Transforaminal Endoscopic Lumbar Decompression for Isthmic Spondylolisthesis: Technique Description and Clinical Outcome

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ABSTRACT

Objectives: To describe a transforaminal endoscopic spinal decompression technique for treating adult patients with isthmic spondylolisthesis and report preliminary surgical and radiological results.

Background: Spondylolisthesis is prevalent in the general population. Surgical approaches for symptomatic spondylolisthesis that is refractory to conservative treatment vary. Direct repair of pars fractures and spinal nerve decompression with or without fusion have been reported with varied clinical results. The de facto gold standard, "fusion," is often associated with high complication rates and costs, and may not be necessary for many patients whose spine is relatively stable.

Methods: Transforaminal endoscopic lumbar decompression (TFELD) was performed to resect fractured bone or bone fragments and inflamed tissue compressing the exiting nerve root in 2 patients with isthmic spondylolisthesis (grade 1 in one patient and grade 2 in another). We describe the technique step-by-step and assess the Oswestry Disability Index and pain scores for back and leg pain before and after surgery.

Results: Radiographic images demonstrated spondylolisthesis with L5 pars fracture. The fractured bone and bone fragment were intraoperatively visible in the gap between facets and fractured pars in patients with isthmic spondylolisthesis. The core pathology of the patients was fractured bone and bone fragment coupled with scar or inflamed tissue compressing the exiting L5 nerve roots. After the bone fragments and scar tissue were removed using TFELD, the patients' back and leg pain was significantly reduced, and physical function was restored.

Conclusion: For patients with spondylolisthesis-associated low back and leg pain without spinal instability, TFELD is a safe and effective surgical treatment option.

INTRODUCTION

Spondylolisthesis is prevalent in the general population.[1,2] While degenerative spondylolisthesis mostly affects the elderly, isthmic spondylolisthesis affects both the adult and pediatric populations,[1] and especially adolescent athletes.[2,3] For young adults, isthmic spondylolisthesis is more prevalent in males than in females, and is often associated with pars fractures of L5. Patients with isthmic spondylolisthesis commonly suffer from back and/or lower-extremity pain and neurologic deficits.

While conservative treatment options including anti-inflammatory medication and physical therapy can help reduce the pain caused by isthmic spondylolisthesis, many patients suffer persistent back and/or leg pain and may need surgery to improve symptoms, stabilize the spine, and restore physical function. Spinal fusion remains the de facto "gold standard" for surgically treating isthmic spondylolisthesis, especially for patients with spinal instability. However, dynamic X-ray studies have shown that many patients with isthmic spondylolisthesis do not have spinal instability, and these patients' symptoms are mainly caused by spinal nerve root compression or irritation of inflamed nerve root. Open spinal decompression with or without fusion is commonly used for these patients. However, the surgical procedures are traumatic, require general anesthesia and a long recovery, and are often associated with high complication rates and cost.[4] On the other hand, minimally invasive surgical approaches such as transforaminal endoscopic lumbar interventions that target the pain generator without fusion have recently been reported, with encouraging clinical outcomes and patient satisfaction rates.[5,6]

Transforaminal endoscopic lumbar decompression (TFELD) with foraminoplasty and foraminotomy have been proven to be safe and effective in treating nerve compression caused by disc herniation, scar tissue, osteophytes, and hypertrophic ligaments. The main purpose of foraminoplasty is to release nerve root from compression by ligaments or scars, and the purpose of foraminotomy is to enlarge the foramen to increase space for nerve roots with facetectomy, discectomy, or osteophytectomy. However, the safety and effectiveness of this technique for treating patients with isthmic spondylolisthesis have not been thoroughly evaluated. Here we describe in detail how the technique can be safely and effectively used to treat patients with low-grade isthmic spondylolisthesis.

METHODS

Diagnosis and Radiographic Evaluation

The diagnosis of isthmic spondylolisthesis was based on medical history, physical examination, and radiographic assessment including magnetic resonance imaging (MRI) and (computed tomography) CT scan. Dynamic lumbar X-ray was used to further assess the stability of the spine.

Pain Evaluation and Disability Assessment

The pain levels in the legs and low back were evaluated using the Visual Analog Scale of Pain (VAS; score range, 0 to 10), with higher scores indicating more pain. The MacNab scale was used to rate whether surgery was satisfactory. Low back pain-associated disability was assessed using the Oswestry low back pain disability questionnaire (ODI; score range, 0 to 100), with higher scores indicating higher degrees of disability related to back pain.[7]

Surgical Technique

Preparation

The surgery was performed in the aware state with the patient lying in the prone position on a flexed radiolucent table. Under local anesthesia (a combination of.5% lidocaine with epinephrine) and intravenous sedation, the patient was awake and able to communicate with the surgeon throughout the surgery.

Needle Insertion for Endoscopic Setup

The patients presented in this manuscript both had spondylolisthesis at the L5-S1 level. Under oblique fluoroscopy guidance, a 22-gauge needle was inserted towards the target foramen via a posterolateral approach. For needle entrance, the spinal disc was parallel to the floor by tilting the fluoroscopic C arm slightly towards the caudal. Next, the C arm was rotated to find the translucent triangle zone (between the disc or the endplate of L5, iliac crest, and superior articular process [SAP] of S1). After the triangle zone was identified (Fig. 1), the needle was pointed towards the junction between the iliac crest and SAP. Through the needle, 5 cc of 0.5% lidocaine combined with epinephrine was injected to the extraforaminal area. The needle was then withdrawn slowly and an additional

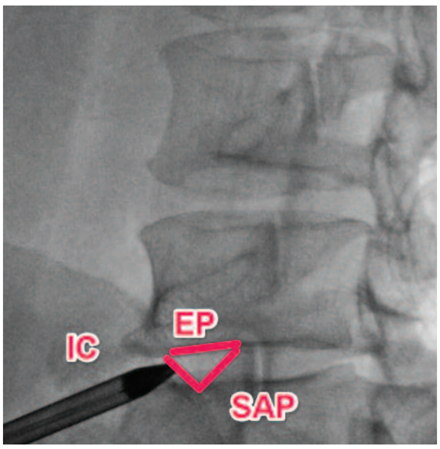

Figure 1. Under oblique fluoroscopic view, a needle was inserted towards the junction between the SAP and iliac crest. EP: endplate of L5; IC: iliac crest; SAP: superior articular process

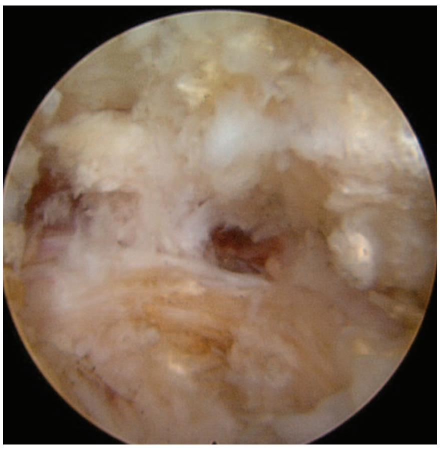

Figure 2. Scar tissue in the gap between the facet joint and fractured pars.

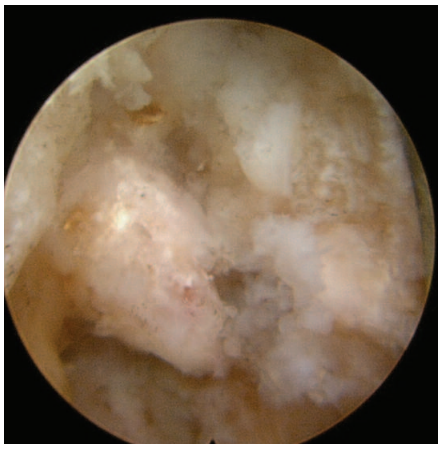

Figure 3. After the scar tissue was removed, a bone fragment (KL Fragment) was visible in the gap between the facet joint and fractured pars. The KL Fragment was located anterior to the facet joint and superior and posterior to the L5 nerve root.

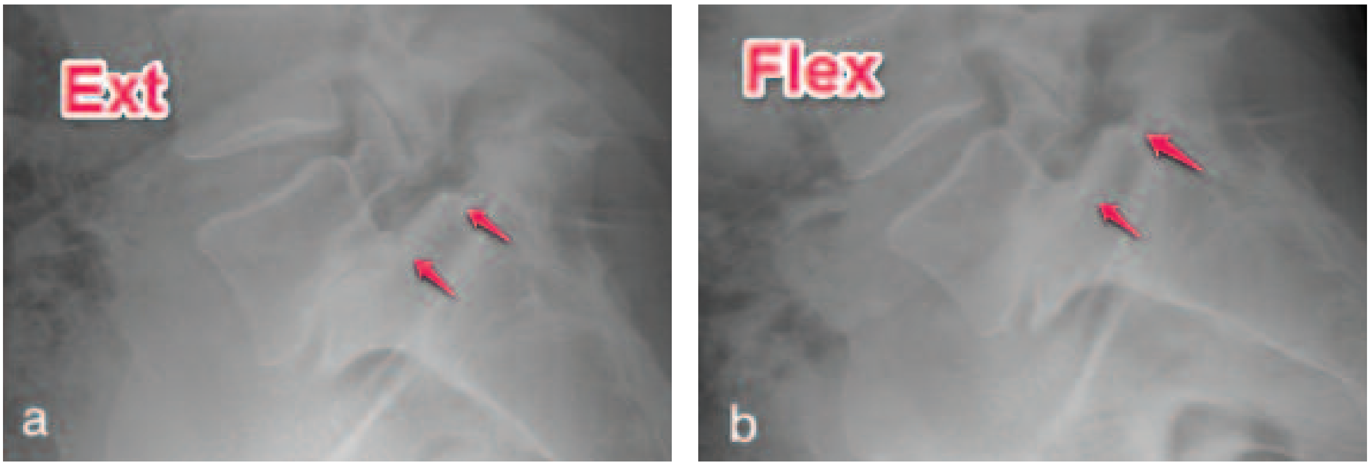

Figure 4. Dynamic lumbar spine X-ray images showed no instability at L5-S1 from extension (a) view to flexion (b) view.

10 cc of 0.5% lidocaine with epinephrine was injected along the needle track. An 18 gauge needle was inserted to the foramen using the exact trajectory for local anesthesia. Once the needle had reached the posterior vertebral line in the foreman, confirmed in AP and lateral views, the needle was advanced to the target disc. A guiding wire was then inserted through the needle to the disc. Over the needle, an endoscope dilator was placed to reach the foramen, and over the dilator an endoscope cannula was placed. Finally, an endoscope was inserted through the cannula to start decompression.

Decompression

The initial step of decompression was to find the base of the SAP and pedicle using a radiofrequency probe under direct visualization, and then expose the SAP (from base to its body and tip) and the facet joint. Following the SAP, the endoscope cannula was moving slowly to the cephalad, the gap between the pars fracture and the facet joint was located. The soft scar and inflamed tissues in the gap (Fig. 2) were removed with a radiofrequency probe to locate bone fragments. Special attention was paid to the L5 nerve root, which was moved interiorly and anteriorly to the pars fracture. Once the gap was exposed, bone fragments and/or protruding bone were visible in the gap between the facet joint and fractured pars, anterior to the facet joint, and superior and posterior to the L5 nerve root (Fig. 3). The bone fragments, which we named the KL Fragments because of their significance in isthmic spondylolisthesis, were undercut using a Kerrison rongeur, a burr, and a shaver; and were resected and extricated with a pituitary rongeur once they became loose.

Patients

We present 2 patient cases to illustrate the feasibility of TFELD for treatment of isthmic spondylolisthesis.

Case 1: A 56-year-old male patient suffered left leg pain along with left foot drop starting in 2011. The pain persisted despite conservative treatments, including pain medication and physical therapy. The patient underwent microdiscectomy at the right side of L5-S1 in 2005 at a different surgical center. In 2013, the patient visited our surgical center to seek further treatment. Medical examination, lumbar spine X-rays, and MRI images confirmed grade 2 L5-S1 isthmic spondylolisthesis without spinal instability. After consulting with the author, the patient chose to undergo TFELD at left L5-S1 in August 2013 to reduce the pain. In 2015, 2 years after the left L5-S1 TFELD, the patient developed right leg radicular pain along the L5 dermatome. Medical examination and imaging studies again showed no instability at L5-S1. In February 2016, the patient underwent TFELD at the right L5-S1.

Case 2: A 63-year-old male patient suffered chronic low back pain and right leg pain for several years before visiting the author's surgical center for treat-

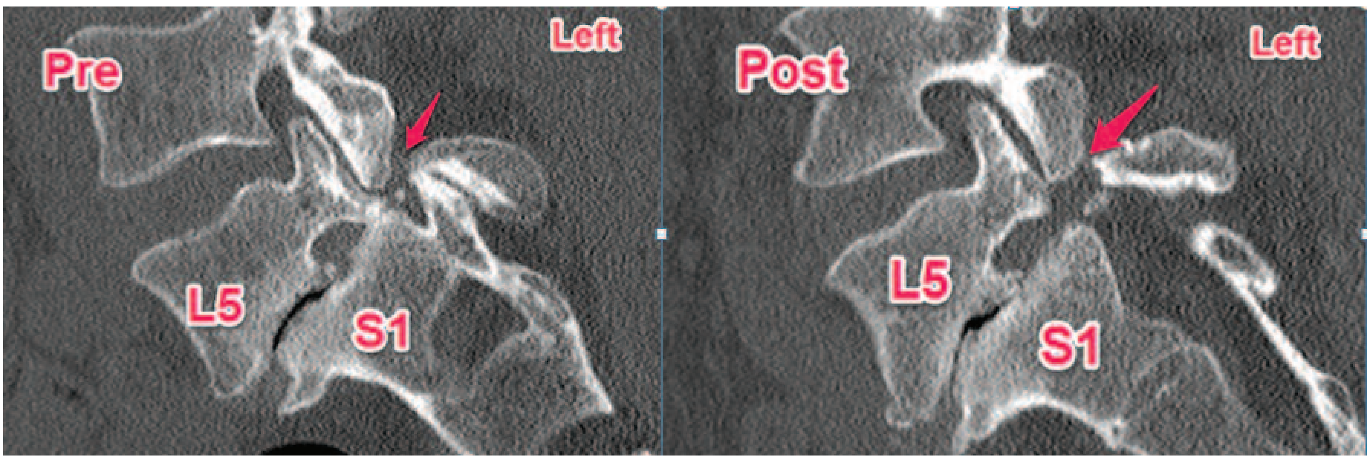

Figure 5. Images of the spine before and after TFELD at left L5-S1 showing that the protruding bony compression in the foramen of L5-S1 (left) was successfully removed and the foramen for the L5 nerve root was enlarged (right). Pre: preoperative CT scan; Post: postoperative CT scan. The red arrows point towards the pars fracture.

ment. His right leg pain was radicular, with tingling and numbness along the right L5 dermatome. Four lumbar nerve blocks and extensive physical therapy failed to reduce the pain. Imaging studies demonstrated grade 1 L5-S1 spondylolisthesis with pars fracture but without spine instability. After consulting with the author, the patient chose to undergo right TFELF in December 2017.

RESULTS

Radiographic Findings

Case 1: Based on medical examination and imaging studies, the patient was diagnosed with grade 2 L5-S1 isthmic spondylolisthesis. Dynamic X-ray studies confirmed no spinal instability. CT scan images demonstrated L5-S1 spondylolisthesis, disc space collapse, and pars fracture. Decompression of nerve root was evident with partial resection of SAP and the fractured pars (Fig. 4).

Case 2: Similar imaging studies were performed in this patient. Imaging studies showed pars fracture and confirmed no spine instability.

Clinical Outcomes

Case 1: Following the first TFELD at left L5-S1 in August 2013, the patient's left leg pain was significantly resolved. The VAS score dropped from 7 before surgery to 4 after surgery. The patient subsequently regained left foot strength and motor function. CT images showed that the foramen was widened, and the compression was resolved (Fig. 5). No surgical complications occurred during or after surgery.

Following the second TFELD at the right L5-S1 in February 2016, the patient's right leg pain again completely resolved. The patient developed temporary right-leg paresthesia, which was resolved with selective nerve blocks. No surgical complications occurred during or after surgery. At the last follow-up (5 years after the initial left L5-S1 TFELD in 2013, and 2 years after the right L5-S1 TFELD in 2016), the patient's VAS scores were 0 for the right leg and 4 for the left leg and back; the patient's low-back ODI was 0, compared to 56 in 2013; and the patient was satisfied with the result.

Case 2: Following the TFELD at the right L5-S1 in 2017, the patient's painful symptoms were markedly improved. At the last follow-up visit (one year after the TFELD surgery), the patient's VAS scores were 3 for both the low back and right leg, compared to 8 and 6, respectively, before surgery. The patient's low-back ODI was 30, compared to 40 in 2017.

DISCUSSION

In 2003, Knight et al. reported their experience of treating isthmic spondylolisthesis through endoscopic decompression.[6] With the use of a YAG laser to remove scar tissue, disc material, and/or bone osteophytes, 79% (17/24) of the patients they treated achieved good or excellent outcomes. However, they did not show or discuss the core pathology, which, we think, based on the information presented in the publication, might be the protruding bone or the KL Fragment along with the secondary scar or inflamed tissue. We think that the protruding bone or KL Fragment in the defect area might exhibit micromovement against a nerve root, consequently resulting in inflammation around the nerve root. However, it is known that a YAG laser is not effective for removing large bone fragments because of its low energy and inadequacy for penetrating bone. On the other hand, endoscopic spinal surgery techniques have markedly advanced in the last decade partly because of the availability of motorized bone cutters such as shavers, burrs, and various Kerrisons. It is reasonable to hypothesize that current endoscopic spinal surgery techniques might be more effective than the YAG laser technique reported by Knight et al. in 2003 for neuroforaminal decompression caused by isthmic spondylolisthesis. However, comparative studies with large sample sizes are needed to verify this hypothesis.

To our knowledge, bone fragments in the neuroforamen of patients with spondylolisthesis have not been previously described in the literature. The bone fragments could be part of fractured pars, displaced and fractured lamina, or displaced or fractured inferior articular process. In this paper, we demonstrated that the core pathology of patients with isthmic spondylolisthesis could be clearly identified and adequately removed using our TFELD technique, with a bone shaver, Kerrison, or burr, under direct endoscopic visualization.

TFELD is associated with a range of benefits because of its minimally invasive nature. The surgical procedure poses a low risk of post-surgery complications, preserves the critical spinal structure, and maintains the stability and motion of the spine. Our experience suggests that, for patients with isthmic spondylolisthesis whose main symptoms are mostly leg pain without much low-back pain, TFELD is a great surgical option; however, for patients whose main symptoms are low-back pain and not leg pain, and in whom imaging studies show spine instability, conventional spinal fusion will most likely be needed. Nevertheless, TFELD as a safe and minimally invasive surgical option should be offered to all patients with isthmic spondylolisthesis whose primary complaints are associated with nerve root compression, such as radicular leg pain, numbness, tingling, or weakness.

CONCLUSION

For patients with spondylolisthesis-associated low back and leg pain but without spinal instability, TFELD is a safe and effective surgical treatment option. STI

AUTHORS' DISCLOSURES

The authors declare no conflicts of interest in the manuscript.

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