JOURNAL OF NEUROSURGERY:
Case Lessons

J Neurosurg Case Lessons 1(6):CASE20138, 2021
DOI: 10.3171/CASE20138

Full-endoscopic decompression for thoracic myelopathy caused by ossification of the ligamentum flavum: patient series

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BACKGROUND This study aimed to describe the least invasive surgical technique of endoscopic decompression for thoracic myelopathy caused by ossification of the ligamentum flavum (OLF) and to review the literature available on the diagnosis and treatment of OLF.

OBSERVATIONS The mean age of the patients was 51.2 (range, 40–62) years, and the mean preoperative, 2-week postoperative, and last follow-up modified Japanese Orthopaedic Association scores were 6.6 (range, 4–10), 9.6 (range, 7–11), and 13 (range, 10–14), respectively. All patients were discharged within 48 hours after the surgery. The mean follow-up period was 13.2 (range, 7–18) months. No complication was found perioperatively, and none of the patients had postoperative instability during the follow-up period.

LESSONS Based on this clinical case series and literature review, the authors conclude that endoscopic decompression surgery is feasible and effective for managing thoracic myelopathy caused by OLF while minimizing surrounding tissue damage. Additionally, it enables shorter periods of hospital stay.

https://thejns.org/doi/abs/10.3171/CASE20138

KEYWORDS ossified ligamentum flavum; full-endoscopic decompression; minimally invasive spine surgery; endoscopic decompression; case series

Ossification of the ligamentum flavum (OLF) is a rare disease that is characterized by ectopic bone formation in the ligamentum flavum (LF). OLF is relatively more common in the Asian race than in others.[1] The cause of OLF remains unclear, and the lower thoracic spine is the most common site of the disease. Myelopathic progression is a common presentation in thoracic OLF, wherein patients who are at first asymptomatic and later present with acute weakness after minor trauma. Surgical decompression is mandatory when patients show prominent myelopathy or neurological deterioration.

Full-endoscopic decompression for thoracic OLF is the least invasive procedure; however, it is a technically challenging procedure. In this clinical case series, we performed endoscopic decompression successfully as confirmed by improvement in the modified Japanese Orthopaedic Association (mJOA) scores and imaging for thoracic OLF. Furthermore, we conducted a literature review regarding the diagnosis of OLF and its current treatment options.

Study Description

Five nonconsecutive patients who were diagnosed with symptomatic thoracic myelopathy caused by single-level OLF and who underwent full-endoscopic decompression in our institutes between January 2019 and March 2020 were included. The study was conducted in accordance with the principles laid down in the Declaration of Helsinki. Informed consent was obtained from the patients before the operation, and the case series was approved by the ethics committee of the institutes. The complete medical records of the patients were collected and used for evaluation in this study. The series comprised 2 male and 3 female patients with a mean age of 51.2 (range, 40–62)

ABBREVIATIONS CT = computed tomography; LF = ligamentum flavum; mJOA = modified Japanese Orthopaedic Association; MRI = magnetic resonance imaging; OLF = ossification of the ligamentum flavum; RR = recovery rate.

INCLUDE WHEN CITING Published February 8, 2021; DOI: 10.3171/CASE20138.
SUBMITTED December 3, 2020. **ACCEPTED** December 14, 2020.

TABLE 1. The clinical characteristics of the patients in the case series

Case No.	Age (yrs)	Sex	Index Level	OLF Type	Duration of Symptoms (mos)	mJOA Score			Follow-Up (mos)
						PRE	2 W	Last	
1	52	M	T11/T12	Ex	6	10	11	14	18
2	40	F	T10/T11	L	3	5	10	14	18
3	62	F	T10/T11	L	4	5	9	13	12
4	45	M	T9/T10	Ex	2	4	7	10	11
5	57	F	T10/T11	En	6	9	11	14	7

2 W = 2-week postoperative follow-up; En = enlarged type; Ex = extended type; L = lateral type; Last = last follow-up; PRE = preoperative follow-up.

years. The mean preoperative mJOA score was 6.6 (range, 4–10), and the mean duration of symptoms was 4.2 (range, 2–6) months (Table 1). All patients underwent radiography, computed tomography (CT), and magnetic resonance imaging (MRI) preoperatively and 6 months postoperatively.

To conduct a literature review, electronic searches were performed on PubMed. We combined the following terms as either keywords or Medical Subject Headings terms: "ossification ligamentum flavum" or "ossification yellow ligament" and "laminectomy" or "decompression" or "endoscopic decompression" and "thoracic spine." The reference lists of articles were reviewed and assessed using the inclusion and exclusion criteria. Eligible studies included patients who underwent decompression for thoracic myelopathy due to OLF either by open laminectomy or by an endoscopic technique. The inclusion criteria for the search comprised studies conducted in human participants and those published in the English language. Studies that did not report clinical outcomes were excluded. Additionally, abstracts and editorials were excluded.

Case Example: Case 2

A 40-year-old woman presented with progressive weakness of the lower extremities and an inability to walk independently for 3 months. Physical examination showed a slight decrease in motor power (grade IV) and sensory deficit from L2 to S1. Hyperreflexia and the presence of long tract signs were noted. She expressed difficulty in walking and an inability to turn. The mJOA score was 5, which indicates severe myelopathy. MRI showed an obvious hypointense mass on the dorsal side of the spinal cord at level T10/T11 with severe spinal cord compression and significant myelomalacia (Fig. 1A). Thin-slice CT scan showed a bone-like structure in the yellow ligament (Fig. 1C).

We achieved adequate decompression using a full-endoscopic procedure by removing the OLF mass. The pathological report confirmed ossification of the yellow ligament. The symptoms significantly improved the day after surgery, and the mJOA score increased to 14 at the 18-month follow-up. Postoperative CT scan and MRI showed significant decompression of the spinal cord (Fig. 1A–C).

Results

The mean operative time and blood loss were 68.2 (range, 47–95) minutes and 15.5 (range, 10–20) mL, respectively. The patients' symptoms gradually improved after 2 weeks of treatment. The reduction of mJOA scores was clinically significant (they reached the minimal clinically important difference level[1]); the mean preoperative, 2-week postoperative, and last follow-up mJOA scores were 6.6 (range, 4–10), 9.6 (range, 7–11), and 13 (range, 10–14), respectively, as shown in Table 1.

The duration of hospitalization ranged from 2 to 4 days (mean, 3 days). All patients were discharged within 48 hours after surgery. No serious adverse events were observed perioperatively and during follow-up. The mean follow-up period was 13.2 months, ranging from 7 to 18 months.

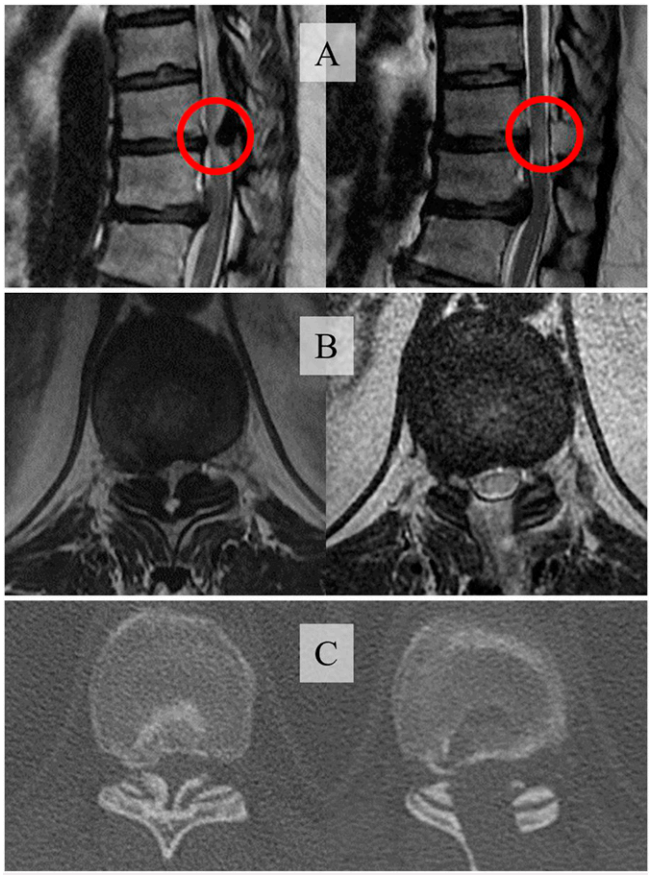

FIG. 1. Comparison between preoperative and postoperative T2-weighted MRI in the sagittal and axial planes (**A** and **B**). *Red circles* signify the area of decompression in the sagittal image. **C:** Depiction of the decompression area in the CT images.

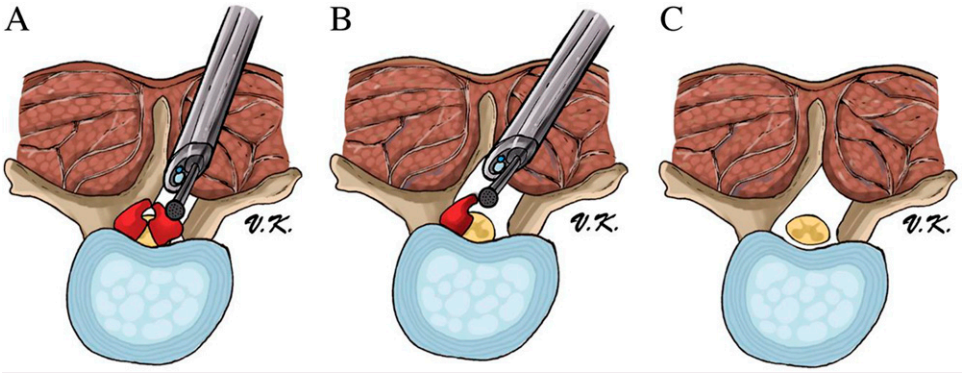

FIG. 2. Schematic diagrams of the procedures. Demonstrations of the ipsilateral approach (**A**) to the ossified mass and its subsequent decompression, compared with the contralateral approach by levering the endoscope down (**B**). Adequate decompression was achieved (**C**).

Surgical Technique

Measurements of the OLF mass on CT and MRI are completed for intraoperative correlation. Under general anesthesia, the patient was placed prone. Fluoroscopy was used to locate the index level of surgery, and the skin was marked. After adequate antiseptic skin preparation and draping, the index level was rechecked. A 0.7- to 1-cm stab incision was made approximately 1–1.5 cm from the midline. A soft tissue dilator was inserted, followed by a working cannula insertion. Fluoroscopy was used to identify the mass in the lateral view, aiding the craniocaudal orientation. The endoscope was inserted through a working cannula. The water pressure and flow were set at 60–90 mm H_2O and 0.6–1 L/min, respectively, during surgery.

Muscle dissection was performed using the dissecting radiofrequency probe and pituitary rongeur. After the index lamina was clearly exposed, bone work was performed. By using different kinds of burrs (cutting, side-cutting, and diamond head), the lamina was partly removed. The LF was encountered after the lamina was incised (Fig. 2A). A dissecting probe was used to determine whether the LF was ossified or normal. In cases with a normal LF, a pituitary rongeur and Kerrison punch were used. If the LF had an ossified appearance, the diamond burr was used to carefully drill deeper until the epidural space was reached. For ossified lesions that were adherent to the spinal cord, we used a diamond-tip burr to thin down the LF mass, and a small dissector was carefully introduced between the spinal cord and the lesion, and the same was flicked away from the spinal cord to remove the thinned LF (Fig. 3A). The same procedure was performed until unilateral decompression was achieved in both the mediolateral and craniocaudal directions. The scope was pulled back and levered down, and the cutting burr was used to undercut the lamina, enabling the scope to advance toward the contralateral pathological lesion (Fig. 2B). Careful removal of the contralateral OLF was performed using the same method. The decompression was checked thoroughly (Figs. 2C and 3B), and bleeding was controlled. The skin was closed using subcutaneous sutures without a surgical drain. All operations were performed using the Vertebres system (RIWOSpine, GmbH).

Discussion

Observations

The term OLF or ossification of the yellow ligament signifies a disease with ectopic bone formation in the LF. OLF is relatively common in the Asian population, occurring in individuals with an average age of 50–60 years.[1,2] Early ossified lesions are composed of lamellar bone with fibrocartilaginous cell proliferation until matrix hyperplasia with cartilaginous conversion occurs.[3] Although the cause of OLF is still unclear, various factors associated with the ossification mechanism have been reported, such as genetic factors, basic metabolic elements, and mechanical effects.[4] Mechanical stress to the enthesis site and dura mater leads to chondrocyte activation, endochondral ossification, and dural adhesion. In the last stage, the osteogenic cytokine is transported from the ossified LF to the compressed dura mater via the adhesion pathway, causing fused bony tissue.[1,4–6] The most common site of OLF is the lower thoracic spine at the thoracolumbar junction (80% at T9/T12) owing to its highest mechanical tensile stress.[3] Symptomatic OLF can present with local thoracic pain, stiffness, and slow progression of myelopathy or spastic paraparesis.[7] Diagnostic tools of OLF include CT and MRI. OLF is indicated as a linear or beak-like excrescence that is uniformly hypointense on T1- and T2-weighted images, located posterior to the thecal sac, causing its compression (thoracic myelopathy secondary to ossification). OLF is

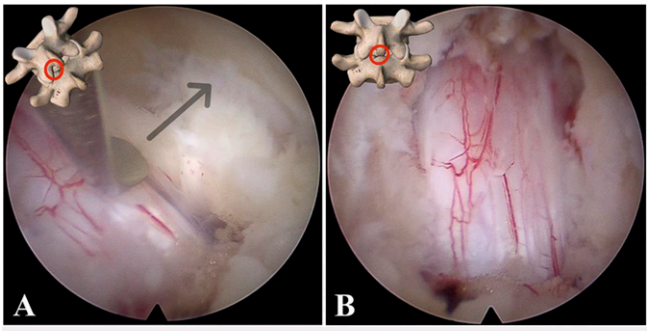

FIG. 3. Intraoperative endoscopic views in different orientation, which are demonstrated by the spine model and *red circle* (location of the endoscope portal) in the upper left corner. The technique used for release of the adhered ossified mass from the spinal cord is by careful application of a small dissector between the spinal cord and the lesion. The midline structure was pushed outwards in the direction of the *arrow* (**A**). Adequate decompression attained is shown by the extricated spinal cord (**B**).

categorized into 5 types according to Sato's classification: lateral, extended, enlarged, fused, and tuberous.[5] Wang et al. recommended that the decompression technique should depend on the OLF type (fused or nonfused).[8]

Current surgical options in OLF include traditional open techniques and microendoscopic surgery with or without fusion. The posterior tension band structures are affected more in the traditional open technique without fusion, leading to late kyphosis and neurological deterioration. Therefore, minimally invasive spine surgery was introduced to address these concerns.[2] Miao et al. reported 2 cases of percutaneous endoscopic decompression via the interlaminar approach for thoracic myelopathy caused by the lateral OLF type.[9] The postoperative neurological status and spinal cord compression improved without any complications. The authors suggested the use of the interlaminar endoscopic technique for direct decompression of the ossified ligament in the nonfused type of OLF.[9] An et al. reported that 18 patients (8 males, 10 females) with lateral or enlarged OLF (excluding the nodular and fused types), who had been chosen for full-endoscopic decompression via the interlaminar approach and the over-the-top technique or partial floating method, had satisfactory postoperative results without neurological complications or dural tears.[2] The authors recommended full-endoscopic decompression by well-trained endoscopic surgeons in thoracic OLF when a single vertebral level is involved with the lateral, extended, or enlarged types of OLF without comma and tram track signs (on axial CT scan). Liu et al. reported that percutaneous endoscopic surgery via bilateral translaminar osseous channels should be considered in patients with progressive myelopathy caused by thoracic OLF and thoracic disc herniation at the same level. The results showed immediate improvement in the visual analog scales and mJOA scores. At the 6-month follow-up, lower extremity motor power had returned to normal, and there was complete resolution of the sensory deficits.[10] Our results were consistent with those of a previous study in terms of clinical outcomes. Moreover, we detected no recurrence of OLF and continued patient satisfaction at the last follow-up.

However, there are many factor-related outcomes that vary widely in thoracic OLF. Several studies have reported that various factors influence surgical results, including the duration of preoperative symptoms, preoperative neurological status, intramedullary signal changes, age, sex, and type of OLF.[11,12] Miyakoshi et al. analyzed surgical outcomes after open decompressive surgery in 34 patients with thoracic OLF with a minimum 5-year follow-up (mean follow-up period, 8 years).[13] The mean preoperative duration of symptoms was 19.7 ± 16.2 months. The percent recovery rate (RR) ([postoperative JOA score − preoperative JOA score]/[11 − preoperative JOA score] × 100) was 34.6 + 22.7 (fair) at 1 month postoperatively and 44.2 + 40.1 (fair) at the final follow-up. Furthermore, the authors found a significant negative correlation between the duration of symptoms and the JOA scores at the final follow-up, RR at 1 month, and RR at the final follow-up. Accordingly, they inferred that the duration of preoperative symptoms is the best predictor of long-term outcomes in thoracic OLF. Apart from the duration of preoperative symptoms, concomitant cervical or lumbar ossification, dural tear, and dural adhesion were also considered as factors suggestive of poor postoperative outcomes.[13]

Limitations

It is worth mentioning that there are some limitations of full-endoscopic decompression for the symptomatic thoracic myelopathy caused by OLF. If the OLF lesion is enclosed or adherent to the spinal cord, a lack of surgical skill could lead to injuries in the neural structures and compromise patient outcomes. A prompt conversion to open surgery is warranted in cases of incidental durotomy or neural injuries. Visualization during a procedure is crucial. Continuous irrigation of the surgical field with fluid during full-endoscopic surgery and proper techniques are required to minimize bleeding and thereby improve visualization. The other concern is the limited availability of the endoscopic system.

Lessons

Based on our review and experience, we believe that thoracic OLF can be treated effectively with minimally invasive techniques. Advantages are avoidance of unnecessary surrounding soft tissue damage, minimal blood loss, and a shorter hospital stay. We propose a full-endoscopic decompression as an alternative procedure for decompression without fusion in thoracic OLF with myelopathy. This approach is supported by our satisfactory clinical results. Studies conducted in a larger patient cohort and a prospective comparative design may add strength to the outcomes of this technique.

Thoracic OLF is a rare disease that often leads to symptomatic thoracic myelopathy. A full-endoscopic interlaminar technique is a good option for decompression without fusion and has the advantages of being less invasive with a shorter duration of recovery and better clinical results.

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Disclosures

Dr. Kim reports grants from RIWOspine and Elliquence for work outside the present work.

Author Contributions

Conception and design: Kotheeranurak, Pholprajug, Lin, Yingsakmongkol, Kim. Acquisition of data: Kotheeranurak. Analysis and interpretation of data: Kotheeranurak. Drafting the article: Kotheeranurak, Pholprajug. Critically revising the article: Kotheeranurak, Lin, Pruttikul, Yingsakmongkol, Tejapongvorachai, Kim. Reviewed submitted version of manuscript: Kotheeranurak, Pholprajug, Lin, Pruttikul, Tejapongvorachai, Kim. Approved the final version of the manuscript on behalf of all authors: Kotheeranurak. Statistical analysis: Kotheeranurak, Pholprajug. Administrative/technical/material support: Kotheeranurak. Study supervision: Pruttikul, Tejapongvorachai, Kim.

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