Retrospective Study

Translaminar Osseous Channel–Assisted Full-Endoscopic Flavectomy Decompression of Thoracic Myelopathy Caused by Ossification of the Ligamentum Flavum: Surgical Technique and Results

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Background: Previous surgical procedures for the treatment of thoracic myelopathy (TM) due to ossification of the ligamentum flavum (OLF) were accompanied by significant trauma and risk.

Objectives: Report a novel minimally invasive technique, translaminar osseous channel–assisted posterior percutaneous full-endoscopic flavectomy (p-PEF), as an alternative surgical strategy for the treatment of OLF-related TM.

Study Design: A retrospective cohort study.

Setting: A center for spine surgery and pain medicine.

Methods: Thirteen patients with TM caused by isolated OLF who underwent translaminar osseous channel–assisted p-PEF were retrospectively analyzed. Preoperative and postoperative radiographic findings and clinical results were compared to confirm the efficacy of the procedure and perioperative complications were investigated to evaluate the technical safety.

Results: All 13 patients with 23 isolated ossified sites were successfully treated with the translaminar osseous channel–assisted p-PEF technique and no additional internal fixation was needed. With an average follow-up of 29.2 months (range, 24–36 months), no local instability was detected. The preoperative and final follow-up cross-sectional area of the stenotic dural sac was 47.87 ± 8.98 mm^2 and 130.47± 19.07 mm^2, respectively ($P < 0.0001$). The mean modified Japanese Orthopaedic Association score was significantly improved from 3.54 ± 1.26 points preoperatively to 9.07 ± 1.48 points at final follow-up ($P < 0.0001$). The Visual Analog Scale scores of thoracolumbar backaches were 5.3 ± 1.2 before surgery and 0.69 ± 0.75 at final follow-up ($P = 0.001$). No serious complications ensued.

Limitations: This was a retrospective study with several limitations, including the lack of a control group, small number of included samples and unavoidable nature of the single-center study design.

Conclusions: Translaminar osseous channel–assisted p-PEF technique, with less tissue trauma and impact on the stability of the spine, can provide adequate decompression and satisfying outcomes in the treatment of OLF-related TM and should be considered as an alternative procedure for isolated OLF.

Key words: Translaminar osseous channel, percutaneous full-endoscopic flavectomy, thoracic myelopathy, ossification of ligamentum flavum, minimally invasive spine surgery

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Ossification of the ligamentum flavum (OLF), as one of the major causes of thoracic spinal canal stenosis (1,2), frequently results in thoracic myelopathy (TM) (3,4). With a prevalence ranging from 3.8% to 63.9% (5-7), OLF is relatively common in East Asian populations (8), particularly in Chinese and Japanese populations (5,6,8,9). With a predilection location at the lower thoracic spine (10,11), OLF can result in various symptoms, such as sensory abnormality of the trunk, muscle weakness or abnormal sensation of the lower extremities, gait disturbance, urinary dysfunction and, in severe cases, complete paraplegia (3,12,13).

Because of the slowly progressive and various clinical features of thoracic OLF, it is usually diagnosed when the patients have advanced symptoms due to severe spinal cord compression (8,10,14), and it generally requires surgical treatment owing to the poor response to conservative treatment (1,15,16). The goal of the surgical treatment for symptomatic TM should be to achieve adequate decompression of the neural structures (17-19). Therefore multiple surgical techniques have been explored, including en bloc laminectomy (20,21), partial laminectomy (17), and laminoplasty (21). Although even neurologic decompression results have been reported with these conventional decompression techniques, the optimal surgical procedure remains controversial (8,22), and the surgical outcome is not always satisfactory (8,20,23). In addition, most of these procedures are accompanied by greater iatrogenic trauma (24,25), higher risk of neurologic deterioration and complications (8,16,26), and postoperative instability (10,17,27), and this requires the use of internal fixation. With the goal of achieving adequate decompression of the neural structures, while minimizing surgical disruption to the spinal stabilizing structures, technical modifications of TM surgery have been reported during the past few years (25,28), however, an effective method is still controversial (8,14,21,26).

The current study presents a novel technique, translaminar osseous channel–assisted posterior percutaneous full-endoscopic flavectomy (p-PEF), as a minimally invasive spinal surgery (MISS) to address TM caused by isolated OLF. The efficacy and safety of this procedure were evaluated, the surgical complications are discussed, and the technical tips are presented.

Table 1. *Demographics and clinical characteristics of the 13 patients with TM caused by OLF.*

No.	Age (yrs)	Gender	Symptom Duration (mos)	OLF Level	Axial Image (CT)	Follow-Up (mos)
1	42	F	16	T11/12	Bilateral	36
2	38	M	10	T7/8	Bilateral	24
3	67	F	11	T11/12	Bilateral	27
4	59	M	23	T10/11	Right	29
5	66	F	38	T9/10	Bilateral	31
6	52	F	33	T11/12	Bilateral	36
7	48	M	30	T8/9	Bilateral	24
8	39	M	24	T10/11	Left	24
9	45	F	6	T11/12	Bilateral	26
10	62	F	18	T11/12	Bilateral	28
11	40	M	7	T10/11	Right	36
12	69	F	24	T9/10	Bilateral	25
13	51	F	36	T10/11	Bilateral	34

Abbreviations: F, female; M, male.

Methods

Patient Characteristics

Sixteen consecutive patients with a clinically approved diagnosis of TM caused by isolated OLF who underwent translaminar osseous channel–assisted p-PEF after failure with all conservative management options between January 2015 and June 2016 were included. The inclusion criteria included patients with TM that was diagnosed as isolated and of a unilateral or bilateral nature based on imaging studies and clinical features, and with a complete medical follow-up record for at least 2 years. Patients with cervical/lumbar myelopathy, a concurrent ventral compressive lesion at the same segment of OLF, history of trauma, or spinal tumor were excluded. Patients with incomplete medical records were excluded as well. Ultimately, 8 women and 5 men ranging in age from 38 to 69 years (average 52.2 ± 3.5 years) were included and analyzed. Informed consent was obtained from all patients, and approval was obtained from the institutional review board of our hospital. The patient demographics are summarized in Table 1.

Surgical Technique

Preoperatively, a precise surgical plan

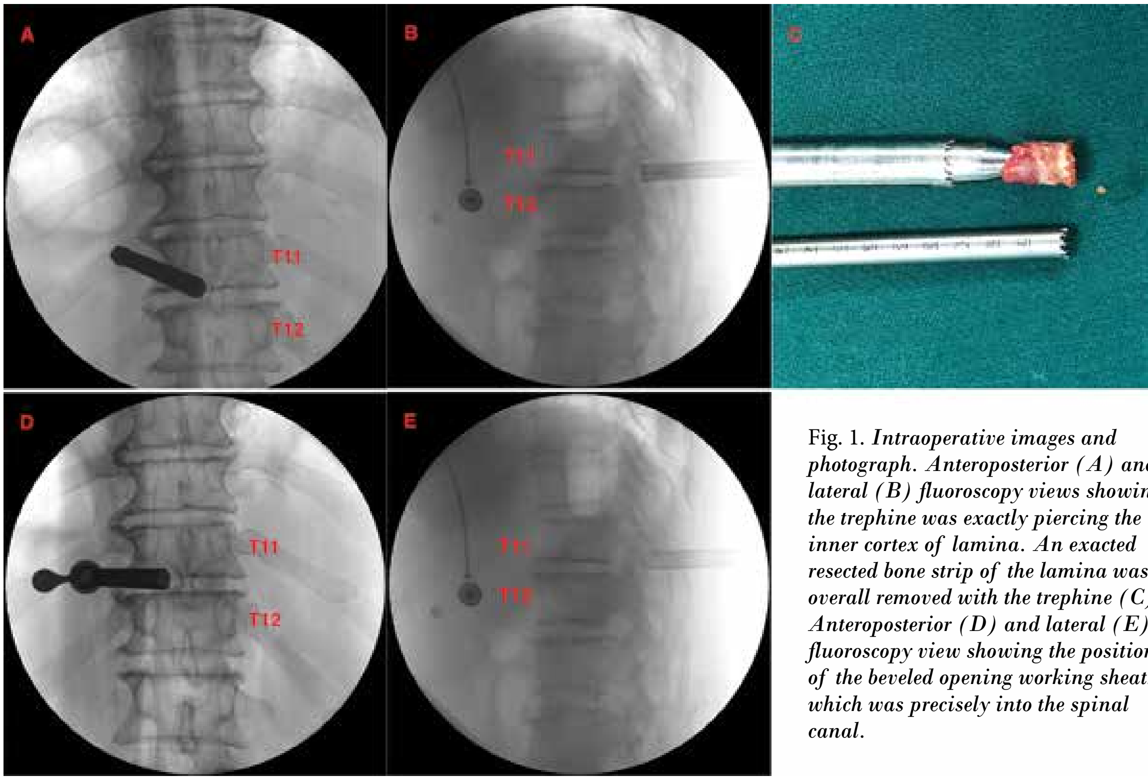

Fig. 1. *Intraoperative images and photograph. Anteroposterior (A) and lateral (B) fluoroscopy views showing the trephine was exactly piercing the inner cortex of lamina. An exacted resected bone strip of the lamina was overall removed with the trephine (C). Anteroposterior (D) and lateral (E) fluoroscopy view showing the position of the beveled opening working sheath, which was precisely into the spinal canal.*

was made by the surgeon according to the individual neurologic status and imaging findings, including clinical symptoms and the location and size of the lesions, to minimize iatrogenic damage to the spine structure. Translaminar osseous channel–assisted p-PEF and resection of the OLF at the involved levels were performed in all patients by a highly experienced spine surgeon (Liao).

After general anesthesia and neurologic monitoring were performed, patients were placed in a prone position. Intraoperative radiography was used to confirm the target region, and the surface projection of the reference segment was marked on the skin with ink. The starting side for patients with bilateral OLF lesions of single-segment depended on the preoperative surgical plan. A needle was inserted under fluoroscopic guidance to target the portion of the lamina dorsal to the OLF. Then the insertion of a 6-mm dilator along the guide needle to the target position of the lamina was performed to bluntly separate the muscles. The insertion of the trephine (OD: 7.5 mm, ID: 6.5 mm, Joimax, Germany) was performed via the dilator and punching on the target position of the lamina. Then a clockwise rotation followed by advancement to the accurate depth, which was measured using the preoperative imaging of the vertebral lamina and OLF, were carried out. The appropriate depth of the trephine was confirmed by intraoperative radiography (Fig. 1A and B). Then the exacted resected area of the lamina was entirely removed with the trephine (Fig. 1C), and a translaminar osseous channel was made that allowed the beveled opening working sheath to reach the canal (Fig. 1D and E).

Then the endoscope was inserted through the working sheath and further operation was performed under visual control and continuous fluid flow with 0.9% saline solution. If the entire removal of the exacted resected area of the lamina failed, the residual bone structure, including the ossified ligaments, were cautiously stripped using a 3-mm diameter endoscopic high-speed drill (Midas Rex; Medtronic, Fort Worth, TX). During this procedure, particular attention was paid to ensure that the ossified mass was excised without any trauma to the dural sac. Limited lamina stripping was performed, and a translaminar osseous channel was established (Fig. 2A). Then the adequate resection of

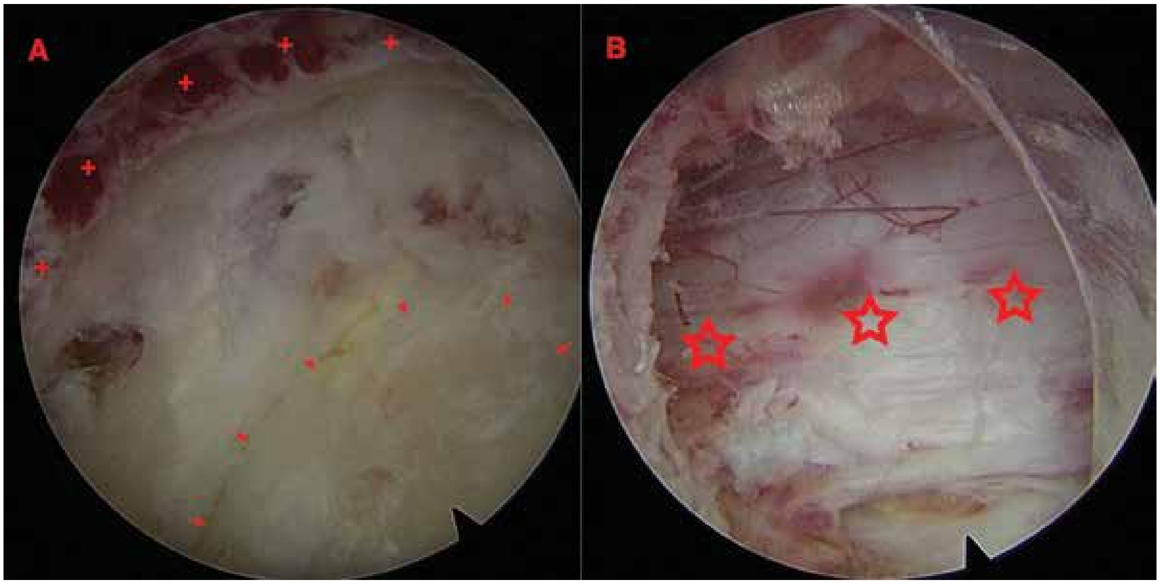

Fig. 2. *Endoscopic views. Intraoperative endoscopic view before decompression demonstrated a circular osteal groove (crosses) made by a trepan on the lamina and the ossified mass (OLF, arrows) presenting in the enlarged endoscopic visual field (A). Intraoperative endoscopic view after resection of the ossified mass (OLF) revealed the decompressed dural sac (stars) (B).*

the OLF and stenotic portions were performed under endoscopic visualization (Fig. 2B). In this procedure, the decompression was only performed on the ipsilateral side of the ossification lesion by slightly tilting the working sheath together with a 30° endoscope to achieve accurate, adequate decompression of the target area.

Full exposure of the lateral margin and medial part of the dural sac was carried out to achieving full decompression, and care was taken to reduce excessive retraction of the spinal cord during decompression. After adequate decompression, the wound was closed by suturing the skin without the need for instrumentation or a drain.

Outcome Assessment

Radiologic evaluation, including sagittal alignment of the local kyphosis on lateral radiographs (29), morphometrics of the ossified area on computed tomography (CT) scans, and degree of endorachis expansion (30) of the cross-sectional area measured on axial magnetic resonance imaging (MRI), were carried out before and after surgery. The modified Japanese Orthopaedic Association (mJOA) (31), with a maximum score of 11 indicating normal function (Table 2), was used to evaluate the neurologic outcome of patients at the following times: preoperative, postoperative, and last follow-up. The Visual Analog Scale (VAS) was used to evaluate the degree of the thoracolumbar back pain. At the final follow-up, the Hirabayashi recovery rate of all patients were calculated using the preoperative and final follow-up mJOA scores (32), which were categorized into 5 groups as excellent (100%–75%), good (74%–50%), fair (49%–25%), unchanged (24%–0%), or worse (< 0%) (33). In addition, the operation time, bleeding volume, surgical complications, and lengths of postoperative hospital stay were also investigated.

Statistical Analyses

Statistical analyses were performed using SPSS 18.0 (SPSS Inc., Chicago, IL) and continuous data are presented as the mean ± standard deviation (SD). The one-way analysis of variance was used to evaluate whether there were differences between preoperative, postoperative, and final parameters, and P values < 0.05 were considered statistically significant.

Results

Patient Characteristics

Twenty-three ossified sites of the 13 single-segment lesions were successfully resected with the translaminar osseous channel–assisted p-PEF technique, including 3 with a unilateral nature and 10 with a bilateral nature (Table 1). The postoperative follow-up ranged from 24 to 36 months with a mean of 29.2 ± 4.83 months. The radiographic evaluation was performed for all patients, and the preoperative, postoperative, and final kyphosis of the involved vertebrae segments were 3.6° ± 2.2° (range, –1° to 8°), 5.0° ± 2.1° (range, 1°–9°), and 4.9° ± 1.66° (range, 2°–8°), respectively, which showed no evidence of postoperative instability (F = 1.915, $P = 0.165$; Table 3). The cross-sectional area of the dural sac at the level of the stenosis, which was measured with MRI, was significantly improved from preoperative 47.87 ± 8.98 mm^2 (range, 31.8–60.2 mm^2) to postoperative 99.97 ± 11.39 mm^2 (range, 82.2–124.0 mm^2), and 130.47 ± 19.07 mm^2 (range, 107.6–176.6 mm^2) at final follow-up (F = 118.51, $P < 0.001$; Table 3).

Imaging Results

The morphometric evaluation of the surgical location was performed using CT and MRI scans, and a sufficient decompression of the spinal cord was demonstrated (Figs. 3–5).

Clinical Improvement

After the operation, all of the patients showed improved clinical symptoms. The mean preoperative mJOA score was 3.54 ± 1.26, which was significantly improved to 6.15 ± 0.99 and 9.07 ± 1.48 postoperatively and at the last follow-up, respectively (F = 69.294, $P < 0.001$; Table 3). The mean Hirabayashi recovery rate at the final follow-up was 73.85% ± 18.02% (excellent in 8 cases, good in 3, fair in 2) (Table 3). The VAS for thoracic back pain was improved from 5.3 ± 1.2 preoperatively to 2.1 ± 0.95 postoperatively, and 0.69 ± 0.75 at the last follow-up (F = 76.179, $P < 0.001$; Table 3). The average operative time was 133.6 ± 32.8 minutes (range, 79–185 minutes) with a less amount of intraoperative bleeding can be accurately calculated. No serious complications were noted except for one intraoperative dura tear, and no postoperative cerebrospinal fluid (CSF) leakage was encountered after meticulous close suturing of the soft tissue. However, one postoperative temporary neurologic deterioration occurred, and rehabilitation was observed after treatment with corticosteroid therapy. All patients were discharged within 4 days after the operation, with an average duration of postoperative hospitalization of 3 ± 0.8 days (range, 2–4 days; Table 3).

Table 2. *The mJOA scoring system for TM.*

Neurologic Status	Score
Lower-limb motor dysfunction	
unable to walk	0
able to walk on flat floor w/walking aid	1
able to walk up/downstairs w/handrail	2
lack of stability and smooth reciprocation of gait	3
no dysfunction	4
Lower-limb sensory deficit	
severe sensory loss or pain	0
mild sensory deficit	1
no deficit	2
Trunk sensory deficit	
severe sensory loss or pain	0
mild sensory deficit	1
no deficit	2
Sphincter dysfunction	
unable to void	0
marked difficulty in micturation	1
minor difficulty in micturation	2
no dysfunction	3
Normal condition = 11 points.	

Discussion

Thoracic OLF progresses slowly and symptoms are insidious, therefore it is generally discovered when myelopathic symptoms appear, which are caused by the secondary stenosis of the thoracic canal and severe spinal cord compression (3,9), which often requires surgical treatment (17,26). Based on the goal of surgical decompression, which is to achieve safe, effective, and adequate decompression of severe spinal cord compression, many surgical techniques have been recommended (2,20,22,26). Among these, the posterior decompression techniques, including laminectomy and laminoplasty, are the most advocated because the thoracic OLF usually causes dorsal cord compression (17,26).

Because of excellent visualization and the potential for complete resection of the OLF, laminectomy is the most favored option by practitioners (18). However, as an open procedure, a posterior laminectomy is associated with extensive posterior element destruction, greater iatrogenic trauma, a prolonged recovery period, and higher risk of intersegmental instability or spinal cord injury (1,34). Several studies have reported the delayed development of spinal kyphotic defor-

Table 3. *Clinical and radiographic results of the 13 patients who were surgically treated for OLF by p-PEF.*

No.	OA	OT (min)	PHS (day)	Follow-Up (mos)	mJOA Score			VAS Score			Cobb Angle (°)			CSA (mm^2)			SC	RR (%)	Final Result
					Preop	Postop	Final	Preop	Postop	Final	Preop	Postop	Final	Preop	Postop	Final			
1	Bilateral	142	2	36	3	6	10	4	2	1	-1	1	3	52.2	124.6	176.6	No	87.5	Excellent
2	Bilateral	167	4	24	4	7	8	6	4	1	8	9	13	45.4	98.5	125.7	No	57.1	Good
3	Bilateral	131	4	27	4	6	7	5	2	0	3	5	6	48.2	102.8	116.5	No	42.9	Fair
4	Unilateral	79	3	29	5	6	10	6	3	2	7	8	9	37.9	103.4	127.32	No	83.3	Excellent
5	Bilateral	185	4	31	2	6	9	4	1	1	3	4	4	44.0	88.9	115.3	DT	77.8	Excellent
6	Bilateral	114	3	36	3	7	10	6	1	0	4	6	7	56.8	95.3	127.32	No	87.5	Excellent
7	Bilateral	162	2	24	2	5	9	8	3	1	4	6	5	52.1	105.7	138.7	No	77.8	Excellent
8	Unilateral	84	4	24	3	6	10	5	2	0	2	5	3	48.3	95.5	143.4	No	87.5	Excellent
9	Bilateral	137	3	26	2	5	6	4	1	0	3	4	6	60.2	82.2	112.8	TND	44.4	Fair
10	Bilateral	142	2	28	5	6	9	5	2	2	3	5	7	33.9	117.2	145.7	No	66.7	Good
11	Unilateral	95	3	36	3	5	10	4	2	0	2	3	4	56.2	89.4	107.6	No	87.5	Excellent
12	Bilateral	163	4	25	4	7	11	6	3	1	5	7	7	55.3	94.5	132.7	No	100	Excellent
13	Bilateral	136	3	34	6	8	9	6	1	0	4	4	5	31.8	102.2	116.4	No	60	Good

Abbreviations: CSA, cross-sectional area; DT, dural tear; OA, operative approach; OT, operative time; PHS, postoperative hospital stay; Postop, postoperative; Preop, preoperative; RR, recovery rate; SC, surgical complication; TND, temporary neurologic deterioration.

mity and neurologic deterioration after posterior laminectomy for the treatment of thoracic OLF (17,35). Therefore laminoplasty, with or without a tubular retractor system, as a relatively less traumatic surgical technique with the preservation of most of the posterior element, has been recommended (10,25). However, some authors have found the outcome from laminoplasty to be less favorable and the procedure to be technically difficult owing to the narrow operational space and inadequate visualization (19,21). As such, to achieve the advantages of MISS combined with excellent visualization and ease to operate, we have introduced a novel technique to treat TM caused by OLF, translaminar osseous channel–assisted p-PEF.

In this study, 13 patients with 23 isolated thoracic OLF lesions underwent translaminar osseous channel–assisted p-PEF and good surgical results have been obtained. The mean mJOA score was significantly improved from preoperative 3.54 ± 1.26 to postoperative 6.15 ± 0.99 and to 9.07 ± 1.48 at the final follow-up, with the overall Hirabayashi recovery rate of 73.85% ± 18.02%, which is comparable to the reported rates of 60.5% to 65% in the literature (17,21,36,37).

In those cases, we performed a p-PEF procedure by creating an osseous-channel in the lamina to resection the OLF, while leaving the lamina edge bone, spinous processes, interspinous ligaments, and paraspinal muscles intact, which played an important role in stability maintenance. No instrumentation was needed after surgery and that effectively reduced the patient's economic burden, while no obvious instability or kyphotic deformity was observed during the follow-up. Another advantage of our technique was that the 30° bevel

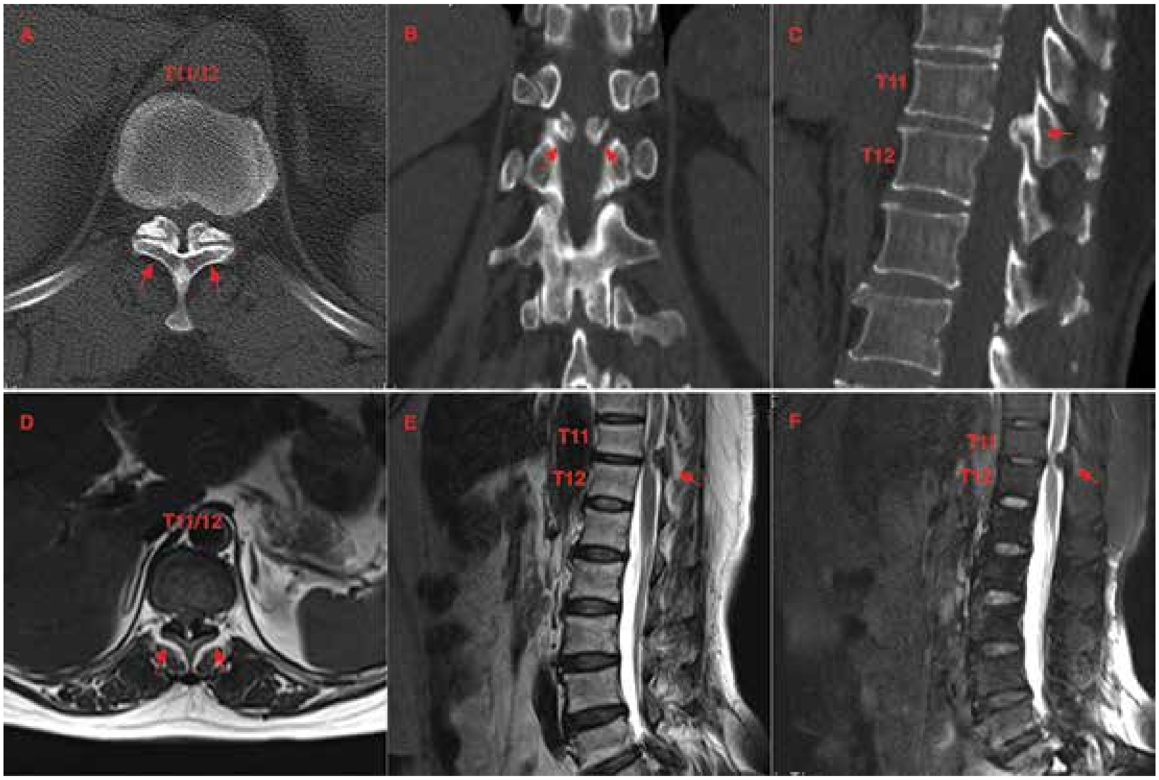

Fig. 3. *Preoperative CT scan. Axial (A) and sagittal (B) CT scan showing narrowing of the spinal canal because of the bilateral OLF (arrows). (C) Coronal CT scan demonstrating isolated OLF (arrows) presenting in the spinal canal. (D) Axial T2-weighted MRI of the stenotic segment shows a nodular low-signal intensity mass (OLF, arrows). Sagittal T2-weighted (E) and fat suppression (F) MRI showed dorsal spinal cord compression by low-signal masses (OLF, arrows) at the T11/12 level and hyperintense signal in the spinal cord owing to the compression.*

percutaneous endoscopic system could provide wide, illuminated, and excellent visualization, which enables surgeons to obtain direct vision of the operating field and is helpful in increasing surgical safety. In addition, with special percutaneous endoscopic surgical instruments, such as the endoscopic high-speed drill and rongeur, our technique is safe and easy, and it is possible for surgeons to complete resection of the OLF in the target region and to achieve sufficient decompression of the spinal cord, and this was supported by the increased cross-sectional area of the dural sac at the level of maximum compression.

Although Ruetten et al (38) and Miao et al (39) have reported an interlaminar endoscopic decompression technique to treat OLF-related TM, there are still many differences between our translaminar osseous channel–assisted p-PEF technique and their technique. First, we used a translaminar osseous channel, which keeps the rim of the laminar intact in both superior and inferior margins and provides more stability, rather than laminoplasty. Second, under the guidance of an intraoperative C-arm x-ray guide, we used trephine to replace the high-speed drill to punch the lamina and establish an osseous channel to assist the p-PEF, which provided more efficiency and security to avoid frequent stimulation of the spinal cord by high-speed drill buffeting. Third, we performed ipsilateral decompression with a bilateral approach rather than bilateral decompression with a uniportal approach because accurate and direct ipsilateral decompression provides more security. After all, even a fine hook or 1-mm rongeur into the stenotic thoracic canal may cause irreversible neurologic deterioration (20).

There are also some disadvantages to this translaminar osseous channel–assisted p-PEF technique. One disadvantage is that the time required for operative decompression might be longer than the traditional open techniques. The main reason is that it takes a long

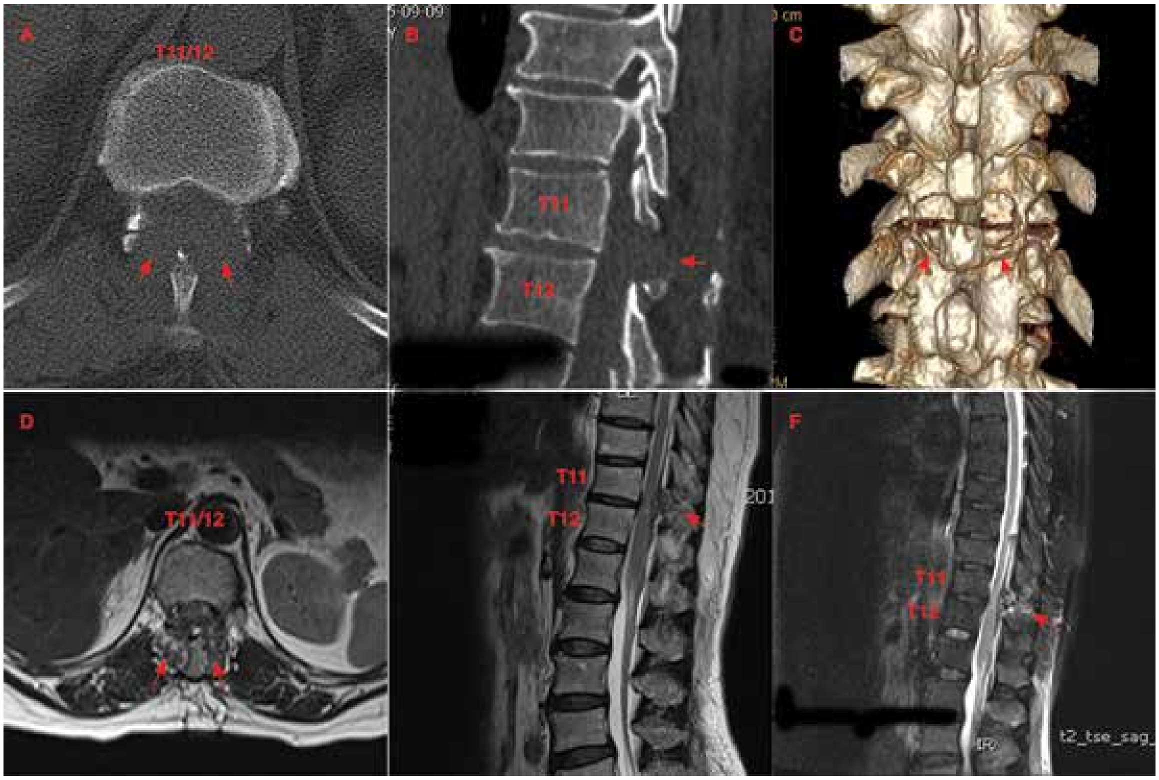

Fig. 4. *CT scans and MRI scans obtained immediately postoperatively. Axial (A) and sagittal (B) CT scan showed a translaminar osseous channel was established and ossified mass (OLF) was completely removed after the p-PEF procedure. Three-dimensional CT reconstruction showed bilateral fenestrated holes of the lamina and the superior and inferior margins of the lamina being preserved (C). Axial T2-weighted image showed decompression of the spinal cord at T11/12 (D). Sagittal T2-weighted (E) and fat suppression (F) MRI showed a dorsal sufficient decompression of the spinal cord at T11/12 and a surgical region soft-tissue response to the p-PEF procedure.*

time to punch the osseous channel on the lamina. We therefore use a trephine as the main tool for lamina punching, which can effectively shorten the operation time when compared with the hole punching process using the endoscopic high-speed drill. In addition, the circular translaminar osseous channel made by the trephine is more regular and all manipulation is carried out outside the thoracic canal with detection by intraoperative x-ray, which is safer. Of course, if the exacted area of the lamina cannot be removed entirely with the trephine, the endoscopic high-speed drill can also be used to assist the translaminar osseous channel establishment. The other disadvantage is that a long learning curve is required. There are technical difficulties combined with the endoscopic technique, such as 2-dimensional visualization, video assistance during the procedure, difficulty of hand-eye coordination, and a constrained working space. Superb surgical skills are required, and the surgeon should be well trained in the endoscopic technique before this technique is applied for decompression of TM caused by OLF. Based on our extensive experience in the early stage of cervical and lumbar endoscopic surgery, we developed this technique to treat TM secondary to OLF (40-42).

Although all patients in the present study had an improved mJOA score after surgery, surgery-related complications were also encountered during and after surgery. A dural tear, as the most commonly reported surgical complication in thoracic surgery of OLF (10,20), was noticed intraoperatively in one patient (case 5), whereas no CSF leakage was observed after direct suturing of the wound. Because duraplasty was difficult because of the fragility of the dura and the limited operating space under endoscope visualization, we suggest not trying to repair the dural defects but instead meticulously suturing the deep fascia and skin

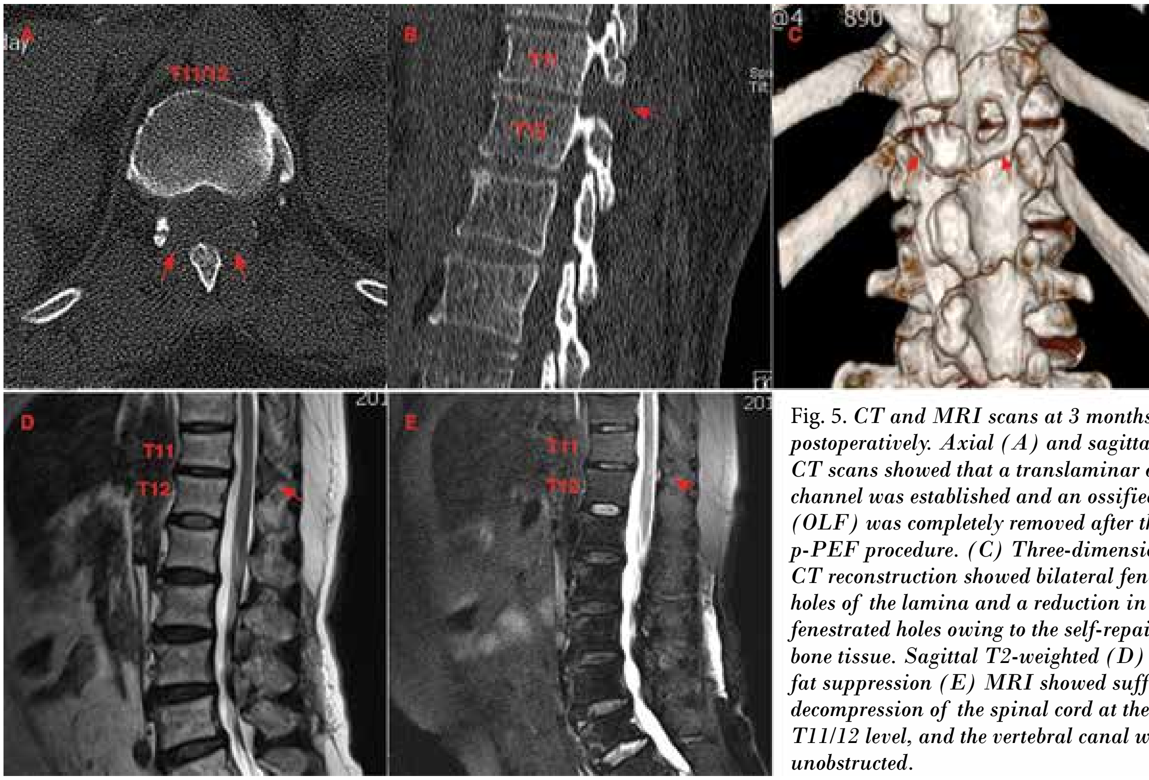

Fig. 5. *CT and MRI scans at 3 months postoperatively. Axial (A) and sagittal (B) CT scans showed that a translaminar osseous channel was established and an ossified mass (OLF) was completely removed after the p-PEF procedure. (C) Three-dimensional CT reconstruction showed bilateral fenestrated holes of the lamina and a reduction in the fenestrated holes owing to the self-repair of bone tissue. Sagittal T2-weighted (D) and fat suppression (E) MRI showed sufficient decompression of the spinal cord at the T11/12 level, and the vertebral canal was unobstructed.*

after the operation and applying continuous pressure to the wound. In addition, postoperative neurologic deterioration, as the second most common complication reported in prior literature (22,26), was encountered in one (case 9) of our patients, and this patient recovered to preoperative levels after 3 days of treatment with corticosteroid therapy. Transient neurologic deterioration after surgery usually occurs because of irritation of the spinal cord due to improper intraoperative manipulation or injury to its blood supply (18,20). Especially at the narrowest part of the thoracic canal, irreversible neural damage can occur even when inserting a 1-mm Kerrison rongeur or a fine hook (20). Therefore intraoperative manipulation should be gentle and meticulous to avoid iatrogenic neural injury as much as possible. In addition, the use of a trephine as the main tool for the establishment of the osseous channel facilitates the complete removal of the lamina excision at once, and this technique avoids the repeated irritation to the spinal cord caused by a sequential excision process, which can reduce the risk of neural injury. Of course, the help of preoperative imaging data auxiliary to preoperative planning are necessary, which can improve the accuracy of the operation and reduce the risk of surgical complications, particularly to evaluate the presence of dural ossification and its parts, as well as the stenotic location of the thoracic spinal canal (1).

There are many advantages to this technique, such as minor iatrogenic trauma, rapid postoperative recovery, no effect on spinal stability, and lower economic burden owing to the lack of instrumentation (43-45). However, this translaminar osseous channel–assisted p-PEF technique is not applicable to all patients with OLF-induced TM. Due to its precise and limited decompression, we recommend that translaminar osseous channel–assisted p-PEF is more suitable for patients with TM caused by isolated OLF involvement. Patients with continuous multisegmental lesions (more than 2 levels) are recommended to undergo open laminectomy, a procedure that can provide internal fixation and more sufficient decompression.

Conclusions

Based on the results of the current study, the translaminar osseous channel–assisted p-PEF has been proven as a safe, effective, and feasible supplementation and alternative option for the treatment of OLF-related TM. As an MISS technique with advantages and tips, spinal surgeons should be aware of this technique when treating patients with thoracic OLF, especially for patients with isolated OLF involvement.

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