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Technical Note

Transumbilical Retroperitoneal Lumbar Interbody Fusion: A Technical Note and Preliminary Case Series

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Objective: Anterior lumbar interbody fusion (ALIF) has advantages over posterior lumbar interbody fusion or transforaminal lumbar interbody fusion techniques in that it minimizes damage to the anatomical structure of the posterior spinal segment and enables indirect decompression of the foramen by insertion of a tall cage. However, the predominant abdominal scar tissue reduces patients' satisfaction after ALIF. Herein, we describe the technique of transumbilical lumbar interbody fusion (TULIF) and its preliminary results in a case series.
Methods: A retrospective review of 154 consecutive patients who underwent TULIF between the L2–3 and L4–5 levels was performed. After preoperatively selecting patients by evaluating the location of the umbilicus and vessel anatomy, a vertical skin incision was made on the umbilicus to minimize the abdominal scar tissue.
Results: There were 120 single-level (110 L4–5 and 10 L3–4), 31 two-level, and 3 three-level surgeries. All patients were very satisfied with their postoperative abdominal scars, which were noticeably faint compared to those after conventional ALIF.
Conclusion: TULIF is a feasible, minimally invasive surgical option that can achieve both the treatment of degenerative spinal disease and satisfactory cosmesis. Although it is technically demanding, patients obtain sufficient benefits.

Keywords: Anterior lumbar interbody fusion, Transumbilical lumbar interbody fusion, Scar less surgery, Lumbar interbody fusion

INTRODUCTION

From its first introduction by Dr. Cloward in the 1950s, anterior lumbar interbody fusion (ALIF) has been widely performed for treating degenerative spine disease (including spondylolisthesis), deformity, infection, and trauma.[1] The anterior approach has advantages over conventional posterior lumbar interbody fusion and transforaminal lumbar interbody fusion techniques as it minimizes damage to the anatomical structure of the posterior spinal segment[2] and enables indirect decompression of the foramen by insertion of a tall cage.[3]

Aside from these advantages, however, undergoing spinal surgery through laparotomy is a great psychological burden for some patients, and the predominant abdominal scar tissue resulting after the procedure, reduces patients' satisfaction after ALIF. Given that many surgical techniques are now minimally invasive and aim to cause as few scars as possible postoperatively, this disadvantage of ALIF should be addressed.

The transumbilical approach already has been widely used for laparoscopic surgeries and plastic surgeries, such as breast augmentation, to minimize abdominal scars[4-6]; however, its application for spinal surgery has rarely been reported. Herein, we describe the transumbilical lumbar interbody fusion (TULIF) technique for addressing the disadvantage of the retroperitoneal approach for ALIF via a small incision on the umbilicus and its preliminary results in a case series of TULIF for degenerative lumbar disease.

MATERIALS AND METHODS

A retrospective review of consecutive patients who underwent TULIF between the L2–3 and L4–5 levels from November 2012 to December 2015. This study was approved by the Institutional Review Board of Wooridul Spine Hospital (IRB No. 2019-12-WSH-009) and informed consent was obtained from the patients. The inclusion criteria were the following: (1) instrumented TULIF and (2) clinical and radiological follow-up duration for a minimum 6 months. Indication of surgery included patients who presented with spondylolisthesis (n = 84), discogenic low back pain (n = 22), disc herniation (n = 21), spinal stenosis with instability (n = 16), foraminal stenosis (n = 6), degenerative scoliosis (n = 4), and pseudoarthrosis (n = 1) between the L2–3 and L4–5 levels (Table 1), and did not respond to intensive conservative treatments. Exclusion criteria were spondylodiscitis, a history of previous abdominal surgery or radiotherapy, inappropriate vascular anatomy for the anterior approach, and severe obesity (body mass index [BMI] ≥ 30 kg/m^2).

Table 1. Patients' demographic and clinical data

Characteristic	Value
Age (yr)	58.3 ± 10.2
Sex, male:female	41:113
Body mass index (kg/m^2)	25.4 ± 3.2
Bone mineral density (T-score, lumbar)	-0.84 ± 1.47
Surgical levels	
1 Level	
L3-4	10
L4-5	110
2 Levels	
L2-3-4	1
L3-4-5	30
3 Levels	
L2-3-4-5	3
Diagnosis	
Spondylolisthesis	84
Discogenic low back pain	22
Disc herniation	21
Spinal stenosis with instability	16
Foraminal stenosis	6
Degenerative scoliosis	4
Pseudarthrosis	1

Values are presented as mean ± standard deviation or number.

1. Radiological and Clinical Evaluation

Follow-up dynamic lumbar radiographs were evaluated in all patients. At 12-month follow-up, computed tomography (CT) scan was performed. Fusion was defined as solid when there was osseous continuity observed in CT reconstruction images and mobility less than 4 degree as seen in flexion-extension lateral radiographs. Nonunion was defined as the presence of a visible gap, instrument loosening and mobility greater than 4 degree. Clinical outcomes were assessed by the visual analogue scale (VAS; 0–10, with 0 reflecting no pain) and functional outcomes were measured by the Oswestry Disability Index (ODI; 0%–100%) score.

2. Surgical Technique

Before the surgery, preoperative magnetic resonance image (MRI) and sagittal scout CT were evaluated to identify the location of the umbilicus centered on the index levels (Fig. 1A, B). Under general anesthesia, patients were placed in the supine position. Sterile skin preparation and surgical draping were done. To detect over traction of the abdominal or left common iliac artery during the surgery, an oximeter was placed on the patient's left great toe. C-arm-guided marking was conducted to evaluate the index level. Anterior retroperitoneal surgical approach was made by approach surgeon. An approximately 3-cm (1.5 inch) long vertical skin incision was made into the dermal layer on the midline of the umbilicus with an 11th or 15th blade (Fig. 2). The subcutaneous fat under the umbilicus was carefully exfoliated to reach the linea alba and anterior sheath of the rectus muscle using Adson forceps and Bovie cautery. Then the anterior fascia was incised and retracted laterally with the rectus

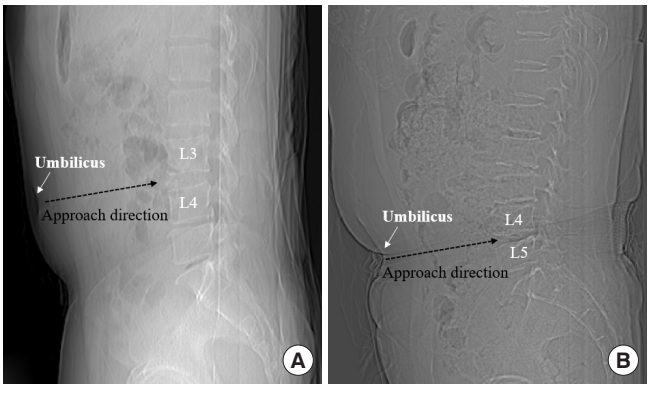

Fig. 1. Preoperative sagittal scout computed tomography view used to identify the location of the umbilicus centered on the index levels. These images show examples of cases where the position of the patient's umbilicus is parallel to the L3–4 levels (A) or parallel to the L4–5 levels (B).

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muscle using the light retractor (Fig. 3). The rectus muscle was elevated to reveal the posterior sheath of the rectus muscle and arcuate line (linea semicircularis). Next, the peritoneal sac was separated from the posterior sheath by blunt dissection, starting from the lateral border of the arcuate line (approximately 4 cm lateral from the midline). In order to prevent peritoneal sac injury, we cut the posterior sheath vertically toward the index disc level (Fig. 4). If a peritoneal injury occurred, we evaluated whether peritoneal organ injury occurred and performed primary repair of the organ with an absorbable suture. The surgical procedures performed after accessing the peritoneum are the same as those used in conventional ALIF. The intraperitoneal contents were bluntly displaced from the retroperitoneal space from the left side toward the midline (Fig. 5A). When the index disc level was reached, the field of view was secured using the level retractor (Fig. 5B). Suture after discectomy and cage insertion is the same as typical ALIF. However, in order to suture the skin layer and subcutaneous layer of umbilicus without

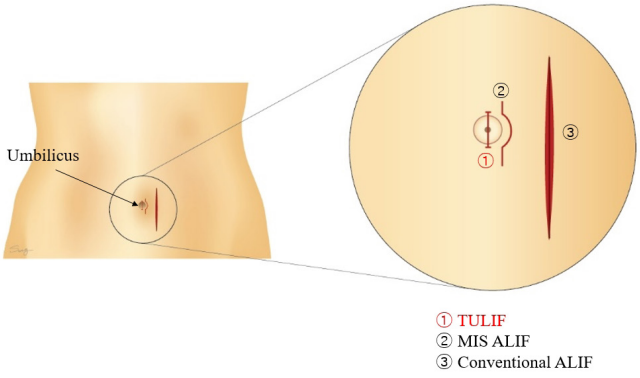

Fig. 2. Comparison of the incisions in transumbilical lumbar interbody fusion (TULIF), minimally invasive spine (MIS) anterior lumbar interbody fusion (ALIF), and conventional ALIF.

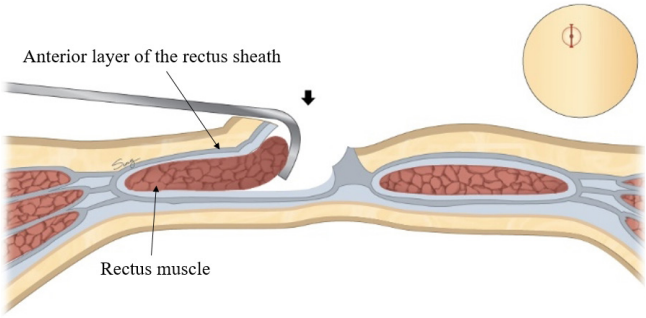

Fig. 3. The anterior fascia is incised and retracted laterally with the rectus muscle using the light retractor.

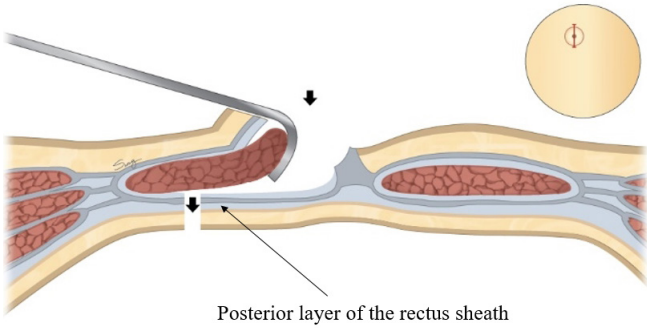

Fig. 4. Axial illustration showing the procedure of cutting the posterior sheath.

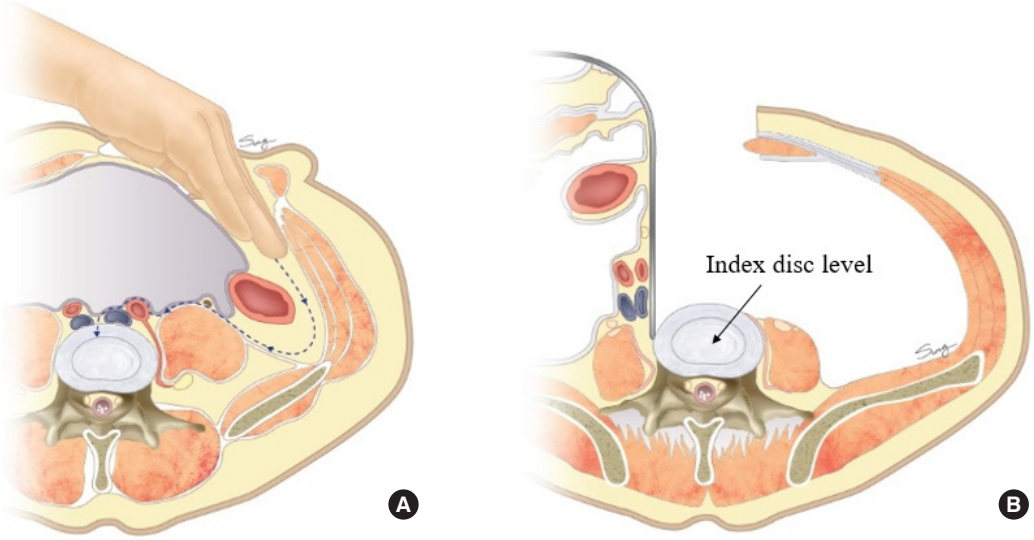

Fig. 5. (A) The intraperitoneal contents are bluntly displaced from the retroperitoneal space from the left side toward the midline. (B) When the index disc level is reached, the field of view is secured using the level retractor.

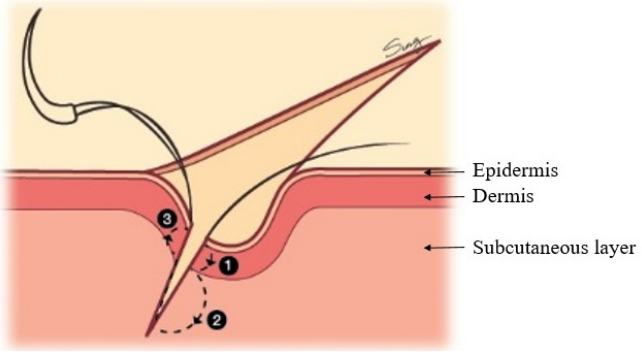

Fig. 6. Illustration showing the technique of suturing the abdominal layer.

dimpling, the connection between layers must be appropriate. After the suture needle passes through the skin and subcutaneous layer of the medial part of umbilicus, the subcutaneous layer of the lateral part is skipped and the skin layer is then connected (Fig. 6). It is important not to include the subcutaneous layer of the lateral part, which is to preserve the belly naturally present in the umbilicus. If the suture is connected as layer by layer like a normal surgery, the navel will be pitted downwards to restore flatness, leaving an unnatural look.

Suturing after discectomy and cage insertion are the same as those performed in conventional ALIF. However, in order to suture the skin layer and subcutaneous layer of the umbilicus without causing dimpling, the 2 layers must be aligned with each other.

After completion of the ALIF, the patient was turned to prone position. Percutaneous pedicle screw fixation was performed under the C-arm guidance. In selected patients with severe stenosis, additional decompressive laminectomy/facetectomy was performed.

RESULTS

A total 154 patients (41 males; mean follow-up, 21.3 ± 12.6 months) were evaluated. Patients' mean age was 58.3 ± 10.2 years, and mean BMI was 25.4 ± 3.2 kg/m^2 (Table 1). Mean bone mineral density was -0.84 ± 1.47 (T-score, lumbar). There were 120 single-level (110 L4–5 and 10 L3–4), 31 two-level, and 3 three-level surgeries. The most common cause of surgery was spondylolisthesis (n = 84). Among the 84 patients who diagnosed with degenerative spondylolisthesis, 18 patients had additional decompressive laminectomy after the pedicle screw fixation. Mean operative time was 90.9 ± 34.3 minutes with a mean blood loss of 189.7 ± 146.9 mL for the anterior surgery. The amount of drainage (anterior drainage) was 175.3 ± 60.6 mL. There was 1 case (0.6%) of intraoperative peritoneal tear and 1 case (0.6%) of wound revision (Table 2). Radiographs of all patients at the last follow-up showed fusion. All patients were very satisfied with their postoperative abdominal scars (recorded through a questionnaire at follow-up after 6 months), which were noticeably faint compared to those after conventional ALIF. VAS for back and leg pain and ODI demonstrated statistically significant differences between the preoperative and postoperative periods (Table 3).

Table 2. Patients' operative data

Variable	Value
Operative time (min) (anterior)	90.9 ± 34.3
Blood loss (mL) (anterior)	189.7 ± 146.9
Drain output (mL) (anterior)	175.3 ± 60.6
Complication	
Peritoneal tear (intraoperatively)	1 (0.6)
Wound revision (postoperatively)	1 (0.6)

Values are presented as mean ± standard deviation or number (%).

Table 3. Clinical and functional outcomes

Variable	Preoperative	Postoperative	p-value
VAS (back)	8.4 ± 1.3	2.3 ± 1.6	< 0.0001
VAS (leg)	7.3 ± 1.7	1.8 ± 0.9	< 0.0001
ODI (%)	63.4 ± 16.8	17.5 ± 12.8	< 0.0001

1. Case Examples

1) Case 1

A 61-year-old man suffered from low back pain and leg numbness in both legs for 5 years (Fig. 7). He experienced neurogenic intermittent claudication at 100 m. The physical examination showed hypoesthesia of both legs, and heel gait was impossible due to motor weakness. The radiological examination revealed degenerative spondylolisthesis with spinal stenosis at the L4–5 levels (Fig. 7A). He underwent TULIF of the L4–5 levels using the described technique, followed by percutaneous pedicle screw fixation. Postoperatively, he showed improvement without any complication (Fig. 7B). At 6 months postoperatively, his scars were very faint (Fig. 7C).

2) Case 2

A 72-year-old woman had low back pain and radiating pain in her right leg for 3 years (Fig. 8). The physical examination showed hypoesthesia of her right leg and foot drop of her right ankle. The radiological examination revealed right foraminal

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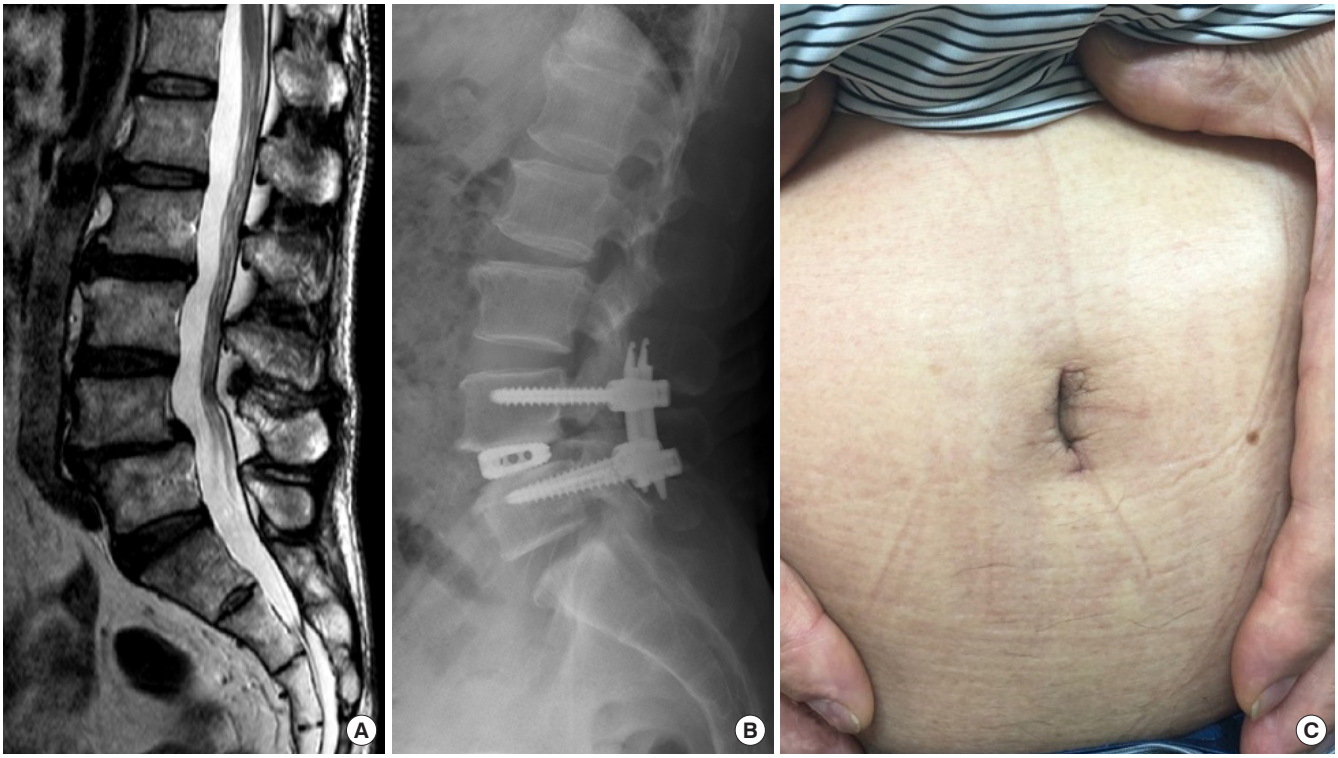

Fig. 7. (Case 1) Preoperative magnetic resonance imaging scan (A), postoperative x-ray (B), and photograph of the abdominal scar after 6 months postoperatively (C).

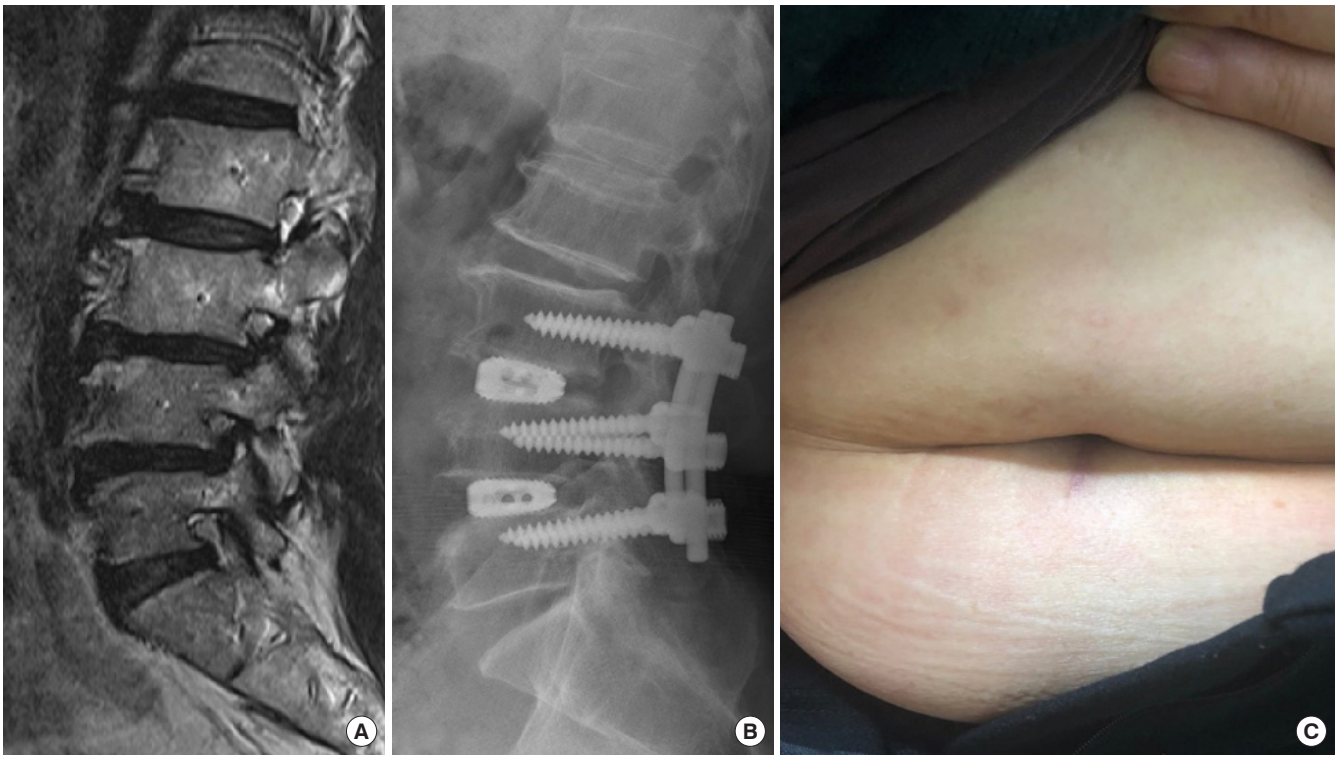

Fig. 8. (Case 2) Preoperative magnetic resonance imaging scan (A), postoperative x-ray (B), and photograph of the abdominal scar after 6 months postoperatively (C).

stenosis at the L3-4-5 levels (Fig. 8A). She underwent TULIF of the L3-4-5 levels using the described technique, followed by percutaneous pedicle screw fixation. At 2 months postoperatively, her leg pain improved from a VAS score of 8 to 1, and she showed improvement in motor function of her right ankle from grade 2 to 3+ (Fig. 8B). At 6 months postoperatively, her scars were very faint and only visible slightly below the navel (Fig. 8C).

DISCUSSION

Currently, many techniques of spine surgeries are pursuing minimally invasive spine (MIS) procedures.[7,8] The concept of MIS procedure includes shortening the surgical time, preserving normal tissue, and minimizing the length of the incision, which lead to rapid recovery of the patient. Fusion through the anterior approach is one of these MIS techniques in that it can minimize injury of the posterior spinal segment.

Conventional ALIF is a mini-laparotomy concept that typically starts with a 3- to 5-inch long incision on the left side of the abdomen.[9] As aforementioned, this approach results in a noticeable scar and is associated with postoperative abdominal pain. A surgical technique for performing ALIF with as small of an incision as possible next to the navel needs developed in order to reduce this complication. Brau[10] introduced a "mini-open approach" for performing an incision transversely parallel to the index level. Although the size of the incision is smaller than that of conventional ALIF, there is a possibility that wound healing may be affected by blood vessel damage and supply, as most blood suppliers in the abdomen are vertically distributed. Recently, Bassani et al.[11] introduced the "keyhole approach" using a perinavel incision, which creates a rounded incision under the navel to create a skin lid and is then closed again postoperatively. This type of incision reduces postoperative scars more than the conventional "mini-open approach." However, all of the existing methods cause some incision scar because they require incision of the normal skin tissue area of the abdomen.

TULIF described herein is a surgical operation through the navel rather than the abdominal skin. The first advantage of this approach is that most of the incisions are performed in the navel, leaving a minimal sign of surgery. Based on the recently reported keyhole approach,[11] incision scars are still noticeable postoperatively. Scarring induced by TULIF is trivial enough to be barely discernible (Figs. 7C, 8C). The second advantage of TULIF is that unlike the "mini-open approach," the incision is performed vertically and parallel to the vessel, thus reducing the risk of vascular damage, which will be helpful for wound recovery.[12,13] The third advantage is that this surgical approach uses a natural orifice. Surgery through the natural orifice transluminal approach has already been performed a lot in the general surgery fields. The advantages this surgical approach are faster recovery, fewer adhesions, fewer postoperative ileus, avoidance of incisional hernias, fewer abdominal wound infections, less postoperative pain, and better cosmetic results.[14,15]

Conventional ALIF has already been proven in many papers as a surgery with high fusion rate and good surgical outcome.[16-20] TULIF is revised technique of conventional ALIF only at the initial abdominal approach stage, and the basic retroperitoneal approach and fusion method are the same as the existing ALIF. Therefore, fusion rate and clinical outcome are thought to be the same as the existing ALIF. This will be verified in an additional clinical article after the technical note is published in the future.

However, since TULIF can be performed within a much smaller window than conventional surgery, an understanding of the normal anatomy of the abdomen is essential and technically, a longer training period is required. Considering the small operation field of abdomen and emergent management for the major vessel injury, co-operation with the approach surgeon can be an ideal solution for this difficulty. Additionally, because each patient has a different anatomy, the index level may be difficult to access through the navel in some patients, and an additional incision may be required for multilevel fusion surgery (more than 3 levels). According to our experience, appropriate level of this technique is mainly L3–4 and L4–5 level. Before the surgery, it is necessary to review preoperative MRI or sagittal scout CT to ensure that the index level is a level that can be approached with TULIF. Despite some limitations, the scar after TULIF improved dramatically, compared to those after previous approaches. TULIF seems to have developed the conventional ALIF into a more suitable approach for MIS procedures.

CONCLUSION

TULIF is a feasible, minimally invasive surgical option that can achieve both treatment of degenerative spinal disease and satisfactory cosmesis. Although it is technically demanding (e.g., extensive experienced with ALIF is needed and skin closure takes longer than that in conventional ALIF), patients obtain sufficient benefits. Within its limited indication, TULIF seems to be an alternative surgical option for better cosmetic satisfaction after using the anterior spinal approach.

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CONFLICT OF INTEREST

The authors have nothing to disclose.

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