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HOW I DO IT - NEUROSURGICAL TECHNIQUE EVALUATION

How i do it: biportal endoscopic thoracic decompression for ossification of the ligamentum flavum

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Abstract

Background Currently, decompressive laminectomy with or without concomitant fusion is a standard treatment for ossification of the ligamentum flavum (OLF). However, conventional thoracic decompressive laminectomy is not free of the inevitable destruction of the posterior ligamentous complex, and facet injury may lead to various sequelae.

Method We used the biportal endoscopic technique for posterior thoracic decompression (BE-PTD) and describe the steps with discussion regarding the indications, advantages, possible complications, and ways to overcome complications.

Conclusion BE-PTD can obtain endoscopic visualizations of all the boundaries of the OLF lesion and achieve direct neural decompression of thoracic OLF.

Keywords Biportal endoscopic technique · Posterior thoracic decompression · Ossification of the ligamentum flavum · Thoracic compressive myelopathy

Abbreviations

LF	Ligamentum flavum
OLF	Ossification of the ligamentum flavum
bRFa	Bipolar radiofrequency thermo-controlled ablator
SAP	Superior articular process
BE-PTD	Biportal endoscopic technique for posterior thoracic decompression
CSF	Cerebral spinal fluid

Relevant surgical anatomy

Anatomically, the posterior aspects of the thoracic vertebrae possess broad, sloping, and longer laminae than the cervical vertebrae, forming a wider spinal canal. They meet posteriorly to form long, slender spinous processes that point downward and overlap the vertebral arches of the inferior vertebra. The facet joints of the thoracic spine are oriented in the coronal plane, with the inferior facet of the superior vertebrae overlapping the superior facet of the inferior vertebrae as do shingles on a roof. At the thoracolumbar junction, they assume a more oblique sagittal orientation. Particularly, most areas of the ligamentum flavum (LF) are covered by the vertebral lamina and the inferior articular process of the superior vertebrae.

The most affected area of ossification of the ligamentum flavum (OLF) is between T10 and T11, where the maximum tensile force is received [9]. OLF originates in the capsular portion of the LF and extends to the interlaminar portion of the LF, eventually progressing to the dural side. Sometimes, on both sides, the paramedian cords meet at the midline and form a nodular mass, which usually progresses in a superior direction [7].

Description of the technique

Anesthesia, position, and surgical ports

The patient was placed in the prone position on a radiolucent Jackson spinal table under general anesthesia with motor-evoked potential monitoring. Under C-arm fluoroscopic anteroposterior imaging, the target level was confirmed, and then, it was identified on the patient's skin, including

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the margin of the spinous process, lamina, facet, and costovertebral joints, and transverse process. Two independent vertical surgical incisions were made 1 cm above and below the point where the upper boundary of the transverse process and the line 1 cm from the mid-line meet (Fig. 1). Customarily, these two surgical incisions are used as a viewing portal for the endoscope on the left side and working portal for surgical instruments on the right side. A pressure-controlled automatic irrigation pump was connected to the endoscope and set to a pressure of 30 mmHg during the surgery; while continuous fluid irrigation through each surgical port was maintained, the soft tissue was managed using an arthroscopic tissue shaver and tissue cauterization using a bipolar radiofrequency thermo-controlled ablator (bRFa).

Thoracic laminotomy and partial medial facetectomy

After endoscopic visualization of the medial portion of the inferior articular process and lamina of the superior vertebrae, upper lamina of the inferior vertebrae, and interlaminar portion of the LF was achieved, unilateral laminotomy was performed using a small-head high-speed diamond drill until the superior articular process (SAP) of the inferior vertebrae below the lamina of the superior vertebrae was identified. To identify the lesion of the OLF, many portions of the vertebral laminar and inferior articular processes need to be removed, and the lack of a distinct landmark can be a major cause of difficulty in posterior thoracic decompression. However, OLF confined to the LF other than the fused type can be identified by partial resection of the inferior articular process by first identifying the medial boundary of the SAP of the inferior vertebrae and extending the laminotomy in the upper direction (Fig. 2A–C).

Decompression of ossification of the ligamentum flavum

When the spinal cord compressed by OLF was visible, OLF was decompressed using the biportal endoscopic technique for posterior thoracic decompression (BE-PTD): a drill was used until all the boundaries of the OLF were identified

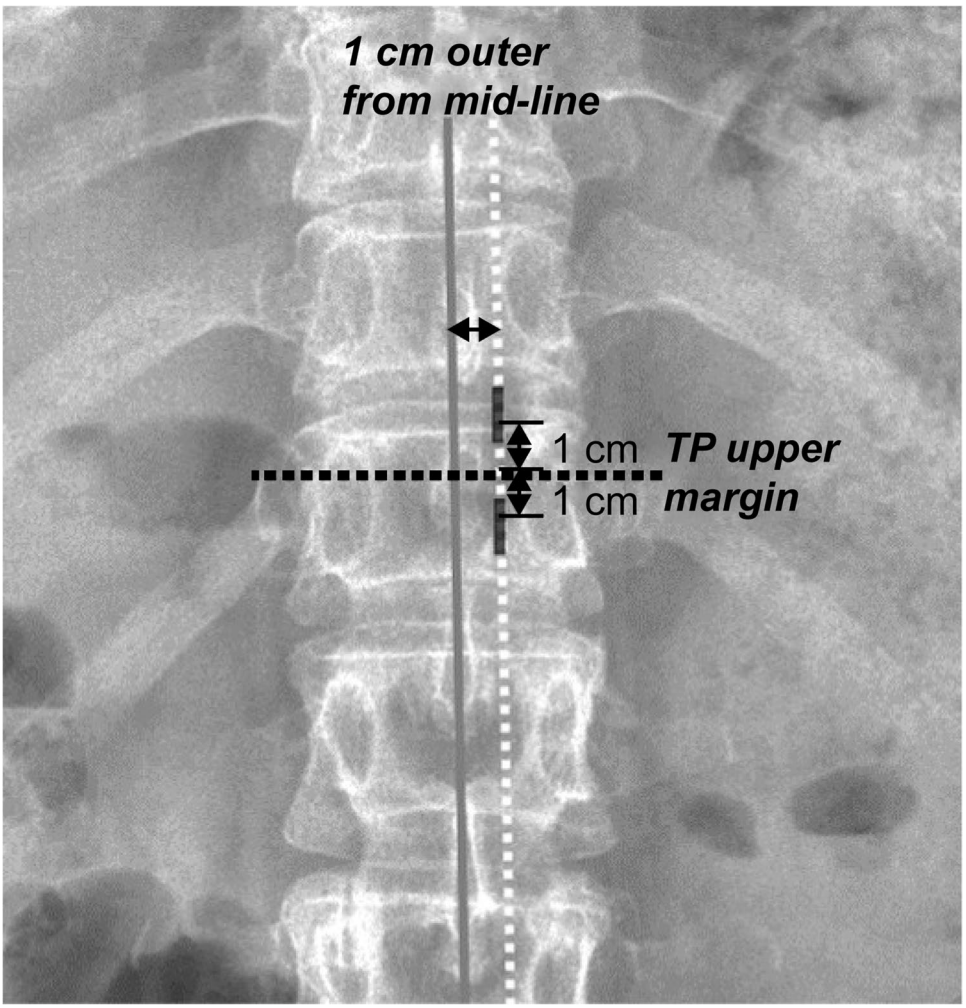

Fig. 1 The two independent vertical surgical incision are made 1 cm above and below the point where the upper boundary of the transverse process and the line 1 cm from the mid-line meet

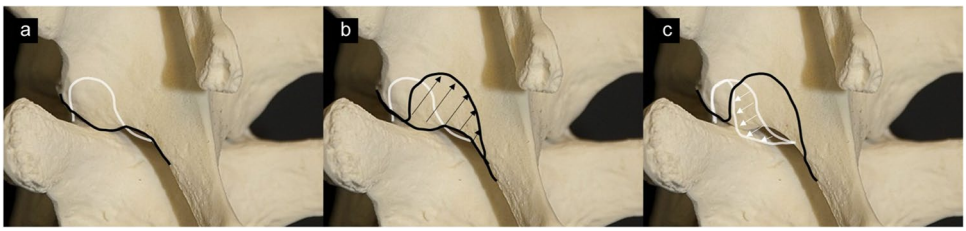

Fig. 2 Schematic diagram of thoracic laminotomy and partial medial facetectomy. **A** Black line: boundary of the inferior articular process of the superior vertebrae; white line: boundary of the superior articular process of the inferior vertebrae. **B** Partial resection of the inferior articular process of the superior vertebrae. **C** Identification of the medial boundary of the superior articular process of the inferior vertebrae and extension of the laminotomy in the upper direction

and only the paper-thin plate in contact with the dura mater remained. Finally, the adhesion of the OLF lesion and dura mater was released using a small nerve probe, and then OLF was completely removed and confirmed by dural pulsation

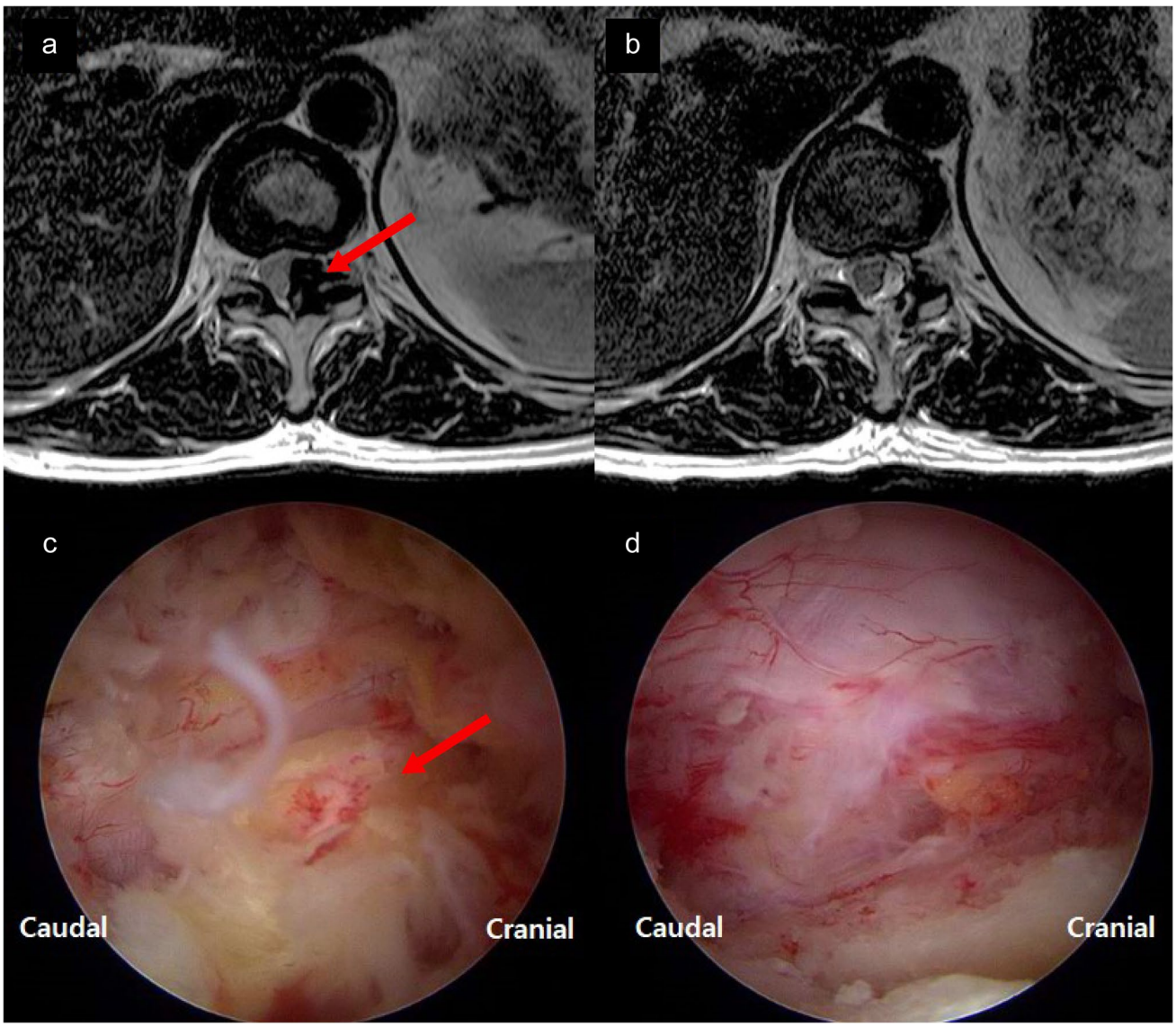

Fig. 3 Postoperative well-decompressed spinal cord. Preoperative (**A**) and postoperative (**B**) magnetic resonance imaging and preoperative (**C**) and postoperative (**D**) endoscopic images. Red arrow: ossification of the ligamentum flavum

restoration (Fig. 3A–D; Video clip 1). Bleeding control was achieved by BRFc and bone wax, and surgical drain insertion was performed before skin closure. A neurological evaluation was performed in the recovery room immediately postoperatively. Patients were monitored 24 h postoperatively if there were any complications.

Indications

The choice of decompressive procedure depends on the morphology of OLF according to computed tomography and magnetic resonance imaging evaluations, which is classified as follows: lateral, extended, enlarged, fused, and tuberous on axial images and round and beak-shaped on sagittal images [2, 8]. Considering that the fused, tuberous, and beak type adheres to the dura mater or fuses with ossifications, total laminectomy and concomitant fusion are recommended because of the technical difficulties and high need for dural reconstruction procedures. For the same reason, a minimally invasive technique for OLF with comma and tram track signs would not be recommended [3, 4].

Limitations

In microscopic decompressive laminectomy alone for thoracic myelopathy due to OLF, postoperative complications are common, with incidences of durotomy, cerebral spinal fluid (CSF) leakage, surgical site infection, and early neurological deterioration of 18.4%, 12.1%, 5.8%, and 5.7%, respectively [10]. However, the occurrence of incidental durotomy and CSF leakage in BE-PTD may require conversion to open surgery, leading to poor prognosis.

How to avoid complications

The most important strategy for avoiding complications is to remove the SAP of the inferior vertebrae, perform decompression from the inferolateral side to the superomedial side of the OLF, and identify all the boundaries of the OLF lesion.

Specific perioperative considerations

In endoscopic spine surgery using fluid as a medium, there is concern about the potential risk of neurological complications due to locally isolated irrigation fluid in the epidural space, which could increase intracranial pressure [5]. However, the actual pressure in the work space communicating with the epidural space is lower than the pump set pressure and does not increase the cervical epidural pressure, which reflects the intracranial pressure, in the situation of continuous fluid irrigation through two independent surgical ports [6].

Specific information for the patient

In progressive thoracic myelopathy due to OLF, BE-PTD does not guarantee a good prognosis. The severity of symptoms and the time interval before surgery were the most important prognostic factors [1].

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-021-05031-7.

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Author contribution MSK, DHH, and HJP contributed to the conception of the study. MSK, KHY, and HJP wrote the manuscript. SYH, HJC, and HJP reviewed the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

Declarations

Ethics approval This study protocol was approved by the Hallym University Institutional Review Board (IRB FILE No. 2021–09-002) and adhered to the guidelines of the Declaration of Helsinki.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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Key points I. The posterior aspects of the thoracic vertebrae possess broad, sloping, and longer lamina, and most areas of the LF are covered by the vertebral lamina and inferior articular process of the superior vertebrae.

II. OLF begins from the capsular portion of the LF and extends to the interlaminar portion of the LF, eventually progressing to the dural side.

III. Occasionally, OLF lesions fuse with facet articular processes.

IV. Even if endoscopic visualization of the posterior aspects of the target vertebra is obtained, OLF lesions are often covered by the thoracic lamina of the superior vertebra.

V. The lack of clear surgical landmarks can be a major cause of difficulty in posterior thoracic decompression.

VI. The authors recommend performing sufficient laminotomy and partial medial facetectomy to safely identify all the boundaries of the OLF lesion.

VII. In particular, the medial border of the SAP of the inferior vertebra can be used as a landmark to identify OLF lesions.

VIII. The boundaries of OLF lesions can cause bleeding via nutritional vessels, and all the boundaries of OLF lesions can be identified through vascular cauterization using a bRFa.

IX. The OLF lesion is thinned like a paper-thin plate using a diamond drill, and OLF can be completely removed after adhesiolysis is performed.

X. BE-PTD can obtain endoscopic visualizations of all the boundaries of the OLF lesion and achieve direct neural decompression of thoracic OLF.