Fully Endoscopic Lumbar Laminectomy and Transforaminal Lumbar Interbody Fusion Under Local Anesthesia with Conscious Sedation: A Case Series

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■ OBJECTIVE: **To evaluate clinical outcomes of a case series of 18 patients who underwent fully endoscopic foraminotomy, laminectomy, and transforaminal lumbar interbody fusion combined with percutaneous screw fixation.**

■ METHODS: **This was a retrospective case series of a single surgeon. Average age of patients was 66 years (range, 51–82 years). All patients had grade I or grade II spondylolisthesis and severe central canal stenosis. Patients underwent endoscopic transforaminal access through Kambin triangle for foraminotomy, discectomy, endplate preparation, and interbody fusion, which was followed by fully endoscopic unilateral laminectomy and bilateral decompression and percutaneous pedicle screw and connecting rod placement.**

■ RESULTS: **All procedures were successful without conversion to open surgery. Mean operative time was 168 minutes, and average estimated blood loss was 36 mL. Mean length of hospital stay was 1.2 days. There were no intraoperative or postoperative complications. Comparison of preoperative and final clinical metrics demonstrated that average Oswestry Disability Index score improved from 48 ± 14 (range, 37–61) to 13 ± 11 (range, 0–27) (*P* < 0.001). Average visual analog scale back pain score improved from 8.1 ± 2.0 (range, 6.8–10.0) to 1.8 ± 0.9 (range, 0.0–3.5) (*P* < 0.001). Oswestry Disability Index and visual analog scale back pain scores at last follow-up showed 73% and 78% improvement, respectively, from the preoperative period. There were no cases of nonunion clinically or radiographically on final follow-up of >12 months.**

■ CONCLUSIONS: **Fully endoscopic laminectomy and interbody fusion under conscious sedation is an effective treatment with minimal complications for patients with lumbar spondylolisthesis and severe spinal stenosis.**

INTRODUCTION

Interbody spinal fusion with cages was first described by Bagby[1] and has been performed to treat a variety of different spine conditions. The transforaminal corridor in the lumbar spine allows access to the traversing and exiting nerve roots, the thecal sac, and the intervertebral disc space. The transforaminal lumbar interbody fusion (TLIF) approach was developed by Harms and Jeszenszky.[2] In open surgery, muscle degeneration occurs secondary to prolonged muscle traction.[3] Foley et al.[4] developed TLIF using minimally invasive surgery (MIS) employing a tubular retractor, which is beneficial for preserving the back muscles[5] and has been shown to have comparable results to traditional open TLIF with the benefits of a shorter hospital stay, less blood loss, and shorter recovery time. However, long tubular retractors are still difficult to work with in a deep operative field with limited working space. Recently, with the combination of endoscopic visualization and expandable cage technology, an endoscopic lumbar interbody fusion technique was developed.[6-8] Wang and Grossman[9] reported a case series of endoscopic TLIF without general anesthesia. Complications of TLIF, including exiting nerve root injury, a high rate of cage migration, and a relatively long delay to obtain fusion, have been reported.[7] In this case series, a fully endoscopic technique was used for foraminotomy, laminectomy, discectomy, and endplate preparation combined with percutaneous screw fixation to achieve bilateral direct decompression and interbody fusion.

Key words
- Fully endoscopic
- Interbody fusion
- Lumbar laminectomy

Abbreviations and Acronyms
MIS: Minimally invasive surgery
ODI: Oswestry Disability Index
TLIF: Transforaminal lumbar interbody fusion
VAS: Visual analog scale

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MATERIALS AND METHODS

Study approval was received from the local institutional review board. Eighteen patients with single-level spondylolisthesis and significant central canal stenosis (L4-5: 17 patients; L3-4: 1 patient) were treated with fully endoscopic TLIF with expandable spacers, unilateral laminectomy and bilateral decompression through a separate posterior approach, and bilateral percutaneous pedicle screw instrumentation, as described subsequently. Average age of patients was 66 years (range, 51–82 years). All patients had grade I ($n = 16$) or grade II ($n = 2$) spondylolisthesis. Preoperative images of 1 of the patients are shown in Figure 1. Patients with grade III or worse spondylolisthesis or with diseases that impair bone quality (significant osteoporosis, other metabolic diseases, neoplasm, or systemic diseases) were excluded from this study.

All patients had >12 months of postoperative follow-up. Clinical outcomes were assessed using the visual analog scale (VAS) for back pain at preoperative and follow-up examinations. Oswestry Disability Index (ODI) scores were also recorded at preoperative and follow-up examinations. Preoperative radiologic studies included lumbar spine standing x-rays (standing anteroposterior and lateral neutral, flexion, and extension views), computed tomography, and magnetic resonance imaging studies. Surgical times, any complications, estimated blood loss, and duration of hospitalization were recorded from patients' charts. Diagnosis and work-up of nonunion included assessment of clinical symptoms (i.e., worsened back pain after initial post-surgery healing), followed by flexion/extension x-rays and computed tomography scan. X-ray criteria for fusion included lack of hardware loosening or failure and cage migration at final follow-up of >12 months.

Student t test was used to compare preoperative and final follow-up VAS and ODI scores. P value <0.05 was considered to be statistically significant.

Surgical Technique

All procedures were performed in the prone position under local anesthesia with conscious sedation. First, bilateral pedicle screw Kirschsner wires were placed percutaneously through 4 separate stab incisions under fluoroscopy guidance with standard technique. Next, fully endoscopic foraminotomy/foraminoplasty was performed to medialize the discectomy entry point. This 9-mm separate skin incision was approximately 10–12 cm off midline. Following single-step tissue dilation, the endoscope cannula was placed on the undersurface of the superior facet. Under direct endoscopic visualization, a high-speed diamond-tip drill (joimax Inc., Irvine, California, USA) was used to drill the superior facet and to enlarge the foramen. By turning the endoscope and exploring proximately, the exiting root was subsequently visualized and protected behind the bevel of the cannula (Figure 2). Next, the disc space and annulus were identified under direct endoscopic visualization and confirmed with fluoroscopy (Figure 2E and F). After removing the degenerated nuclear material with a standard discectomy using pituitary forceps, an endplate preparation was performed using a high-speed diamond-tip drill, curettes, and rasps through the endoscopic cannula under direct endoscopic visualization (Figure 3). Next, an extra-small collagen sponge soaked with bone morphogenetic protein 2 (Infuse; Medtronic, Minneapolis, Minnesota, USA) was placed anteriorly to the prepared interbody space, and then an expandable interbody cage (Spineology, St. Paul, Minnesota, USA) was placed through the cannula and filled with morselized demineralized bone matrix allograft (Figure 3D and E).

Fully endoscopic lumbar laminectomy (bilateral decompression with unilateral approach) was done next with a separate 1.1-cm paramedian incision using the iLESSYS Delta endoscopic system (joimax Inc.). The endoscope has a 10-mm outer diameter, a 6-mm working channel, and a 15° viewing angle. Under

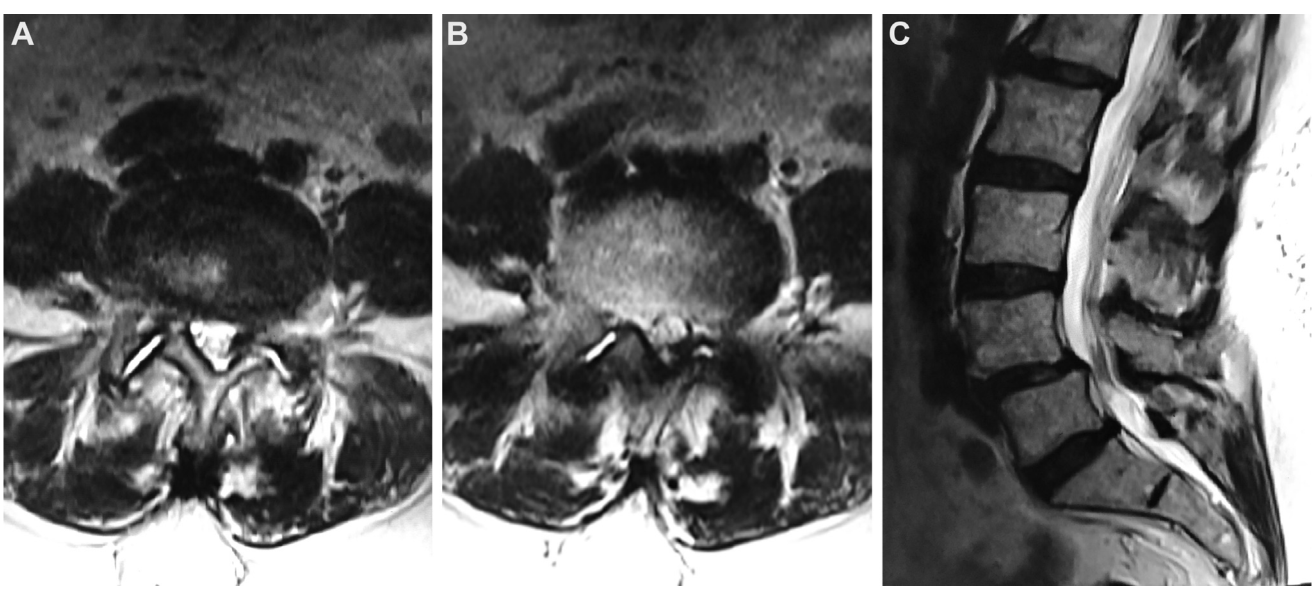

Figure 1. (**A**–**C**) Preoperative magnetic resonance imaging of a 66-year-old woman with grade I degenerative spondylolisthesis and severe central stenosis.

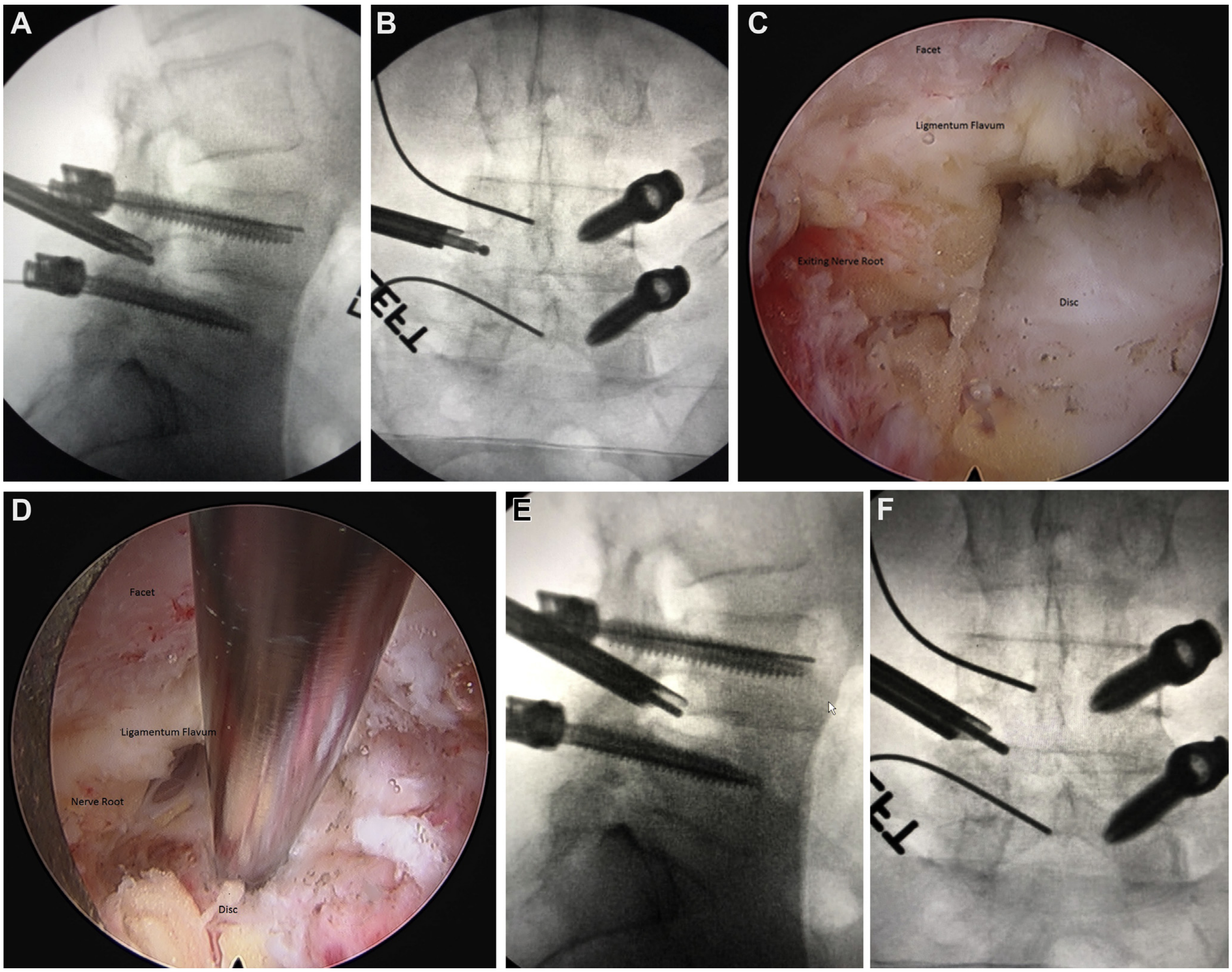

Figure 2. (**A** and **B**) Intraoperative fluoroscopy images showing foraminoplasty through a transforaminal approach with a high-speed drill. (**C** and **D**) Endoscopic images showing identification of the exiting nerve root and disc space and insertion of a guidewire into the L4-5 disc space for discectomy under direct visualization. (**E** and **F**) Intraoperative fluoroscopy images showing guidewire insertion into the L4-5 disc space.

endoscopic view, bilateral decompression was achieved using the high-speed endoscopic drill, graspers, and endoscopic Kerrison punches. Hemostasis was achieved with a radiofrequency probe. At the end of decompression, the thecal sac and bilateral traversing nerve roots were seen to be well decompressed (Figure 4). Next, bilateral pedicle screw percutaneous instrumentation was done over the 4 Kirschner wires, and connecting rods (K2M, Leesburg, Virginia, USA) were placed with standard technique (Figure 5).

RESULTS

All patients underwent the procedure successfully without conversion to open surgery. Mean operative time was 168 minutes, and average estimated blood loss was 35 mL (range, 10–60 mL). The mean length of hospital stay was 1.2 days (range, 0–2 days). There were no intraoperative or postoperative complications (e.g., dural tear, nerve root injury, postoperative hematoma, postoperative infection). All patients had >12 months of postoperative follow-up. Comparison of preoperative and final clinical metrics demonstrated that the average ODI score improved from 48 $\pm$ 14 (range, 37–61) to 13 $\pm$ 11 (range, 0–27) ($P < 0.001$). The average VAS back pain score improved from 8.1 $\pm$ 2.0 (range, 6.8–10.0) to 1.8 $\pm$ 0.9 (range, 0.0–3.5) ($P < 0.001$). The ODI and VAS back pain scores at the last follow-up showed 73% and 78% improvement, respectively, from the preoperative period. There were no cases of nonunion clinically (worsened pain after initial post-surgery healing) or radiographically (hardware loosening or failure or cage migration) on follow-up.

DISCUSSION

Fully endoscopic posterior interbody fusion as a minimally invasive technique offers many advantages over traditional open TLIF,

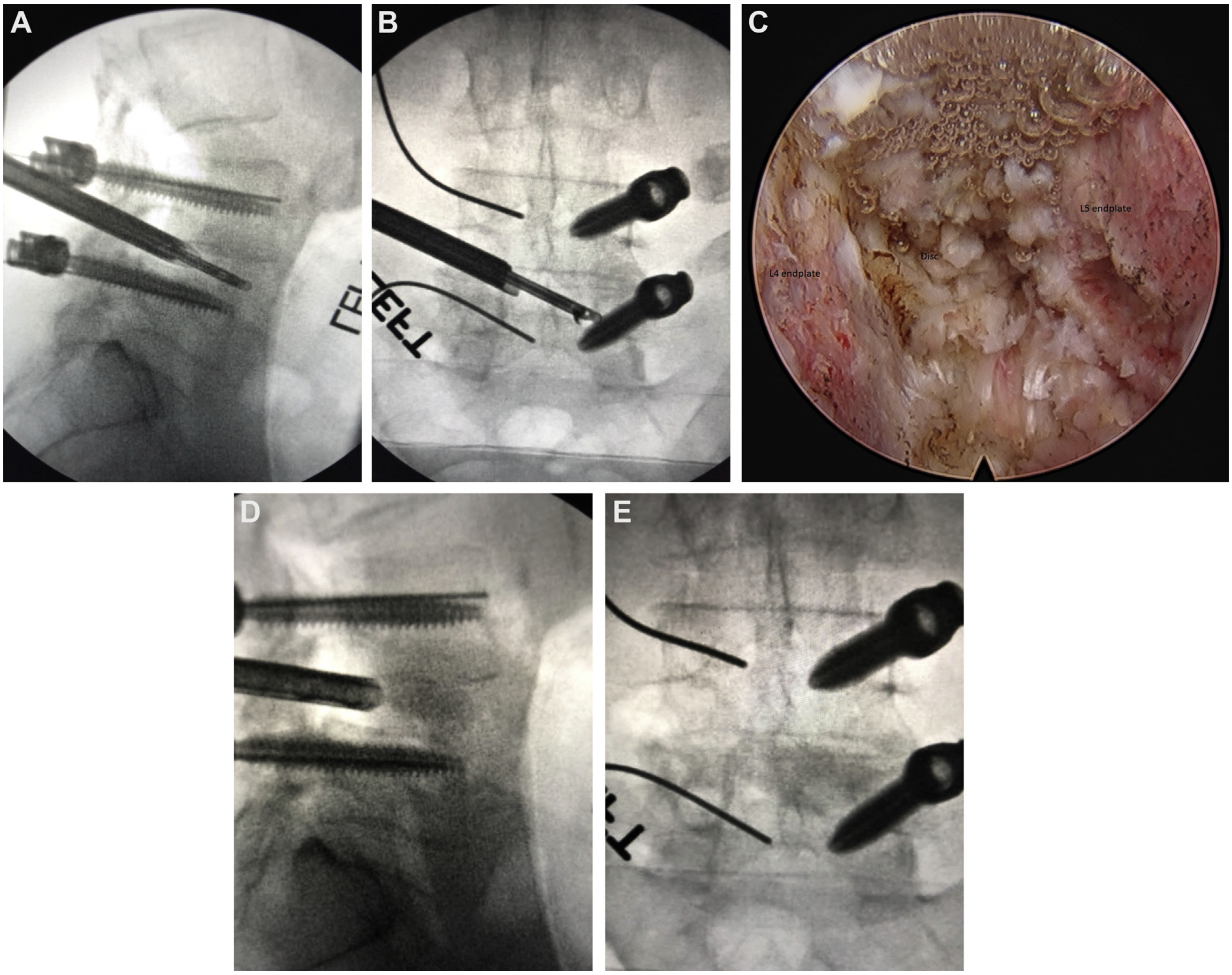

Figure 3. (**A**–**E**) Intraoperative fluoroscopy images showing transforaminal discectomy (**A** and **B**), endoscopy image of prepared endplates (**C**) and placement of expandable interbody spacer and bone graft (**D** and **E**).

including less blood loss; shorter hospital stay and quick recovery; and fewer complications, such as deep venous thrombosis and pulmonary embolism. In this case series, perioperative bleeding was minimal, and no postoperative drains were used. No cerebrospinal fluid leak, no postoperative hematoma, no postoperative cauda equina syndrome, and no postoperative infection occurred. Operative muscle trauma was minimal at the time of the surgery. Moreover, compared with other reported endoscopic lumbar interbody fusion studies,[7,8] there was no exiting nerve root injury, no cage migration, and no clinical nonunion.

As with other endoscopic spine surgeries, the technique in this study has a steep learning curve. A thorough understanding of foraminal anatomy is fundamental for considering how to safely access the disc space. Choi et al.[10] reported a 4.3% exiting nerve root injury rate (postoperative dysesthesia or motor weakness) in a series of 233 endoscopic transforaminal lumbar discectomy cases. No exiting nerve root injuries occurred in this case series. The use of conscious sedation decreases the side effects caused by general anesthesia and allows for patient-based neuromonitoring with continuous patient feedback to avoid neurologic injury. More importantly, adequate foraminotomy, direct visualization and protection of the exiting nerve root, and medialization of the interbody cage entry point are very important steps to prevent exiting nerve root injury. This is particularly true for the L5-S1 level because of more difficult accessibility at L5-S1 than at the other levels due to the iliac crests and lumbar lordosis.

In this case series, there was no cases of nonunion clinically or radiographically with follow-up of >12 months. A thorough discectomy and endplate preparation are a vital step to achieve fusion. Discectomy and endplate preparation under direct

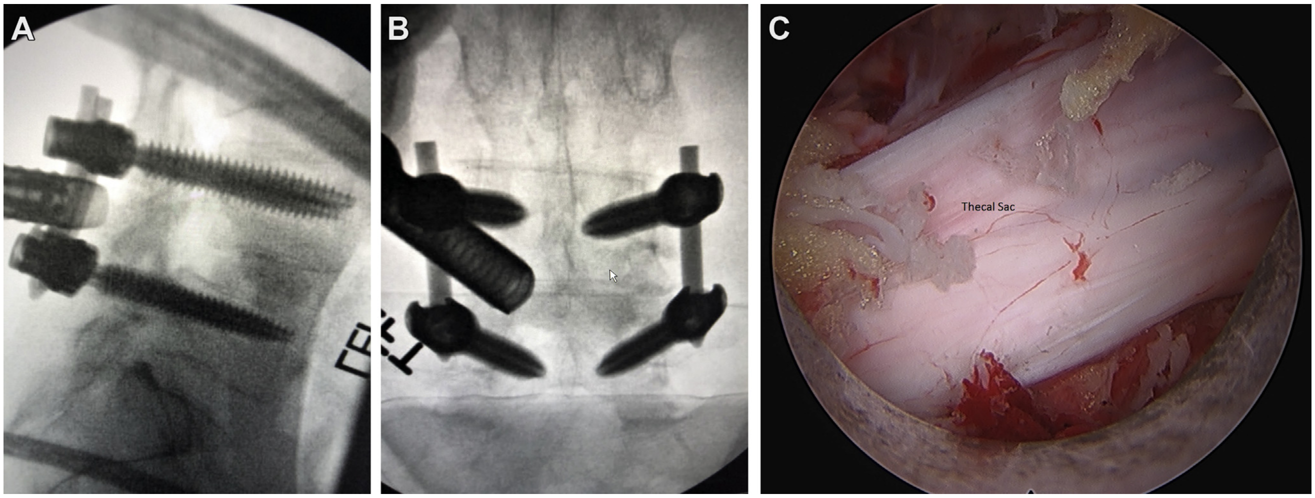

Figure 4. (**A**—**C**) Intraoperative fluoroscopy images showing endoscopic L4-5 bilateral decompression through unilateral posterior approach (**A** and **B**) and endoscopy image of fully decompressed thecal sac and traversing nerve roots (**C**).

endoscopic visualization offer advantages over traditional open TLIF or other MIS TLIF techniques.

Expandable cages allow indirect neural decompression by restoring intervertebral height. Indirect decompression clearly has a role in minimizing the amount of surgery that is required. However, it is important to consider the circumstances where this technique may be effective. Direct decompression with laminectomy, in addition to instrumented fusion, for patients with spondylolisthesis and severe central stenosis usually gives better results and saves patients from unplanned second-stage direct decompression surgery.[11]

This study has some limitations that should be discussed. First, the sample size was too small and the mean postoperative follow-up period was too short for more definitive conclusions on clinical and radiologic results. Prospective, multicenter studies comparing endoscopic interbody fusion techniques with open TLIF and MIS TLIF techniques are needed for better understanding. Larger clinical series are necessary to validate that clinical improvements are sustained and that arthrodesis rates are successful compared with traditional open surgery or MIS techniques.

CONCLUSIONS

Fully endoscopic lumbar laminectomy and transforaminal interbody fusion under conscious sedation/local anesthesia is an effective treatment option with minimal complications for patients with degenerative spondylolisthesis and severe spinal stenosis.

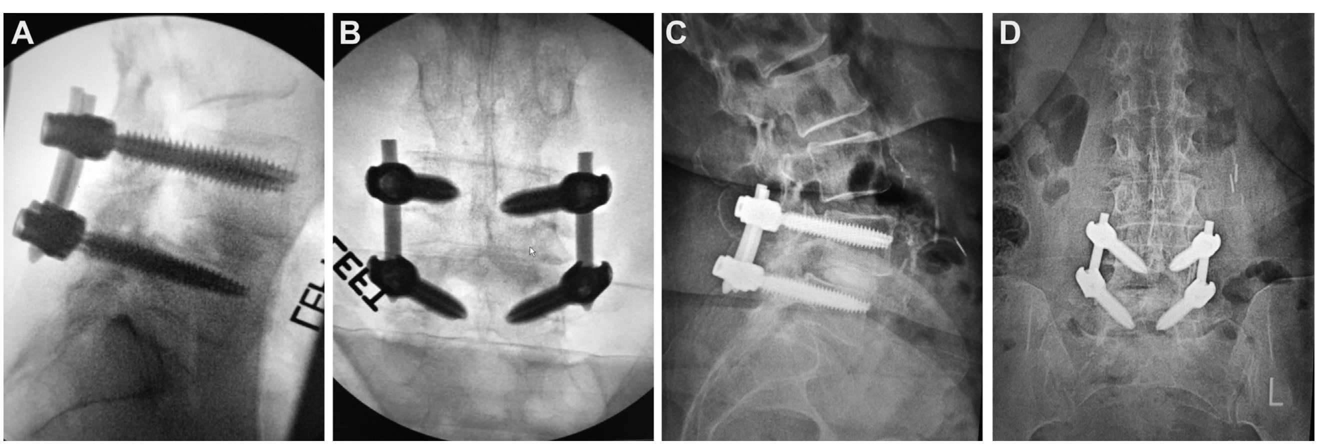

Figure 5. (**A** and **B**) Intraoperative fluoroscopy images showing L4-5 interbody fusion with bilateral instrumentation. (**C** and **D**) Lateral and anteroposterior x-rays at 12-month follow-up. This patient's visual analog scale back pain score was 1.

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