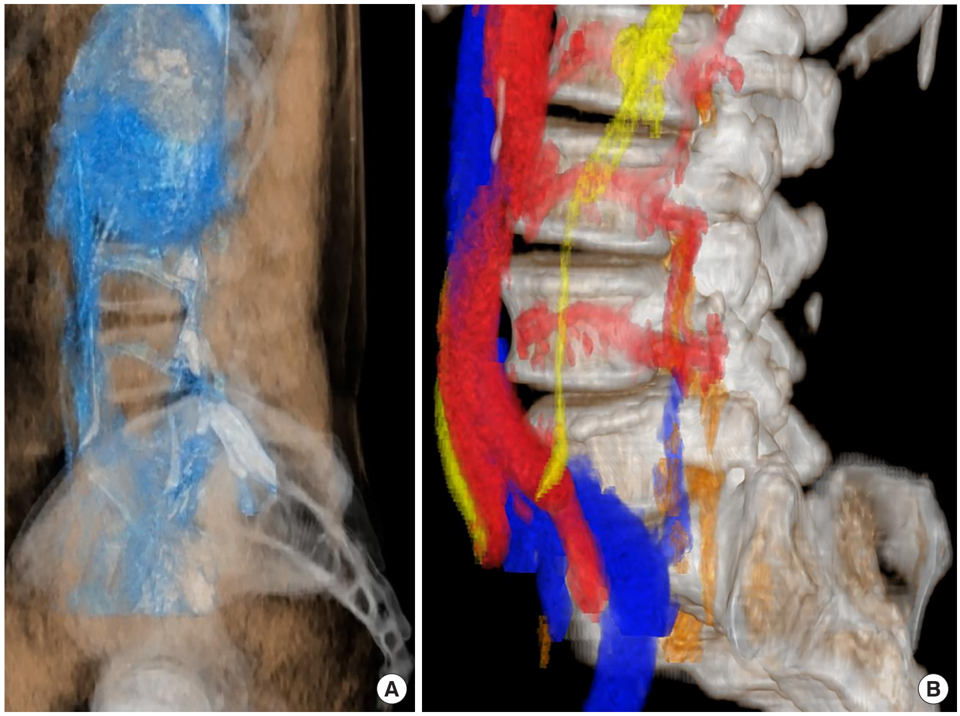

Fig. 9. Three-dimensional computed tomography/magnetic resonance imaging fusion imaging. (A) Quick view. (B) Colored view. Red: artery, blue: vein, yellow: urinary tract, orange: nerve.

small percentage of postoperative neural complications that are often reported with the trans–psoas major approach. Due to the key field operation procedure, there were no major complications. However, the 2 issues of retroperitoneal injury and cage migration have been clarified. With regard to retroperitoneal injury, one patient had a very favorable clinical course, however free air was observed under postoperative radiography. The other patient, postoperative ileus was possibly caused by some effect on the retroperitoneum. Both patients were extremely thin women (body mass index of 18.1 and 13.7 kg/m^2). In thin patients, there is no cavity in the retroperitoneal space and less fat volume decreases the anterior shift effect of the bowel with retroperitoneum. Therefore, there is potential for pinching of the retroperitoneum. During the cage insertion at the end of the surgery, the vertebral body is pushed inward and the sheath can float slightly upward, thus this complication may occur at this point. The lower psoas tends to float from the vertebral body and there is potential for the retroperitoneum to be caught with the cage and drawn into the disc space between the vertebral body and the psoas from the anterior portion.

There are multiple anterior lumbar fusion methods. ELLIF is the same transpsoas approach as direct lateral interbody fusion (DLIF). However, DLIF uses wide cages and wide retractor. Therefore, Neuromonitoring is necessary. In case of ELLIF, it uses 12-mm width cages and uses a small working channel. Furthermore, the visualized view utilizing endoscope achieves fusion without neuromonitoring and no major neural complications are observed.

In contrast to DLIF, OLIF does not require neuromonitoring. However, the surgeon spreads open the anterior to psoas in OLIF. During OLIF, there is a risk of injury to dangerous anatomical structures such as vena cava, aorta, and urinary tract.

ALIF is preferable for L5/S1 fusion while DLIF and OLIF are unsuitable. However, ALIF is highly invasive to the abdominal area. In contrast, ELLIF is minimally invasive and can be utilized in treating L5/S1. Using a 3D CT/MRI fusion imaging device and utilization of endoscope under the visualized view allows L5/S1 fusion via the psoas.

In this ELLIF series, we found that, during dissection of the intervertebral discs, despite feeling manually that the endplate had been sufficiently freshened, when the area was checked endoscopically, a considerable amount of residual tissue persisted. In cases of nonunion with other lumbar interbody fusion techniques, it is possible that remnant tissue is one of the reasons for non-union. It is important to completely confirm the freshness of the endplate by observing the area endoscopically. This is another advantage of the ELLIF technique.

Even posterior fusion which resects facet joint and uses a small-

https://doi.org/10.14245/ns.1938024.012

er cage than ELLIF achieves bone fusion.[10] Besides, ELLIF uses a fully titanium-coated cage. However, in this study using ELLIF, we encountered 4 cases (3.8%) of cage migration, which occurs rarely with OLIF and DLIF. This may be due to the limited variation in cage shapes, which may not necessarily be suitable for all patients. In some cases, the contact area of the cage with the endplate surface is insufficient. These 4 patients required replacement with different cages.

The main purpose of setting the Penrose drain is for drainage of the irrigation fluid. Here, minimal bleeding from bone donor site and minimal hidden blood loss from the psoas muscle is conceivable since discharged fluid is light-colored blood.

Regarding statistical analysis, there was a significant correlation between the postoperative NRS and the number of fusion segments. Here, the cases which require multiple segment fusion almost entirely consisted of patients with degenerative scoliosis. Thus, the author considers that there are limitations to recovery in patients with degenerative scoliosis compared with a short-segment degenerative spondylolisthesis or isthmic spondylolisthesis.

CONCLUSION

The ELLIF technique described here is an innovative surgical technique for a number of reasons. First, it is a combination of minimally invasive spine stabilization and full endoscopic discectomy. Second, this technique is a tailor-made surgery that involves visualization of the patient's individual anatomy with 3D CT/MRI fusion imaging. Third, this technique demonstrates that endoscopic surgery may be safer and easier than open surgery, achieving its aims with minimally invasive techniques. In addition, this surgery can achieve reduction and interbody fusion for degenerative scoliosis with a single 2-cm portal. However, improvements are necessary to prevent cage migration, enable widespread application, and requires further equipment-related innovations to further reduce the risk of complications. In spite of this, we have achieved a certain level of success with the first 106 spinal segments. This has opened the door to the next generation of spinal surgery.

CONFLICT OF INTEREST

The authors have nothing to disclose.

ACKNOWLEDGMENTS

I would like to thank ILC (www.ilc-japan.com) for English language editing.

SUPPLEMENTARY MATERIALS

Supplementary video clips 1–4 can be found via
https://doi. org/10.14245/ns.1938024.012.v1,
https://doi.org/10.14245/ ns.1938024.012.v2,
https://doi.org/10.14245/ns.1938024.012.v3,
https://doi.org/10.14245/ns.1938024.012.v4.

Supplementary video clip 1: The motion of retroperitoneum.

Supplementary video clip 2: The endoscopic approach via psoas.

Supplementary video clip 3: Endoscopic safety annulus opening.

Supplementary video clip 4: Endplate preparation and cage insertion.

REFERENCES

1. Heo DH, Son SK, Eum JH, et al. Fully endoscopic lumbar interbody fusion using a percutaneous unilateral biportal endoscopic technique: technical note and preliminary clinical results. Neurosurg Focus 2017;43:E8.
2. Lee SH, Erken HY, Bae J. Percutaneous transforaminal endoscopic lumbar interbody fusion: clinical and radiological results of mean 46-month follow-up. Biomed Res Int 2017; 2017:3731983.
3. Nakamura H, Ishikawa T, Konishi S, et al. Psoas strapping technique: a new technique for laparoscopic anterior lumbar interbody fusion. J Am Coll Surg 2000;191:686-8.
4. Abe K, Orita S, Mannoji C, et al. Perioperative complications in 155 patients who underwent oblique lateral interbody fusion surgery: perspectives and indications from a retrospective, multicenter survey. Spine (Phila Pa 1976) 2017;42:55-62.
5. Balsano M, Carlucci S, Ose M, et al. A case report of a rare complication of bowel perforation in extreme lateral interbody fusion. Eur Spine J 2015;24 Suppl 3:405-8.
6. Assina R, Majmundar NJ, Herschman Y, et al. First report of major vascular injury due to lateral transpsoas approach leading to fatality. J Neurosurg Spine 2014;21:794-8.
7. Fogel GR, Toohey JS, Neidre A, et al. Fusion assessment of posterior lumbar interbody fusion using radiolucent cages:

X-ray films and helical computed tomography scans compared with surgical exploration of fusion. Spine J 2008;8:570-7.
8. Kanemura T, Satake K, Nakashima H, et al. Understanding retroperitoneal anatomy for lateral approach spine surgery. Spine Surg Relat Res 2017;1:107-20.
9. Wakita H, Shiga Y, Ohtori S, et al. Less invasive corrective surgery using oblique lateral interbody fusion (OLIF) including L5-S1 fusion for severe lumbar kyphoscoliosis due to L4 compression fracture in a patient with Parkinson's disease: a case report. BMC Res Notes 2015;8:126.
10. Fujimori T, Le H, Schairer WW, et al. Does transforaminal lumbar interbody fusion have advantages over posterolateral lumbar fusion for degenerative spondylolisthesis? Global Spine J 2015;5:102-9.