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Retrospective Review

Foraminal Access Strategies in Patients with Lumbar Posterolateral Fusions in Transforaminal Endoscopic Spine Surgery: Case Series and Technical Note

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Background: The treatment of post-laminectomy lumbar radiculopathy in the setting of a large posterolateral fusion mass presents an anatomic challenge to the spine interventionalist.

Objective: To describe outcomes of awake, transforaminal endoscopic surgical treatment for patients presenting with lumbar radiculopathy after instrumented posterolateral lumbar fusions.

Study Design: Retrospective chart review.

Setting: This study took place in a single-center, academic hospital.

Methods: The records of 538 patients who underwent awake transforaminal lumbar endoscopic decompression surgery performed by a single surgeon at a single institution between 2014 and 2019 were retrospectively reviewed. Fifteen consecutive patients who required drilling through their posterolateral fusion masses to access the post-fusion foraminal stenosis were included in this study. All included patients were followed for at least one year after surgery.

Results: Fifteen patients (7 male and 8 female) with an average age of 68.1 years (range 38-89, standard deviation 13.4 years) underwent awake transforaminal foraminal decompression surgeries that utilized special techniques to drill through large posterolateral fusion masses to access their foraminal stenosis. One patient (7%) required repeat surgery in the postoperative period due to lack of surgical improvement. For the remaining 14 patients, at one year follow up, the preoperative visual analog scale (VAS) for leg pain and Oswestry disability index (ODI) improved from 7.0 (± 1.7) and 40.7% (± 12.9) to 1.7 (± 1.6) and 12.1% (± 11.3). There were no complications such as infection, durotomy, or neurologic injury
Limitations: Retrospective case series.

Conclusion: Transforaminal endoscopic spine surgery offers a unique approach to post-laminectomy and post-fusion foraminal compression because it avoids scar tissue resulting from previous posterior approaches. Large posterolateral fusion masses associated with some posterior fusions can be a sizeable bony barrier to transforaminal access. The authors share their techniques and success for navigating large posterior, bony fusion masses in transforaminal post-fusion foraminal decompression.

Key words: Endoscopic discectomy, transforaminal, TESSYS, radiculopathy, posterolateral fusion

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Instrumentation can fixate lumbar spinal anatomy while interbody and posterolateral fusion occurs, yielding improved postsurgical outcomes and decreased rates of postoperative complications like pseudarthrosis and infection (1,2). However, instrumented lumbar fusions can be disadvantageous in patients needing revision surgery to address post-fusion lumbar radiculopathy. Navigating through the sizable posterolateral fusion mass and foraminal scarring poses a critical surgical challenge, compounding the high complication rate and poor efficacy of revision surgeries following instrumented lumbar fusion (3). Suh et al reported complications in 28% of patients undergoing revision surgery after instrumented posterolateral fusion, with 13% of patients requiring further reoperation to address nonunion and implant failure (4).

Transforaminal lumbar endoscopic surgery is a minimally invasive approach that can be performed in awake patients and has shown promise in eluding several complications of posterior lumbar surgery like durotomy and nerve injury because it bypasses scar tissue by avoiding a direct posterior approach (5,6). Although transforaminal endoscopic decompression has been shown to resolve lumbar radiculopathy after laminectomy and lumbar interbody fusion, the bony onlay mass of a robust posterolateral fusion can be a limiting anatomic barrier to the transforaminal corridor used for endoscopic decompression (6,7).

We present a technical description and case series to characterize the operative methods for and demonstrate the success of treating post-fusion lumbar radiculopathy by penetrating the posterolateral fusion mass through one of 2 different techniques.

Methods

Operative Procedure

For the endoscopic (Joimax® TESSYS) spine procedures, the patient was awake, positioned in the prone position on a Wilson frame with flexed hips and knees. The procedure was done under local anesthesia (1% lidocaine with epinephrine) and intravenous sedation; the anesthetic level was titrated, so the patient was able to communicate with the surgeon throughout the procedure. Percutaneous entry was established through the skin 10 to 13 cm lateral to the midline. An 18-gauge 15 cm spinal needle was used to infiltrate the operative area with lidocaine with epinephrine. Then, one of 2 methods was used to access the symptomatic compressed foramen:

1) Using intermittent fluoroscopic guidance, alternating between lateral and anterior-posterior (AP) view, a Jamshidi needle was advanced and placed directly on the posterolateral fusion mass, targeting the superior articulating process (SAP) of the inferior vertebra. The Jamshidi needle was malleted through the posterolateral fusion mass and the superior articulating process into Kambin's triangle, between the exiting and traversing nerves. The targeted zone was the tip of the superior endplate of the inferior vertebral body on lateral fluoroscopy and just at the medial wall of the inferior pedicle on AP fluoroscopy. A 7 mm incision was made over the needle, and a Kirschner (K)-wire was placed in the needle, the needle removed, and sequential dilators placed over the K-wire. Sequential reamers were used to drill through the posterolateral fusion mass and enlarge the neural foramen by removing the ventral aspect of the SAP. At this point, the beveled cannula tubular retractor was placed over the sequential dilators, the dilators removed, and the 7 mm outer diameter Joimax® rigid working channel endoscope was inserted through the tubular retractor. The endoscopic drill (Joimax® Shrill®) with diamond burr (Diamond Abrasor®, Ball Tip, Coarse 3.5 mm outer diameter) was used to perform the foraminotomy at 6500 rpm drill speed, under continuous endoscopic irrigation. The technique used was to target the tip of the drill, step-by-step, circumferentially around the narrowed foramen, thinning the bone until it could be removed with an endoscopic grasper. Any residual compressive disc was removed with endoscopic graspers. The endpoint of the procedure was visualizing the exiting and traversing nerves decompressed and communicating with the patient that they felt improvement.
2) Using intermittent fluoroscopic guidance, alternating between lateral and AP view, the 18-gauge 15 cm spinal needle was advanced and placed directly on the lateral fusion mass, targeting the superior articulating process (SAP) of the inferior vertebra centimeters away. A K-wire was placed through the needle after removing the stylet. A 7 mm incision was made over the needle, the needle removed, and sequential dilators placed over the K-wire. At this point, the beveled cannula tubular retractor was placed over the sequential dilators, the dilators removed, and the 7 mm outer diameter Joimax® rigid working channel endoscope was

inserted through the tubular retractor. The endoscopic drill (Joimax® Shrill®) with diamond burr (diamond abrasor, ball tip, coarse 3.5 mm outer diameter) was used to drill through the lateral mass at 6500 rpm drill speed, under continuous endoscopic irrigation, advancing the drill while checking its position intermittently on AP and lateral fluoroscopic images. The drill and graspers were then used to perform the foraminotomy, as described above.

Case Examples

Fifteen patients were treated with endoscopic foraminotomy procedures utilizing the techniques described above to access the symptomatic foramen through the lateral mass fusion. Two of the patients in this study had instrumented fusions that ended at L5, but the symptomatic level was L5-S1. This series includes these cases because the same techniques were used to drill through the lateral fusion masses to access the symptomatic level. The Jamshidi needle was used to penetrate through the posterolateral fusion mass in 13 patients. The endoscopic drill was used to drill through the posterolateral fusion mass in the other 2 patients. Fourteen of the 15 patients were improved for one year following their endoscopic decompressive surgery.

Case 1

A 67-year-old presented with right L4-5 radiculopathy and partial foot drop and a previous lumbar 3-5 (transitional vertebra) transforaminal lumbar interbody fusion and revision due to pseudarthrosis. The patient never had improvement in his radicular pain despite surgery and multiple injections. A lumbar CT and MRI (Fig. 1) demonstrated severe right L3-4 and L4-5 foraminal stenosis and the extent of the lateral mass fusion. The patient presented with a visual analog scale (VAS) score for leg pain of 5 and an Oswestry disability index (ODI) of 30%, complaining of severe right anterior thigh and lateral calf pain with any activity and weakness in the right foot dorsiflexion. Figure 2 demonstrates the access with the Jamshidi and the final position of the tubular retractor after reaming. At one year follow-up, the patient's VAS score for leg pain improved to 0, and his ODI decreased to 4%.

Case 2

A 59-year-old female underwent an L5-S1 TLIF and subsequent hardware removal by another surgeon 10 years prior. She presented with 10 years of left L5-S1

Fig. 1. *Preoperative lumbar CT and MRI were demonstrating right L3-4 and L4-5 foraminal narrowing post-TLIF and large posterolateral fusion. A. Coronal CT image demonstrates instrumented L3-5 fusion with large posterolateral fusion mass (open arrows). B. Sagittal CT reconstruction demonstrates instrumented L3-5 fusion with large posterolateral fusion mass (open arrow). C. Sagittal T2-weighted MR image demonstrating the right L3-4 and L4-5 foraminal compression (open arrows). D. Axial T2-weighted MR image demonstrating the right L4-5 foraminal narrowing (open arrow).*

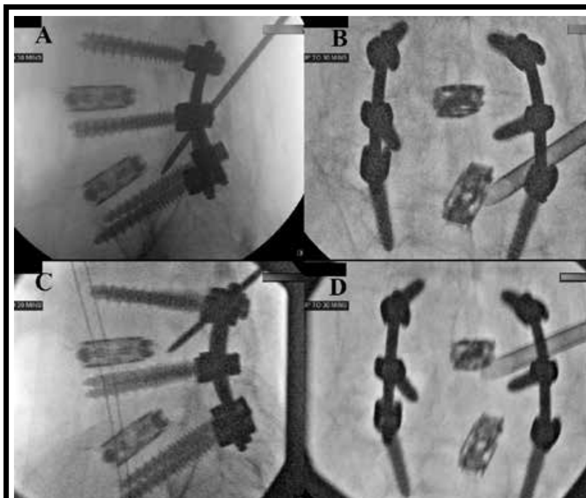

Fig. 2. *Fluoroscopic images demonstrate a technique to penetrate posterolateral fusion to obtain endoscopic access to the foramen. A. Lateral fluoroscopic image demonstrates the Jamshidi needle used to penetrate the posterolateral fusion and target the superior endplate of the L5 vertebra. B. AP fluoroscopic image demonstrates the tubular retractor in the right L4-5 foramen after serial dilation and reaming. C. Lateral fluoroscopic image demonstrates the Jamshidi needle used to penetrate the posterolateral fusion and target the superior endplate of the L4 vertebra. D. AP fluoroscopic image demonstrates the tubular retractor in the right L3-4 foramen after serial dilation and reaming.*

radiculopathy and foot dorsiflexion and plantarflexion weakness. Her preoperative lumbar MRI (Fig. 3A-B) demonstrated heterotopic bone occluding her foramen and a significant fusion mass over the left L5-S1 facet complex. Access to the foramen was obtained with a Jamshidi needle through the posterolateral fusion mass (Fig. 3C), and an endoscopic foraminotomy was performed with the endoscopic drill (Fig. 3D). The patient noted immediate improvement in her leg pain and was able to dorsi- and plantar-flex her foot without difficulty before leaving the operating room. Postoperatively, the patient did very well. Her leg pain and weakness improved. At her 1-year follow-up, her pre-op leg VAS improved from 5 to 0, and her pre-op ODI improved from 30 to 4.

Case 3

A 56-year-old male underwent an L4-S1 TLIF by another surgeon and presented with left L5-S1 radiculopathy. A CT showed a sizeable posterolateral fusion mass (Fig. 4A), in addition to screw loosening, and an MRI revealed an L5-S1 spondylolisthesis with severe foraminal compression of the left L5 nerve. A transforaminal endoscopic decompression was performed using a Jamshidi needle to penetrate the onlay fusion mass (Fig. 4C) and an endoscopic drill to perform foraminotomy (Fig. 4D). The patient improved initially from the surgery but then recurred with his symptomatology 6 months later and chose to pursue a revision of his fusion with an extension of his hardware.

Case 4

A 55-year-old male underwent an L4-5 TLIF and an L5-S1 posterior lumbar interbody fusion (PLIF) and presented with left L4-5 radiculopathy. MRI showed a large left L4-5 herniated disc (Fig. 5A) with foraminal compression, and CT lumbar showed a large posterolateral fusion mass. A spinal needle was used to target the pathology (Fig. 5C), and an endoscopic drill was used to penetrate the posterolateral fusion mass (Fig. 5D). One year following the endoscopic decompression, the patient improved from a preoperative leg VAS score of 5 to 0 and ODI of 26 to 10.

Results

Awake, endoscopic decompression surgery was performed on 538 patients over 5 years from 2015 to 2019. Transforaminal endoscopic foraminal decompression surgery utilizing the above-described techniques to penetrate the posterolateral fusion mass was performed in 15 patients who had previously undergone posterior lumbar instrumented fusions. Table 1 summarizes the clinical data for the 15 patients. There were 7 male and 8 female patients treated with an average age of 68.1 years (range 38-89, standard deviation 13.4 years). Levels treated were L5-S1 (8 patients), L4-5 (5 patients), L3-4 (1 patient), and a single 2 level case (L3-4 and L4-5). One patient (7%) required repeat

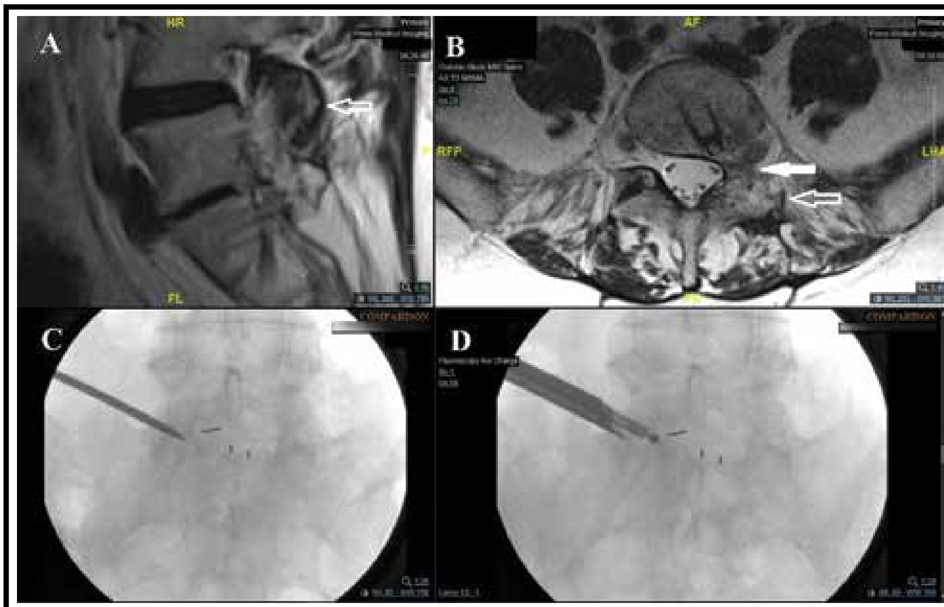

Fig. 3. *Left L5-S1 foraminal decompression after L5-S1 TLIF. B. Sagittal T2-weighted MRI demonstrates the fusion mass over the L5-S1 foramen (open arrow). B. Axial T2-weighted MR image demonstrates the fusion mass over the left L5-S1 foramen (open arrow) and the heterotopic bone occluding the foramen (closed arrow). C. AP fluoroscopic image shows the placement of the Jamshidi needle through the posterolateral fusion mass into the foramen. D. AP fluoroscopic image demonstrates the endoscopic drill decompressing the foramen.*

surgery in the postoperative period due to a lack of durable surgical improvement. For the remaining 14 patients, at one year follow up, the preoperative VAS for leg pain and ODI improved from 7.0 (± 1.7) and 40.7% (± 12.9) to 1.7 (± 1.6) and 12.1% (± 11.3). There were no complications such as infection, durotomy, or neurologic injury.

Failures

One patient required repeat surgery in the 1-year postoperative period (Case 3). He was noted to have pedicle screw loosening at all levels fused before endoscopic decompression. The patient did not have sustained improvement with endoscopic surgery and was referred for deformity surgery.

Discussion

Over a 5 year period, 538 patients were treated with transforaminal endoscopic spine surgery at our institution. The operative techniques described here to access a stenotic foramen were employed in only 15 patients (3%) with sizeable lateralization fusion mass who presented with lumbar radiculopathy following instrumented posterolateral fusion. Esti-

Fig. 4. *Transforaminal decompression of a left lumbar 5-S1 foraminal narrowing after an L4-S1 TLIF. A. Coronal CT image demonstrates the instrumented L4-S1 fusion with large posterolateral fusion mass (open arrow). B. Sagittal T2-weighted MR image depicting the left L5-S1foraminal narrowing (open arrow). C. AP fluoroscopic image shows the placement of the Jamshidi needle through the posterolateral fusion mass into the foramen. D. AP fluoroscopic image demonstrates the endoscopic drill decompressing the foramen.*

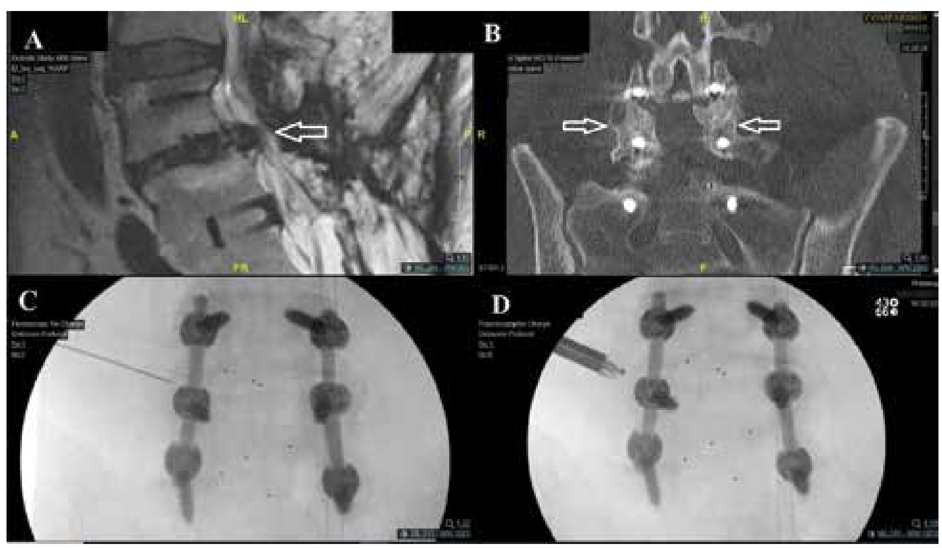

Fig. 5. *Transforaminal decompression of a left L4-5-disc herniation and foraminal narrowing after an L4-S1 fusion. A. Sagittal T2-weighted MR image demonstrating the left L4-5-disc herniation at L4-5. B. Coronal CT image demonstrates the instrumented L4-S1 fusion with large posterolateral fusion mass (open arrows). C. AP fluoroscopic image demonstrates the spinal needle targeting the left L4-5 foramen but being blocked the posterolateral fusion mass. D. AP fluoroscopic image demonstrates the endoscopic diamond drill used to penetrate the fusion mass to allow access to the foramen.*

Table 1. Clinical data.

Age	Gender	Levels Fused	Endoscopic Decompression Surgery Performed	Pre-OD Leg VAS	Pre-Op ODI	1-year Post-Op Leg VAS	1-year Post-Op ODI
38	M	L2-5	Left L5-S1	8	36	1	10
55	M	L4-S1	L L4-5	5	26	0	4
56	M	L4-S1	L L5-S1	9	58	F	F
58	M	L5-S1	R L5-S1	6	32	1	4
59	F	L5-S1	Left L5-S1	5	30	0	4
62	F	L1-5	R L4-5	10	64	5	36
67	M	L3-5	R L3-5	5	30	0	4
72	M	L2-S1	R L5-S1	7	36	2	8
74	F	T8-S1	L L5-S1	8	54	3	26
74	F	T11-L5	R L5-S1	6	32	1	4
75	F	L3-5	L L4-5	8	44	3	15
78	M	L5-S1	L L5-S1	9	62	4	32
82	F	L2-5	R L4-5	5	28	0	2
83	F	L3-4	R L3-4	6	34	1	6
89	F	L4-5	R L4-5	8	44	3	15

mates of the incidence of post-fusion radiculopathy are varied. Fritzell et al identified emergent radiculopathy in 7% of 140 subjects who underwent instrumented lumbar fusion, while Dunne et al and Schär et al found postoperative radiculopathy in 29% of patients treated with posterior spinal fusion and transforaminal lumbar interbody fusion, respectively (8-10).

Given that lumbar radiculopathy is less common after instrumented fusion, the challenges of achieving nerve root decompression while navigating around posterior hardware and a bony fusion mass are not well-characterized (11). The technique descriptions and clinical outcomes we present here reflect our successful experience with penetrating the posterolateral fusion mass to facilitate transforaminal endoscopic decompression. This case series had just one failure (7%) at one-year follow-up, and the average reductions in VAS leg score and ODI in patients who improved after surgery were 76% and 70%, respectively.

Awake outpatient transforaminal endoscopic surgery is usually an excellent approach to treating patients who have undergone posterior spinal surgery because it avoids posterior scar tissue with its more lateral approach (12). Although the posterolateral fusion mass obstructs foraminal access, the techniques described here enabled transforaminal endoscopic decompression with no complications like nerve damage or wound infection. Revision posterior fusion surgery carries a higher risk of surgical site infection and 30-day unplanned reoperation relative to primary posterior spinal fusion, and posterolateral fusion repair is associated with persistent pseudarthrosis and high failure rates (4,13,14). Anterior or lateral approaches could have been considered for patients in this case series (excluding L5-S1 fusions), but these surgeries would require significant fusion exploration (15).

The greatest challenges for those unfamiliar with endoscopic surgical techniques are typically: 1) targeting with the needle to access pathology, and 2) understanding endoscopic visual anatomy. Both of these challenges are magnified in cases with prior posterolateral fusion. Targeting the pathology is more difficult because of the lateral fusion mass, and understanding the endoscopic visual anatomy can be very confusing due to the posterior scar tissue. But with the advent of newer technology in modern spine surgery, navigation and robotic assistance can make targeting through the lateral fusion mass significantly less challenging. Robotic guidance for localization in transforaminal endoscopic surgery has already been documented in the neurosurgical literature (16,17). For the operations described in this case series, a robotic arm could select a start point on the patient's skin and a target point in the foramen with the aid of navigation, and a power drill could then be used to drill through the fusion's bony mass.

Disclosure

Author Contributions: Drs. Telfeian, Bajaj, Sastry, Ali, Oyelese, Fridley, Camara-Quintana, Niu, Lewandrowski, and Gokaslan had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Dr. Telfeian designed the study protocol. Drs. Telfeian and Bajaj managed the literature searches and summaries of previous related work and wrote the first draft of the manuscript. Drs. Telfeian, Bajaj, Sastry, Ali, Oyelese, Fridley, Camara-Quintana, Niu, Lewandrowski, and Gokaslan provided revision for intellectual content and final approval of the manuscript. Conflict of Interest: Drs. Telfeian, Bajaj, Sastry, Ali, Oyelese, Fridley, Camara-Quintana, Niu, Lewandrowski, and Gokaslan have no conflicts of interest to report. None of the authors of the manuscript received any remuneration. Further, the authors have not received any reimbursement or honorarium in any other manner. The authors are not affiliated in any manner with any commercial industry. However, all the authors are members of the Brown Department of Neurosurgery and practicing spine physicians except for Lewandrowski, who is an Orthopedic surgeon, and Ankush Bajaj, who is a medical student. There is no Funding/Support to declare. The study was not sponsored by any entity. The authors also wish to thank the editorial board of Pain Physician for this manuscript.

References

1. Litrico S, Recanati G, Gennari A, Maillot C, Saffarini M, Le Huec JC. Single-use instrumentation in posterior lumbar fusion could decrease incidence of surgical site infection: a prospective bi-centric study. *Eur J Orthop Surg Traumatol* 2016; 26:21-26.
2. Wood GW 2nd, Boyd RJ, Carothers TA, et al. The effect of pedicle screw/plate fixation on lumbar/lumbosacral autogenous bone graft fusions in patients with degenerative disc disease. *Spine (Phila Pa 1976)* 1995; 20:819-830.
3. Cassinelli EH, Wallach C, Hanscom B, Vogt M, Kang JD. Prospective clinical outcomes of revision fusion surgery in patients with pseudarthrosis after posterior lumbar interbody fusions using stand-alone metallic cages. *Spine J* 2006; 6:428-434.
4. Suh SP, Jo YH, Jeong HW, Choi WR, Kang CN. Outcomes of revision surgery following instrumented posterolateral fusion in degenerative lumbar spinal stenosis: a comparative analysis between pseudarthrosis and adjacent segment disease. *Asian Spine J* 2017; 11:463-471.
5. Jiang X, Zhou X, Xu N. Clinical effects of transforaminal and interlaminar percutaneous endoscopic discectomy for lumbar disc herniation: a retrospective study. *Medicine (Baltimore)* 2018; 97:e13417.
6. Telfeian AE, Oyelese A, Fridley J, Camara-Quintana JQ, Niu T, Gokaslan ZL. Transforaminal endoscopic surgical treatment for postlaminectomy lumbar radiculopathy: case series. *World Neurosurg* 2021; 150:e577-e584.
7. Telfeian AE. An awake, minimally-invasive, fully-endoscopic surgical technique for treating lumbar radiculopathy secondary to heterotopic foraminal bone formation after a minimally invasive transforaminal lumbar interbody fusion with BMP: technical note. *J Spine Surg* 2018; 4:162-166.
8. Dunne JW, Silbert PL, Wren M. A prospective study of acute radiculopathy after scoliosis surgery. *Clin Exp Neurol* 1991; 28:180-190.
9 Fritzell P, Hägg O, Nordwall A, Swedish Lumbar Spine Study Group. Complications in lumbar fusion surgery for chronic low back pain: comparison of three surgical techniques used in a prospective randomized study. A report from the Swedish Lumbar Spine Study Group. *Eur Spine J* 2003; 12:178-189.
10. Schär RT, Sutter M, Mannion AF, et al. Outcome of L5 radiculopathy after reduction and instrumented transforaminal lumbar interbody fusion of high-grade L5-S1 isthmic spondylolisthesis and the role of intraoperative neurophysiological monitoring. *Eur Spine J* 2017; 26:679-690.
11. Ye YP, Chen D, Xu H. The comparison of instrumented and non-instrumented fusion in the treatment of lumbar spondylolisthesis: a meta-analysis. *Eur Spine J* 2014; 23:1918-1926.
12. Telfeian AE, Jasper GP, Francisco GM. Transforaminal endoscopic treatment of lumbar radiculopathy after instrumented lumbar spine fusion. *Pain Physician* 2015; 18:179-184.
13. Luhmann SJ, Lenke LG, Bridwell KH, Schootman M. Revision surgery after primary spine fusion for idiopathic scoliosis. *Spine (Phila Pa 1976)* 2009; 34:2191-2197.
14. Malik AT, Yu E, Kim J, Khan SN. 30-day Outcomes in primary vs. revision posterior spinal fusion for pediatric spinal deformity. *Clin Neurol Neurosurg* 2019; 180:106-110.
15. Gumbs AA, Hanan S, Yue JJ, Shah RV, Sumpio B. Revision open anterior approaches for spine procedures. *Spine J* 2007; 7:280-285.
16. Fan N, Yuan S, Du P, et al. Design of a robot-assisted system for transforaminal percutaneous endoscopic lumbar surgeries: study protocol. *J Orthop Surg Res* 2020; 15:479.
17. Liounakos JI, Wang MY. Lumbar 3-lumbar 5 robotic-assisted endoscopic transforaminal lumbar interbody fusion: 2-dimensional operative video. *Oper Neurosurg (Hagerstown)*. 2020;19:E73-E74.