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Comparison of Minimal Invasive Versus Biportal Endoscopic Transforaminal Lumbar Interbody Fusion for Single-level Lumbar Disease

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Study Design: Retrospective study.

Objective: The authors aimed to compare the clinical outcomes of biportal endoscopic transforaminal lumbar interbody fusion (BE-TLIF) with those of minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) using a microscope.

Summary of Background Data: Lumbar spinal fusion has been widely performed for various lumbar spinal pathologies. Minimally invasive transforaminal interbody fusion using a tubular retractor under a microscope is a method of achieving fusion while reducing soft tissue injury. Recently, several studies have reported minimally invasive techniques for lumbar discectomy, decompression, and interbody fusion using biportal endoscopic spinal surgery.

Materials and Methods: This retrospective study included 87 patients who underwent single-level TLIF for degenerative or isthmic spondylolisthesis between 2015 and 2018. Thirty-two and 55 patients underwent BE-TLIF (group A) and MI-TLIF (group B), respectively. Visual Analogue Scale scores of the back and leg and Oswestry Disability Index were collected perioperatively. Further, data regarding perioperative complications, including length of hospital stay, time to ambulation, and fusion rate, were collected.

Results: The Visual Analogue Scale score at 2 weeks and 2 months postoperatively was significantly lower in group A ($P = 0.001$). All other clinical scores showed improvement with no significant difference between the 2 groups ($P > 0.05$). The difference in the fusion rates between group A (93.7%) and group B (92.7%) were not significant ($P = 0.43$).

Conclusions: Because BE-TLIF yieldeds lesser early postoperative back pain than did MI-TLIF, it may allow early ambulation and a shorter hospitalization period. BE-TLIF may be a viable alternative to MI-TLIF in patients with degenerative or isthmic spondylolisthesis with superior clinical results in the early postoperative period.

Key Words: transforaminal interbody fusion, endoscopy, spinal stenosis, degenerative spinal disease

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Degenerative lumbar disease is common and may require fusion surgery if accompanied by instability. Numerous fusion techniques have been introduced including conventional posterolateral fusion. Posterior lumbar interbody fusion (PLIF) was developed by Cloward[1] in 1950, with over 85% of satisfactory outcomes. After transforaminal lumbar interbody fusion (TLIF) was introduced by Harms and Jeszenszky[2] to overcome the drawbacks of PLIF, it gained popularity. TLIF has the advantage of reduced retraction of the dural sac and root, thus reducing root-related postoperative complications such as radiculitis.[3] Nevertheless, conventional open TLIF and PLIF are associated with significant soft tissue morbidity, which could result in adverse outcomes in the patient.[4–6] Foley et al[7] developed a minimally invasive TLIF (MI-TLIF) technique using a tubular retractor and microscope, which reduced iatrogenic soft tissue injury because of muscle stripping and retraction during spinal exposure. However, MI-TLIF has a disadvantage of limited working space and visualization through the tubular retractor, especially in the deeper operative field. In addition, local muscle ischemia may develop because of retraction by the tubular retractor itself. Recently, technical notes and preliminary reports of biportal endoscopic spinal surgery (BESS) techniques including decompression and TLIF have been introduced by various authors. To our knowledge, this is the first study to compare the clinical outcomes of biportal endoscopic TLIF (BE-TLIF) with those of MI-TLIF.

MATERIALS AND METHOD

The study protocol was reviewed and approved by the Institutional review board. We retrospectively reviewed medical charts of patients who underwent BE-TLIF and

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The authors declare no conflict of interest.

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TABLE 1. Demographic Data of the Patients

	n (%)		
Demographic Data	**Group A (N = 32)**	**Group B (N = 55)**	***P***
Age (y)	70.5 ± 8.26	67.3 ± 10.7	0.092
Sex			
Male	17 (53.1)	25 (45.4)	0.814
Female	15 (46.8)	30 (54.5)	
Follow-up duration	27.2 ± 5.4	31.5 ± 7.3	
Disk level (%)			
L2–L3	1 (3)	0 (0)	0.728
L3–L4	3 (9.3)	2 (2.0)	
L4–L5	20 (62.5)	46 (68.5)	
L5–S1	8 (25)	7 (8.5)	
Preoperative diagnosis			
Degenerative spondylolisthesis	26 (81.2)	48 (87.2)	0.41
Lytic spondylolisthesis	6 (18.7)	7 (10.9)	0.26

MI-TLIF with at least 1 year of follow-up and obtained data on clinical outcomes and fusion rates.

Eighty-seven consecutive patients who underwent surgery for degenerative or isthmic spondylolisthesis from March 2015 to January 2018 were enrolled. All patients had undergone single-level surgery. Thirty-two consecutive patients underwent BE-TLIF performed by 1 surgeon, whereas 55 consecutive patients underwent MI-TLIF performed by the other surgeon. The preoperative symptoms of the patients were lower back pain with neurological symptoms (radiating pain or claudication). The following were the inclusion criteria; (1) patients with persistent neurological symptoms and intermittent claudication who do not respond to appropriate conservative treatment over 3 months; (2) a single-level pathology; (3) patients with degenerative spondylolisthesis and spinal stenosis; (4) patients with lytic spondylolisthesis; and (5) patients with concomitant foraminal stenosis and central stenosis. We excluded patients with infection, high-grade (> grade 2) spondylolisthesis, trauma, or previous spinal surgery. Patients who required surgical correction owing to coronal or sagittal deformity were also excluded.

Patients who underwent BE-TLIF and MI-TLIF were included in groups A and B, retrospectively. The demographic characteristics and operative data are summarized in Table 1.

Surgical Technique

Group A: BE-TLIF

The patient was placed in a prone position for conventional spinal surgery. A spinal needle was inserted at the midpoint of the desired intervertebral space on lateral view of the fluoroscope. The landmarks of skin incision were 1-cm above and below the desired disk level on anteroposterior view, and the mid-pedicle on the lateral view. Two 1-cm long transverse skin incisions were made both on the ipsilateral side of the entry to facilitate the passage of surgical instruments, and for continuous saline outflow, the fascia beneath was cut perpendicular to the skin incision. A Cobb elevator was used to sweep and detach the muscle and soft tissue from the proximal lamina and interlaminar space percutaneously. If the

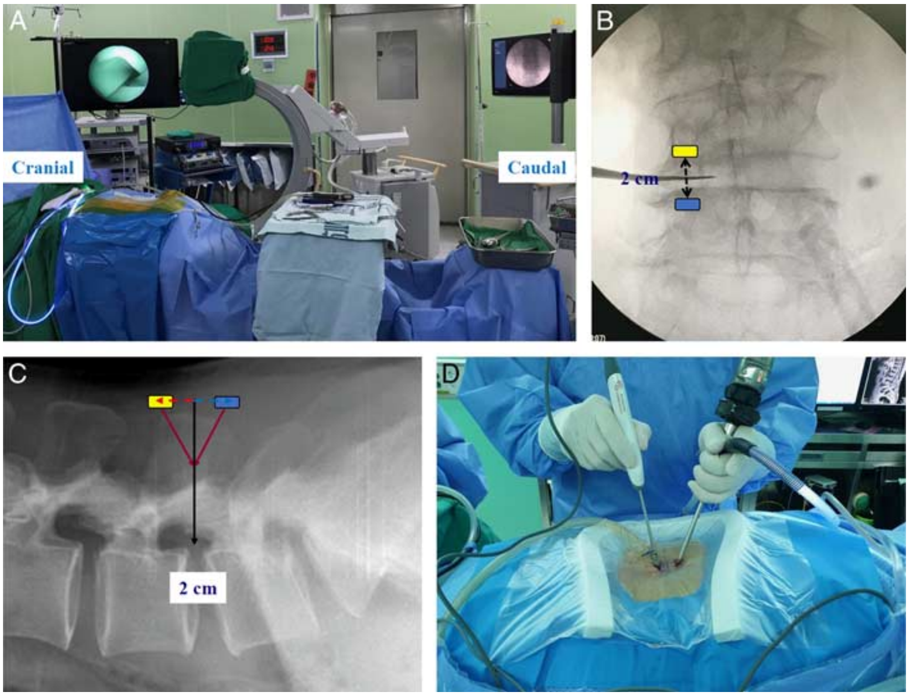

FIGURE 1. A, Operating room set up. B, Anteroposterior fluoroscopic view of portal placement. C, Lateral fluoroscopic view of portal placement. D, Intraoperative view of biportal endoscopic spinal surgery.

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approach was through the left side, then the proximal portal was used as a viewing portal and the distal portal was used as a working portal. The saline bag was hung about 1.7-m high from the ground so that gravity would influence water infusion. Continuous saline outflow through the working portal was monitored. When the saline outflow during surgery was poor, visibility was disturbed owing to soft tissue debris and bleeding. In such a situation, a semitubular retractor was temporarily inserted through the working portal to keep saline outflow fluent, improve surgical view, and prevent water congestion, which can induce soft tissue swelling (Fig. 1).

The basic surgical steps are comparable with those of conventional TLIF. Using a burr, Kerrison punch, and osteotome, ipsilateral laminectomy and facetectomy were performed. Autologous bone harvested during laminectomy and facetectomy was used as bone graft. Similar to open surgery, we performed osteotomy using a specially designed bone chisel with the assistant helping the surgeon with hammering. The osteotomized facets were removed in a piecemeal manner using pituitary forceps and Kerrison rongeurs. After laminectomy and ipsilateral facetectomy, the ligamentum flavum was resected bilaterally. After checking the pathway of the exiting and traversing root, the disk space of the Kambin triangle was exposed. Pituitary forceps were used for removal of disk material. The cartilaginous portion was carefully removed using a curette or freer elevator without insulting the subchondral bone under endoscopic view that directly visualized the endplates (Fig. 2). Autologous local bone was grafted inside the disk space using a funnel-shaped cannula. Under fluoroscopic and endoscopic guidance, the cage was initially inserted diagonally and repositioned transversely using an impactor (Fig. 3). The ipsilateral percutaneous pedicle screws were inserted through the viewing and working portal. The contralateral percutaneous pedicle screws were inserted after making separate incisions. Finally, the rods were locked (Fig. 4).

Group B: MI-TLIF

The patient was placed in a prone position in the regular operating room. The target disk space was identified using fluoroscopy and the location of the incision was marked. A longitudinal skin incision was made 3–4 cm lateral from the midline. By using a standard Wiltse approach, the fascia was incised and further dissection was performed between the longissimus and multifidus muscles. Through the intermuscular plane, sequential dilation

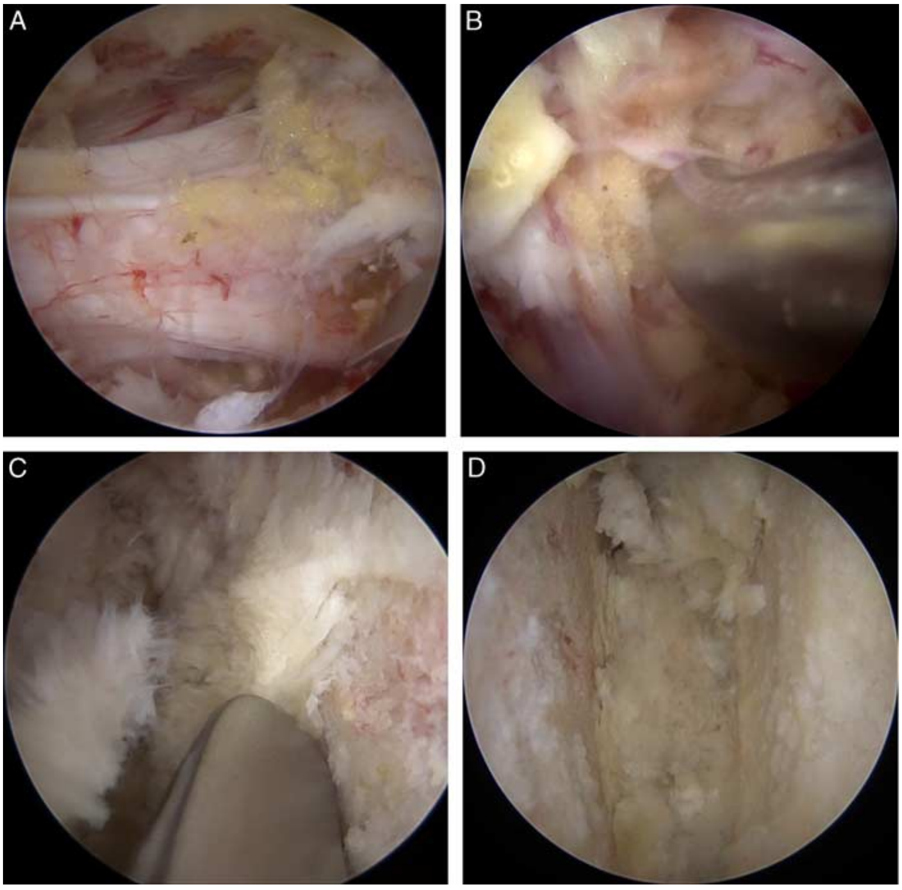

FIGURE 2. Intraoperative endoscopic images. A, Bilateral decompression including the traversing root. B, The Kambin triangle of left L4 root where the cage is inserted. C, Exposure of subchondral bone with double-end elevator (partial removal state of endplate cartilage). D, Intervertebral disk space with the cartilaginous endplate completely removed.

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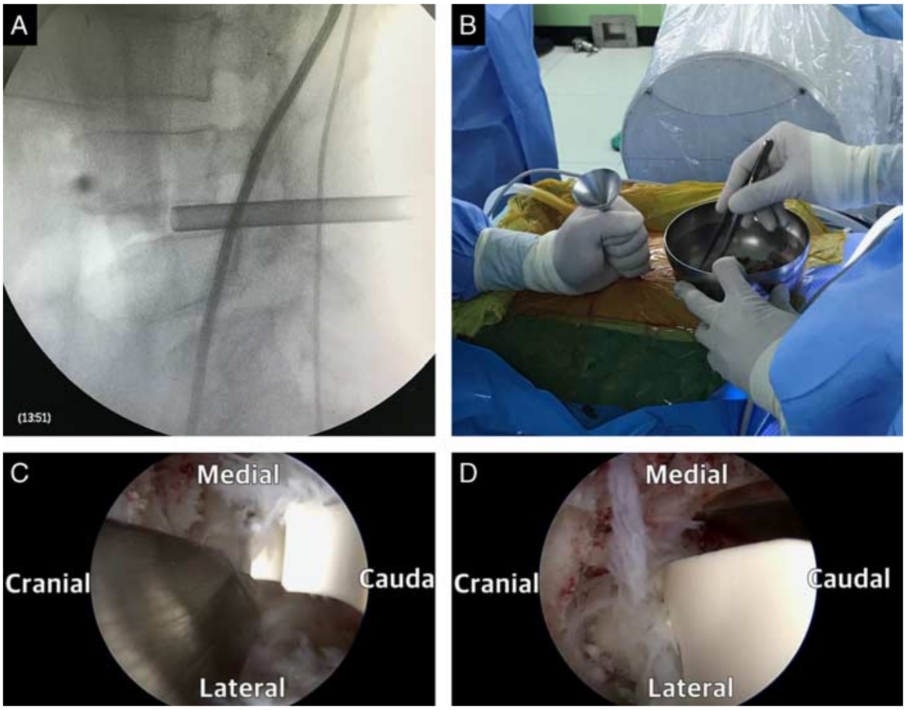

FIGURE 3. A, Fluoroscopic image of a funnel inserted in the intervertebral disk space. B, Bone grafting through the funnel with the guidance of fluoroscopy. C, Use of semitubular retractor protecting the exiting nerve root during cage insertion. D, Use of semitubular retractor protecting the traversing nerve root during cage insertion.

was performed using serial dilator tubes. After docking the final tubular retractor on the facet, soft tissues were stripped from the bone. Laminectomy and facetectomy were performed, and the exiting and traversing roots were exposed under a microscope. Discectomy was performed, and endplate preparation was performed with a shaver. Autologous bone from the lamina and facet was utilized for the graft inside the disk space, and finally, the cage was inserted. Bilateral percutaneous pedicle screws were inserted using separate incisions.

Clinical and Radiologic Evaluations

Clinical and radiologic data were collected using electronic medical records, including patient-administered questionnaires, and a picture archiving and communication system. Clinical data included the Oswestry Disability Index (ODI), Visual Analogue Scale (VAS), modified Macnab criteria, time to ambulation, length of hospital stay, perioperative complications, and operation time. ODI and VAS were measured preoperatively, 2 weeks postoperatively, 2 months postoperatively, and at the final follow-up, which was at least over a year after surgery. Modified Macnab criteria were checked on the final follow-up.

Preoperative radiologic evaluation was performed using anteroposterior, lateral, both oblique, and flexion-extension lumbar plain radiographs, magnetic resonance images, and computed tomography images. The fusion was evaluated by a radiologist using lateral and flexion-extension plain radiographs performed at least 1 year after surgery. Evident fusion was considered as trabecular bony bridge formation and <4 degrees of segmental motion on flexion-extension plain radiographs. The solid fusion was radiographically assessed by 2 independent experienced radiologists. Bridewell et al[8] posterior fusion grade was used to evaluate the fusion state on plain radiographs.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc, Chicago, IL). Values are presented as means and standard deviations. Patient data were analyzed using the independent *t* test, repeated measures analysis of variance, and χ^2 test kappa. A $P<0.05$ was considered statistically significant.

RESULTS

There were no differences in age, sex, level of fusion, or preoperative diagnosis between the 2 groups. The mean follow-up was 18.4 months (range, 14–38). No case was converted to open surgery in either group. There was no significant difference in operation time between group A (169.5 ± 24.9 min) and group B (173 ± 47.1 min). The hospital stay was significantly shorter in group A (6.0 ± 3.1 d) than that in group B (9.1 ± 2.9 d; $P<0.001$). Likewise, the time to ambulation after surgery was shorter in group A (6.8 ± 4.1 h) than that in group B (12.7 ± 7.2 h) ($P<0.001$). Both groups showed significant improvement in VAS leg, VAS back, and ODI scores ($P=0.000$). The VAS back of group A (3.2) was significantly lower than that of group B (4.1) in the postoperative second week ($P=0.001$).

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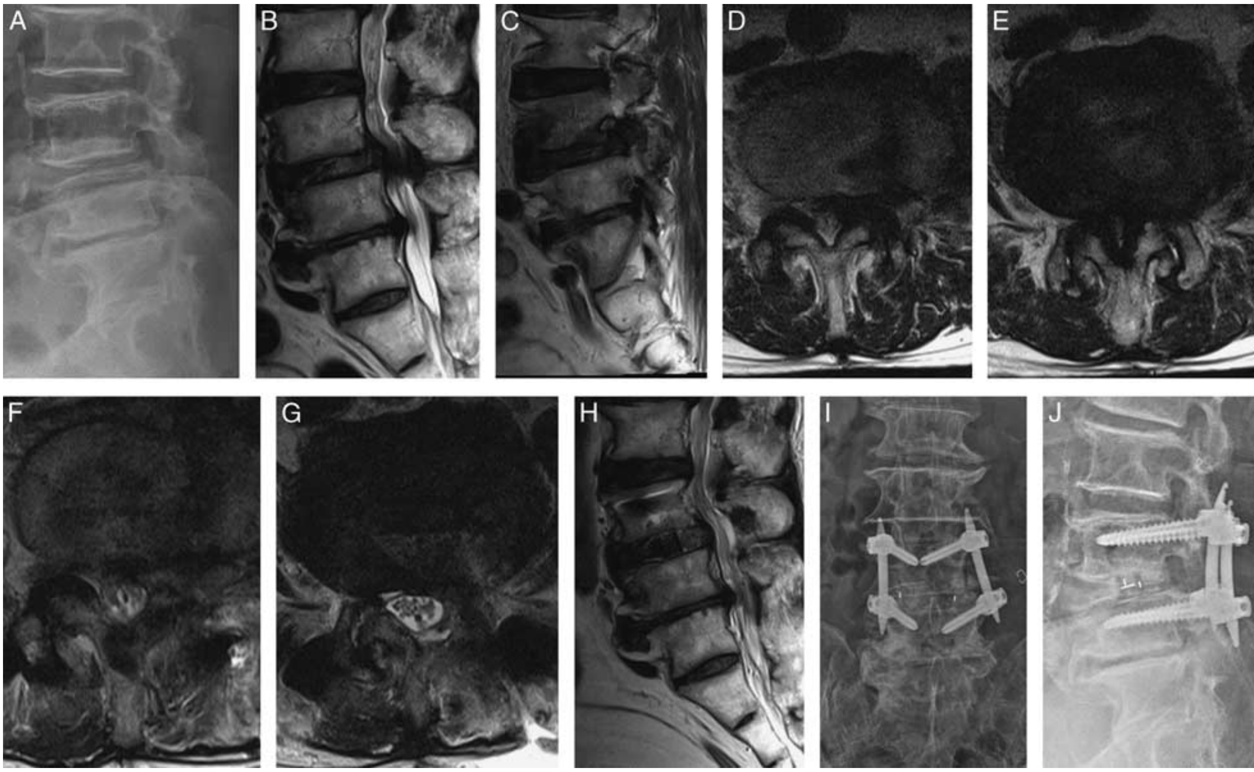

FIGURE 4. 70-year old male individual with left leg pain and neurological intermittent claudication. A, Lateral plain radiograph. B, Midsagittal T2-weighted image showing L3–L4 central stenosis. C, Left parasagittal T2-weighted image showing L3–L4 left foraminal stenosis. D and E, Axial T2-weighted images showing L3–L4 central stenosis with left foraminal stenosis. F–H, Postoperative magnetic resonance imaging showing a reduction of spondylolisthesis and central and foraminal decompression. I and J, Postoperative plain radiographs showing a cage located transversely (32 mm length, 12 mm height) on L3–L4.

However, no statistically significant differences were found in other values such as preoperative and final VAS (both back and leg). The preoperative and final ODI between groups A and B did not show a significant difference (Fig. 5). The modified Macnab criteria showed no difference between the 2 groups with 84.4% (27/32) patients of group A and 85.4% (47/55) of group B showing "good" or better outcome ($P=0.82$). The status of fusion was evaluated by the radiographs obtained at the 1-year follow-up. According to the Bridwell grading system, group A consisted of 19, 11, 2, and 0 cases of grades I, II, III, and IV, respectively, whereas group B comprised 39, 12, 4, and 0 cases of grades I, II, III, and IV, respectively. No statistically significant difference was seen in the fusion rates (percentage of grade I and II) between group A (93.7%) and group B (92.7%). Both intraobserver and interobserver agreements were excellent. The intraobserver mean κ values for grading fusion were 0.866 and 0.914 by radiologists A and B, respectively, whereas the interobserver mean overall κ values were 0.854 and 0.891 for the initial and second interpretations, respectively. No complications such as wound infection or dural tear were found in both groups; however, transient palsy was reported in groups A (1 case, 3.1%) and B (2 cases, 3.6%). In addition, revision surgery was performed owing to postoperative hematoma in 1 case in each group (Table 2).

DISCUSSION

Since the first introduction of the TLIF technique by Harms and Jeszenszky,[2] it has been widely used as an alternative to PLIF. Compared with PLIF, TLIF can decompress the foramen and is relatively easy to restore the height of the interbody. Moreover, TLIF enables the insertion of the cage without nerve retraction; hence, intraoperative bleeding is expected to decrease.[9,10] Conventional open TLIF, however, is related to extensive iatrogenic lumbar soft tissue injury, including the paraspinal muscle.[11–13] In the 21st century, minimally invasive TLIF was introduced to compensate for excessive muscle injury that could occur during conventional open surgery.[14–19] Minimally invasive TLIF can minimize soft tissue and muscle damage, which allows surgeries without damage to the middle and contralateral spinal structures by unilateral access. Minimally invasive surgery using endoscopes was developed after advancements in optical technologies and special instruments. Further, the BESS technique was introduced by several authors.[15–19] The BESS technique uses 2 independent portals, one for viewing and the other for working. It requires triangulation of the endoscope and surgical instruments, which is similar to that in conventional orthopedic arthroscopic or laparoscopic surgery. TLIF surgery using the BESS technique, the so-called BE-TLIF was recently introduced.[17,20]

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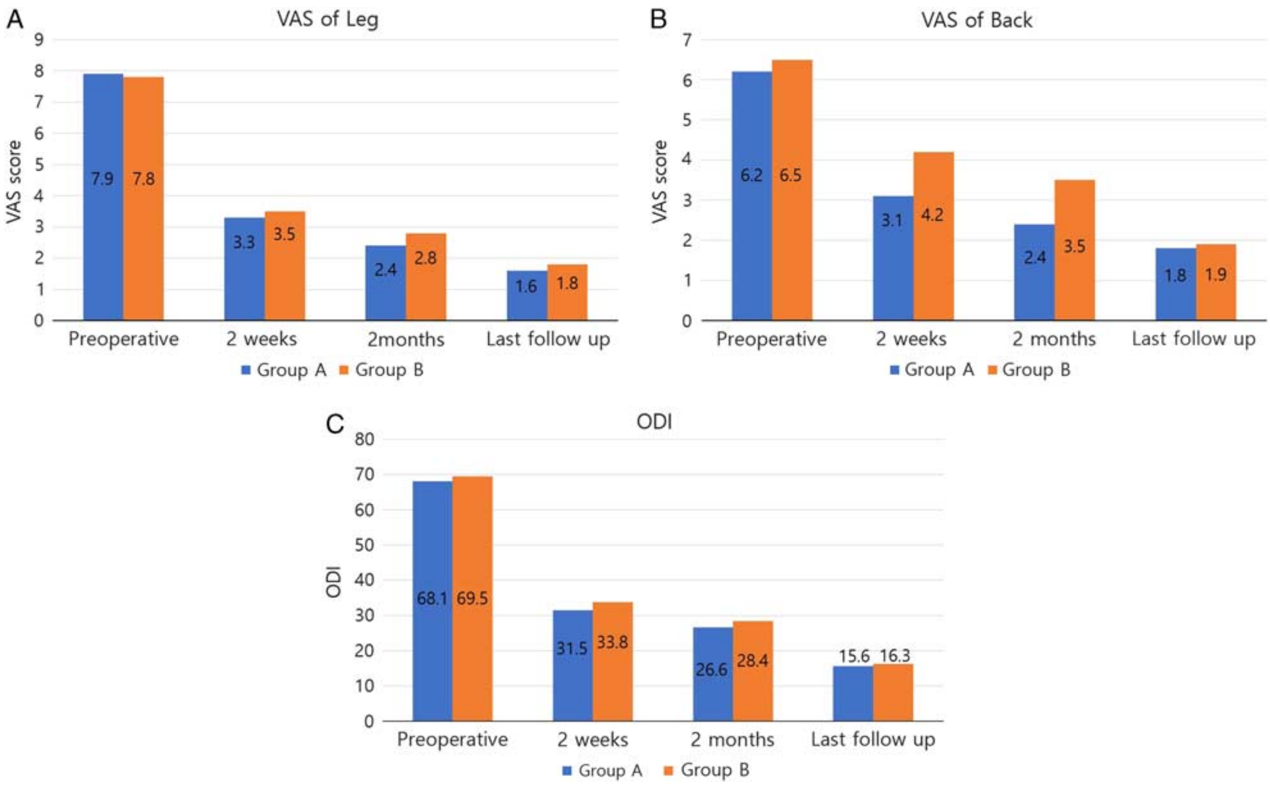

FIGURE 5. Clinical outcomes during follow-up (preoperative, postoperative 2 wk, postoperative 2 mo, postoperative over 1 y). A, VAS of the leg. B, VAS of the back. C, ODI (%). ODI indicates Oswestry Disability Index; VAS, Visual Analogue Scale.

Unlike the conventional minimally invasive TLIF using a tubular retractor and microscope, BE-TLIF relies on endoscopy and 2 portals.

Conventional open TLIF is one of the options for treating degenerative lumbar spinal disease; however, it may lead to several complications, such as atrophy of the back muscles and postlaminectomy syndrome owing to extensive muscle dissection and retraction.[9,10] Minimally invasive TLIF, on the other hand, presents similar fusion rate with conventional open TLIF while reducing intraoperative blood loss, muscle damage, and postoperative pain, which may eventually facilitate early ambulation in patients.[21–23] There have been many comparative studies between MI-TLIF and open TLIF in patients with degenerative lumbar disease. However, to the best of our knowledge, there has been no report on about the clinical outcome and fusion rate between conventional MI-TLIF and BE-TLIF.

According to several studies, the average operation time for minimally invasive TLIF is about 156–216 minutes.[21,23,24] In our study, the operation times for groups A and B were 169.5 ± 24.9 and 173 ± 47.1 minutes, respectively. Previous studies reported that the average operation time of MI-TLIF was ≥ 200 minutes, which was longer than that of open surgery.[21,22,25] During the initial stages of the learning curve, it might be difficult to make an adequate space for the operation or to find a surgical landmark, and it might be time-consuming for adequate decompression and percutaneous pedicle screw fixation. A less traumatic minimally invasive approach tends to cause less postoperative pain and provides better clinical outcomes.[10,22,23] Compared with open surgery, minimally invasive surgery shows shorter muscle retraction time and lesser, risk of paraspinal muscle injury and ischemic damage because of the retractor.[5] In this study, the VAS of back after BE-TLIF was significantly lower than that after MI-TLIF in the second week after surgery. In addition, the initial postoperative outcomes such as the time to ambulation and duration of hospital stay were favorable in BE-TLIF rather than in MI-TLIF. A comparative study between microscopic discectomy and unilateral endoscopic biportal discectomy showed lower initial VAS scores for the back and shorter hospital stay in the endoscopic surgery group than those in the microscopic surgery group.[26] The lengths of stay (LOS) in groups A and B (6.0 ± 3.1 and 9.1 ± 2, respectively) were higher than those in other studies. Patients in South Korea tend to stay longer in the hospital for postoperative pain control than those in other countries. Among other reasons, low hospital fee (usually under US$100/day) could be the main reason for the longer stay. The LOS in other departments is also higher than those in corresponding departments of other countries. Further, LOS of patients undergoing BE-TLIF in our hospital had shorter stays than those in other the hospital.

Intraoperative dissection and paraspinal muscle retraction cause atrophy and denervation of subsequent muscles, thus increasing the possibility of postoperative pain. Kawaguchi and colleagues reported the effect of pressure and duration of the retractor blade on the paraspinal

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TABLE 2. Comparison of Clinical Outcome Outcomes Between BE-TLIF and MI-TLIF

Clinical Data	Group A (N = 32)	Group B (N = 55)	*P*
Preoperative leg VAS	7.9 ± 0.6	7.8 ± 1.7	0.60
Postoperative 2 wk leg VAS	3.3 ± 0.9	3.5 ± 1.1	0.25
Postoperative 2 mo leg VAS	2.4 ± 1.0	2.8 ± 0.8	0.07
Final leg VAS	1.6 ± 0.6	1.8 ± 0.8	0.13
Preoperative back VAS	6.2 ± 1.3	6.5 ± 1.5	0.26
Postoperative 2 wk back VAS	**3.1 ± 1.0**	**4.2 ± 1.6**	**0.001**
Postoperative 2 mo back VAS	**2.4 ± 0.9**	**3.5 ± 0.9**	**0.001**
Final back VAS	1.8 ± 0.8	1.9 ± 0.8	0.72
Preop ODI	68.1 ± 5.4	69.6 ± 6.2	0.26
Postoperative 2 wk ODI	31.5 ± 8.7	33.8 ± 11.6	0.51
Postoperative 2 mo ODI	26.6 ± 9.2	28.4 ± 10.7	0.44
Final ODI	15.6 ± 9.2	16.3 ± 11.9	0.18
Final modified Macnab criteria (excellent or good)	27/32 (84.4%)	47/55 (85.4%)	0.82
Operation time (min)	169.5 ± 24.9	173 ± 47.1	0.32
Time to ambulation (h)	**13.8 ± 4.0**	**18.76 ± 7.2**	**< 0.001**
Hospital stay (d)	**6.0 ± 3.1**	**9.1 ± 2.9**	**< 0.001**
Fusion rate (%)	30/32 (93.7%)	51/55 (92.7%)	0.43
Complication	2 (6.3%)	3 (5.5%)	1.000
Postoperative epidural hematoma	1	1	
Transient palsy	1	2	

Bold values indicate statistical significance.

Values are presented as mean ± SD.

BE-TLIF indicates biportal endoscopic transforaminal interbody fusion; MI-TLIF, minimal invasive transforaminal lumbar interbody fusion; ODI, Oswestry Disability Index; VAS, Visual Analogue Scale.

muscles.[4,5,11,27,28] Unlike MI-TLIF, BE-TLIF does not involve placement of a tubular retractor between the paraspinal muscles, therefore decreasing direct ischemic damage. In addition, the endoscope provides higher magnification with a better surgical view, allowing more precise work. Although soft tissue damage during surgery is inevitable even with endoscopic spinal surgery, such damage might be limited owing to less muscle retraction during BE-TLIF.

Previous studies reported 80%–100% fusion rate of MI-TLIF, which is similar to our case series, indicating that favorable fusion rate in both BE-TLIF and MI-TLIF. However, the vertebral body endplate cannot be clearly identified in open or MI-TLIF, whereas it is well exposed under magnified view with an endoscope during BE-TLIF, facilitating a meticulous endplate preparation (Figs. 2C, D). Such an advantage may offer a favorable fusion environment by complete removal of the cartilaginous portion.[17,20]

No significant difference was found in the overall complication rate of both MI-TLIF (5.5%) and open TLIF (6.3%) ($P = 1.000$). There were no implant-related complications, such as cage migration and hardware loosening during follow-up. However, this study has several important limitations. First, the technique for BE-TLIF has been recently introduced and the 2 techniques were compared retrospectively, involving few patients with a relatively short follow-up period. We are preparing to perform a prospective study to compare both techniques, the results of which will be reported in the future. Second, the 2 surgical procedures were performed by 2 different surgeons.

CONCLUSIONS

BE-TLIF showed lesser early postoperative back pain earlier ambulation and shorter hospitalization period than MI-TLIF. In addition, it showed similar clinical outcome, fusion rate, and complication rate as MI-TLIF. Therefore, BE-TLIF would be a viable alternative to MI-TLIF with better clinical outcomes with regard to earlier recovery.

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