Technical Note

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Biportal endoscopic *en bloc* removal of the ligamentum flavum for spinal stenosis: nuances for the "butterfly" technique

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The introduction of endoscopic spine surgery has led to a paradigm shift in the treatment of spinal disorders. In particular, biportal endoscopic surgery has gained traction for its wider visual field and improved the maneuverability of instruments, familiar anatomy, and cost-effectiveness. In this study, we describe our *en bloc* removal of the ligamentum flavum using a "butterfly" technique. This approach had several advantages: (1) The flavum serves as a protective barrier for the dura during drilling. (2) There is less epidural bleeding, which provides (3) better visualization. (4) In an inadvertent durotomy, this usually occurs later in the procedure, which is more manageable than the early stages of decompression. Biportal decompression for spinal stenosis can be performed using an *en bloc* ligamentum flavum removal technique that is safe, reproducible, and efficient. A systematic approach will help early adopters overcome the steep learning curve.

Keywords: Biportal; Endoscopy; Decompression; Spinal stenosis; Lmbar spine

Introduction

In recent years, interest in endoscopic spine surgery has been growing [1,2]. In particular, biportal surgery has become attractive because of its versatility, shorter learning curve, familiar anatomy, and cost-effectiveness. The strength of biportal endoscopy lies in the workhorse procedure known as the unilateral laminotomy with bilateral decompression, where the spinal canal can be decompressed while offering unparalleled visibility with minimal manipulation of the neural structures [3]. Herein, we share our detailed biportal decompression technique for spinal stenosis for a reproducible, safe, and efficient method by the *en bloc* removal of the ligamentum flavum.

Technical Notes

Case illustration

A 73-year-old woman presented with symptoms of neurogenic claudication. Her physical examination was unremarkable, and radiographs did not show instability on both the erect and dynamic radiographs. Magnetic resonance imaging (MRI) of the lumbar spine revealed severe stenosis of the central and lateral recesses at

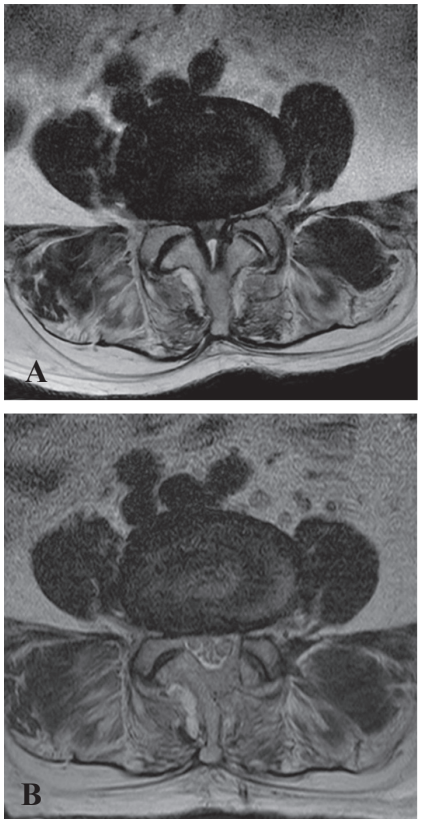

Fig. 1. Magnetic resonance imaging images of the patient who underwent a biportal endoscopic decompression. **(A)** Preoperative and **(B)** postoperative axial view of L4/5.

L4/5 and L5/S1. Endoscopic biportal decompression for both levels was successful, with complete symptom resolution. Postoperative MRI showed adequate decompression of the central canal and lateral recess bilaterally (Fig. 1). Informed consent was obtained from the patient for academic reporting.

Step 1: localization ("lead-gown free" technique)

Initially, the working port (WP) is localized on the anteroposterior view. A spinal needle is utilized to target the intersection between the medial pedicular line and the upper half of the L5 pedicle. A lateral view adds to the accuracy, particularly in the upper and lower levels of the lumbar spine where lordosis can be more pronounced. Methylene blue is administered if the position is satisfactory. This step offers visual confirmation of the intended decompression level once the scope is introduced. The endoscopic portal (EP) is typically cited 2–3 cm cranially from the WP, along the medial pedicular line. This also corresponds to the pedicle of the upper level (L4) on the radiograph (Fig. 2).

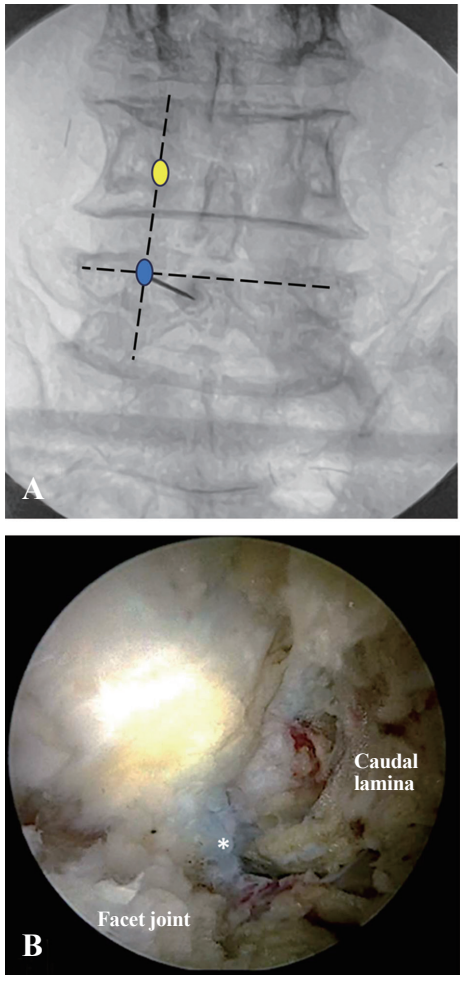

Fig. 2. Localization of the portals using a "lead gown free technique." **(A)** Anteroposterior view showing a spinal needle used to target the working port (WP) at the upper half and medial wall of the L5 pedicle (blue circle). The endoscopic port is usually placed 2–3 cm above the WP (yellow circle). **(B)** Methylene blue next to the facet (*) confirms our surgical level prior to the laminotomy.

Step 2: skin incision and docking of the scope

A transverse incision is preferred for better water outflow and cosmesis. After the skin and deep fascia are incised, the use of a metal dissector to bluntly palpate and peel away the soft tissue from the bony attachments (cranial lamina, medial facet, caudal lamina, and interlaminar space) is recommended. Serial dilation is performed, and a zero-degree scope is then inserted. A pair of transparent endoscopic cannulas is useful for the EP and WP because they not only improve water outflow but also serve as a retractor during surgery (Fig. 3).

Step 3: ipsilateral and contralateral laminotomy

Our bony resection is divided into four zones. Initially, the base of the spinous process at the spinolaminar

junction, which is the key anatomical landmark is located and then drilled. Drilling extends cranially until the deficient midline cleft of the ligamentum flavum is identified, exposing the epidural fat. The rest of the laminotomy is performed by removing the bone from zones "a" and "c" and, if contralateral decompression is necessary, to zones "b" and "d" (Fig. 4).

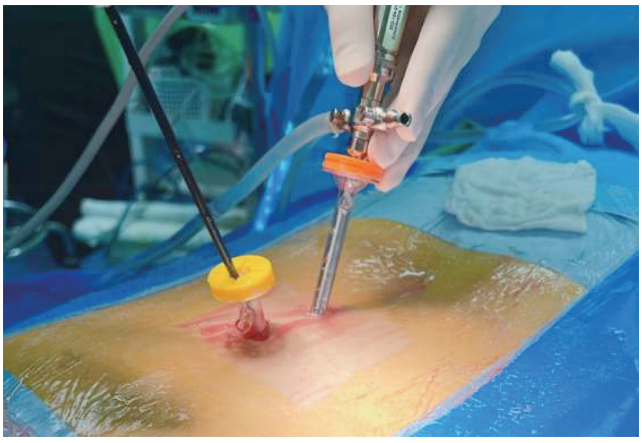

Fig. 3. Overview of biportal endoscopic decompression. A pair of transparent cannulas are used for the endoscopic port (orange) and working port (yellow).

Zone a: ipsilateral cranial laminotomy

Once the epidural fat is identified in the midline cleft, a common tendency is to start curving the laminotomy caudally when drilling laterally from the midline. We call this "umbrella" shape drilling. However, the flavum attaches more cranially as it moves away from the midline, and drilling should proceed in this direction to give a "Y-shaped" laminotomy (Fig. 5). By tracing the flavum until the superior articular process (SAP) is visualized, the lateral boundaries of the laminotomy can be determined. This width is approximately 8 mm from the midline cleft and can be measured using our surgical instruments. Visualizing the ligamentum flavum as the shape of a "butterfly," is helpful, emphasizing a lower midline cleft with more cranial lateral attachments.

Zone b: contralateral "sublaminar" drilling

For adequate endoscopic view for sublaminar frilling, sufficient amounts of bones must be removed from the base of the spinous probing before working on the contralateral side. Thereafter, a curette is used to separate and widen the natural plane between the flavum and the bone. Then, the caudal edge of the lamina is identified, and the sublaminar drilling of the lamina and the

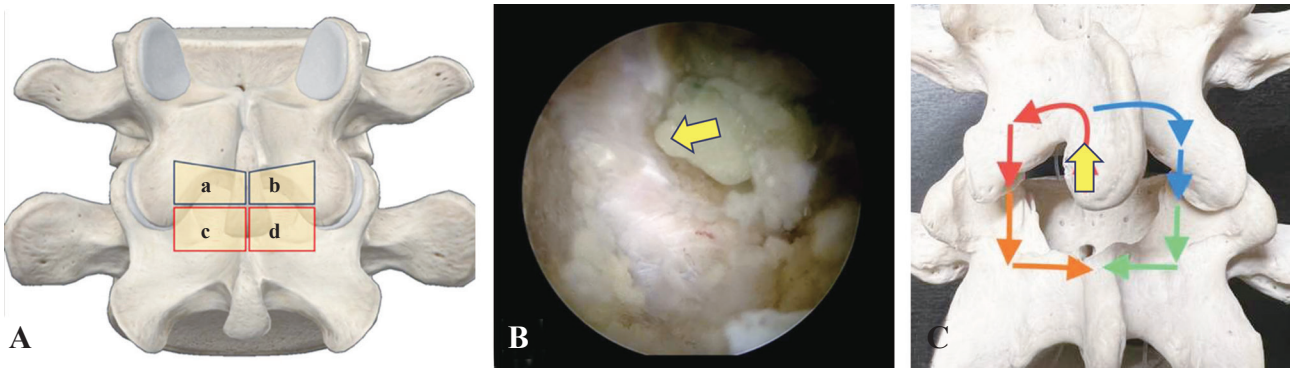

Fig. 4. (A) Overview of the laminotomy illustrates four zones (a, b, c, d), each with unique nuances for the resection of bone and ligament. **(B)** The yellow arrow indicates the spino-laminar junction, which is the starting point for our drilling. **(C)** The sequence of laminotomy starts from the yellow arrow.

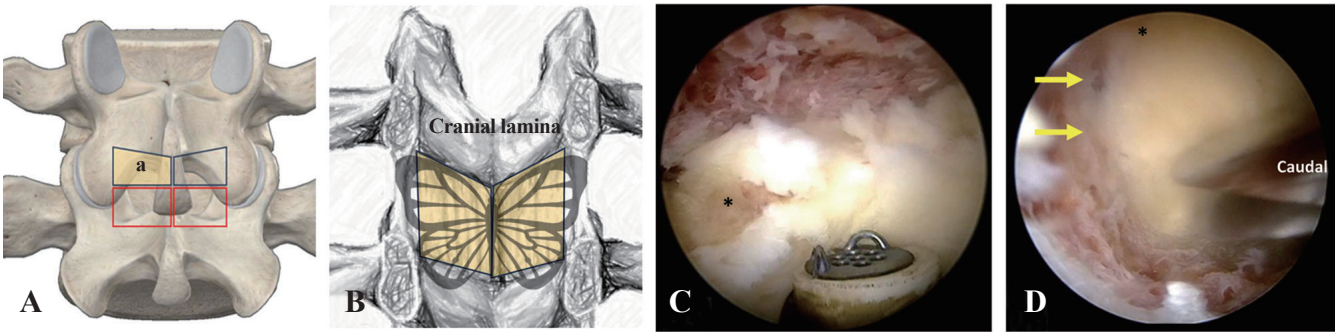

Fig. 5. (A) Overview of bony resection for zone "a". **(B)** The ligamentum flavum has the shape of a butterfly, with a lower midline cleft (head) and more cranial lateral attachments (wings). **(C)** The lower midline cleft (*) is well seen. **(D)** For an *en bloc* flavum removal, we recommend performing a 'Y-shape' instead of an 'umbrella-shaped' laminotomy. The yellow arrow indicates the cranial attachment of the flavum.

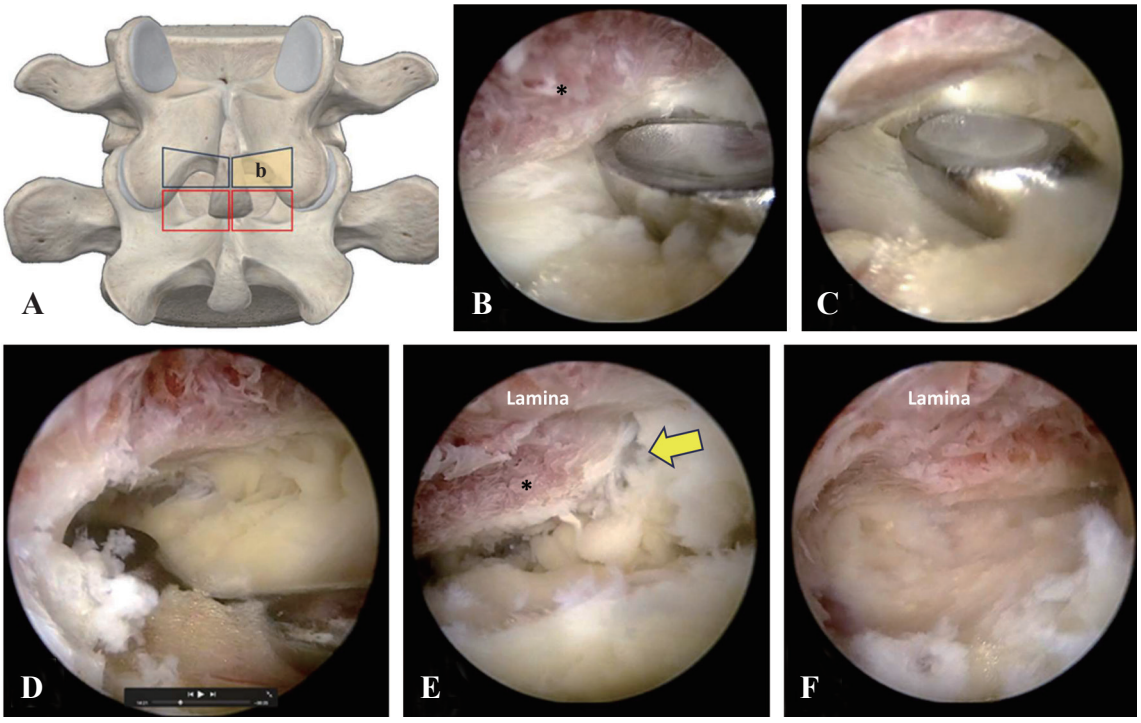

Fig. 6. (A) Overview of sublaminar bony resection for zone "b". **(B)** A curette can be used to separate the natural plane between the lamina and flavum. **(C)** The plane is widened and **(D)** gradually deepened both cranially, caudally, and laterally towards the superior articular process. **(E)** Drilling in a counter-clockwise direction starts at caudal edge of the lamina* (yellow arrow). **(F)** After bony resection, more working space is available and the underlying ligamentum flavum is seen.

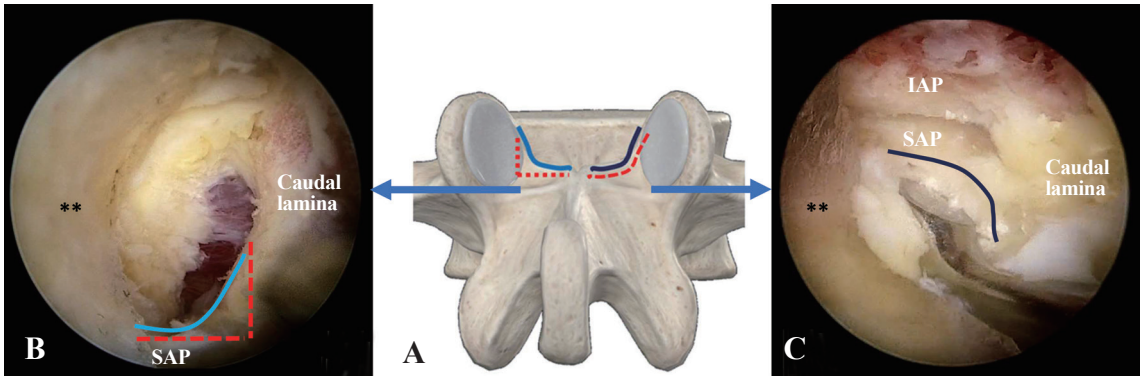

Fig. 7. Overview of the bony resection for zones "c" and "d", corresponding to the ipsilateral and contralateral lateral recess. **(A)** The dark and light blue lines indicated the contralateral "J-line" and ipsilateral "inverted J-line", formed anatomically by the inflection of the superior articular process (SAP) and the caudal lamina. The red dotted lines represent the cuff of bone removed from the lamina, along with the attachment of the ligament flavum. **(B)** Endoscopic view of the left lateral recess: This shows the inverted J-line (light blue), with the flavum detached from the left cauda lamina to reveal the underlying epidural space. **(C)** Right lateral recess: This J-line (dark blue) is seen and a curette is used to detach the flavum from the SAP. In both cases, notice how the transparent cannula (**) functions as a retractor to pull away the ligamentum flavum so that the underlying bony landmarks can be seen clearly. IAP, inferior articular process.

inferior articular process (IAP) is started in a counter-clockwise direction. Drilling is completed once the contralateral cranial epidural fat is seen and laterally when the SAP is seen (Fig. 6).

Zone c+d: ipsilateral and contralateral lateral recess

First, the "J-line" is located. This is a consistent anatomical landmark formed by the junction between the caudal lamina and the SAP. This denotes the lateral recess, and identifying this landmark will ensure satisfactory decompression of the underlying traversing nerve root (Fig. 7). This "J-line" can sometimes be obscured by facet joint hypertrophy and a thickened superficial ligamentum flavum. To expose this area, drilling off part of the IAP is necessary. With a combination of radiofrequency ablation, curettes, rongeurs, underlying

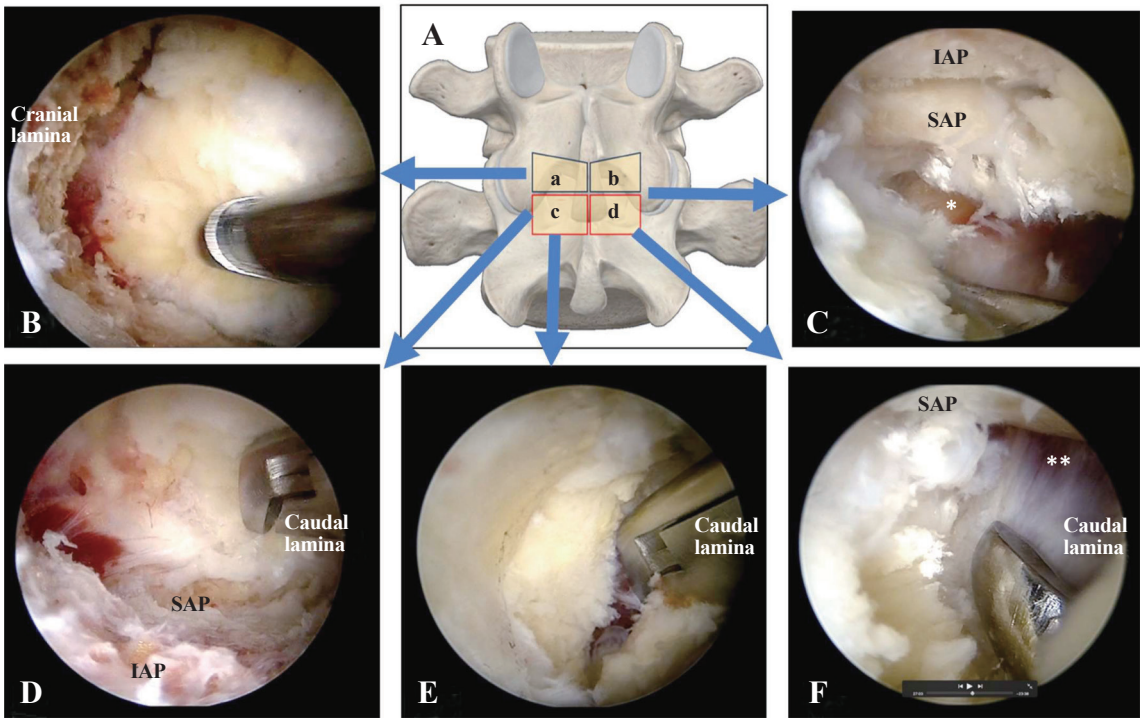

Fig. 8. (A) Illustrates how the flavum is detached from the four zones. **(B, D, E)** Detachment of the flavum from the left, ipsilateral side. **(B)** Cranial attachment. **(D)** Lateral recess with superior articular process (SAP) removed. **(E)** Caudal lamina of L5. **(C)** The ligamentum flavum is detached from the contralateral lateral recess (*) and **(F)** caudal lamina (**). A straight curette is sufficient to peel the flavum from the bony attachments. IAP, inferior articular process.

SAP, and caudal lamina can be exposed better. Once the J-line (or inverted J-line for zone "c") is identified, a Kerrison punch is used to resect a cuff of the bone, which will enable simultaneous detachment of the ligamentum flavum from the caudal lamina. This gives it a final "L-shape" appearance (Fig. 7).

Step 4: detachment of the deep ligamentum flavum

Zones a and b

For cranial attachments of the flavum (zones "a" and "b"), an upward-facing curette or Penfield is sufficient to detach the flavum. If a Kerrison is used, a "punch, rotate, and peel" technique is preferred to disconnect the remaining fibers of the flavum from the bone.

Zone c

The caudal ipsilateral flavum is separated by sliding a 2-mm Kerrison punch between the deep flavum and caudal lamina. This is extended laterally along the "inverted J-line" and cranially to resect some of the SAP, giving the final L-shaped bony laminotomy (Fig. 7, dotted red line). This extra bone resection enables the palpation of the medial wall of the ipsilateral pedicle and visualization of the edge of the traversing nerve root.

Zone d

Once the J-line is identified, the endoscope is advanced for a magnified view to improve visualization. Then, an angled curette was used to gently detach the deep flavum from the caudal lamina and SAP. The overhanging SAP and lamina can be trimmed using a Kerrison punch (Fig. 8).

Once all the flavum is detached and isolated, its undersurface is inspected to ensure that it is not adhering to the dura, which may be possible in revision cases from the scar tissue. Then, using a light "tugging" movement, it is removed in one or two large pieces (Fig. 9). The lateral recess is fully decompressed, and the underlying nerve roots can be visualized (Fig. 10).

Step 5: hemostasis and closure

Meticulous hemostasis using a combination of radiofrequency ablation, bone wax, or Floseal can stop the bone or epidural bleeding. The wound is closed, and under direct vision a suction drain is inserted via WP. The skin is closed using Prolene sutures.

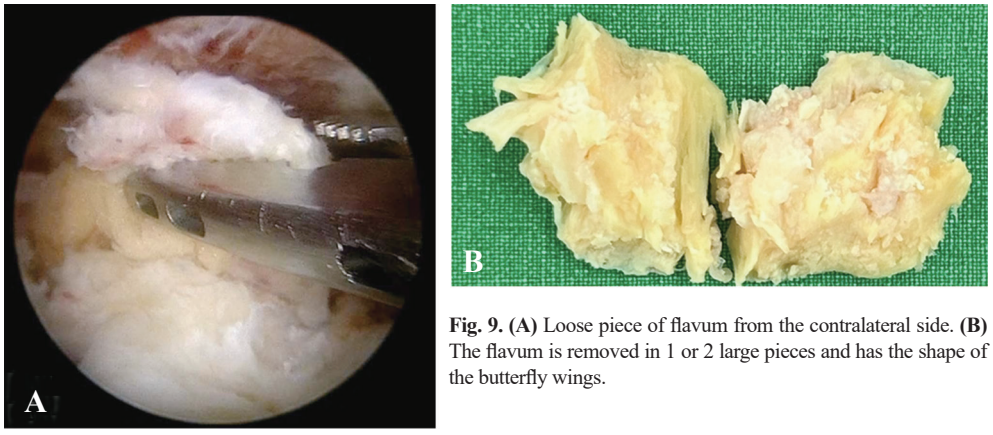

Fig. 9. (A) Loose piece of flavum from the contralateral side. **(B)** The flavum is removed in 1 or 2 large pieces and has the shape of the butterfly wings.

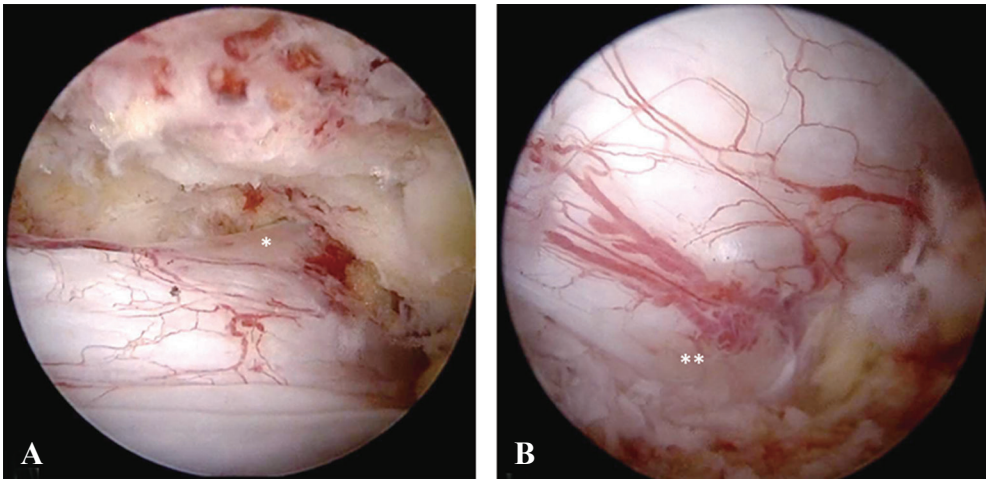

Fig. 10. Following decompression, the lateral recess and the underlying nerve root is seen. **(A)** Contralateral (*). **(B)** Ipsilateral (**).

Discussion

With the aging population, the demand for spine surgery, particularly for minimally invasive (MIS) procedures, is increasing to reduce age-related surgical morbidity [4,5]. Among the MIS techniques available, biportal endoscopy is highly versatile and cost-effective, and it affords a familiar anatomical approach to conventional surgery. The clinical outcomes have been comparable or even better than those of conventional MIS techniques [6,7]. As with any new procedure, overcoming the learning curve can be a major hindrance because the perceived complication risk and a reduction in operating room efficiency may be frustrating [8]. Thus, a systematic methodological approach will help avoid common pitfalls and shorten the learning curve. In the senior author's series of >1,400 cases, the technique was considered reproducible, safe, and efficient that will be easier for beginners to adopt.

The *en bloc* removal of the ligamentum flavum is the hallmark of this technique. Thus, we strongly recommend isolating the flavum from its bony attachments and avoiding from piecemeal removal. This has several advantages: (1) The flavum serves as a protective barrier for the dura during drilling. (2) Epidural bleeding is low, which also enables (3) better visualization. Inadvertent durotomy (4) usually occurs later in the procedure, which is more manageable than the early stages of the decompression. In addition, biportal endoscopic spine surgery, a water-based procedure, poses a risk of transmitting hydrostatic pressure to the brain if the dura mater is compromised during surgery [9]. The *en bloc* method of ligamentum flavum removal is an effective technique to mitigate this risk, particularly in the early stages of dural tearing.

For a successful *en bloc* removal, the bony attachments of the ligamentum flavum must be familiarized. Thus, visualizing the flavum as the shape of a butterfly

is useful. The flavum has a recessed midline cleft (head of the butterfly) compared with the more cranial lateral attachments (wings; Fig. 5A). Intraoperatively, the head of the butterfly serve as a lighthouse that can help orient the surgeon and as a guide for the subsequent direction and extension of laminotomy.

Although this technique is reproducible and offers several advantages, many strategies for endoscopic decompression are available. The ultimate decision depends on the surgeon's training and experience. Notably, preoperative planning is vital because anatomical differences such as facet joint hypertrophy, stenosis grade, scarring, or a calcified ligament flavum can affect the complexity of surgery, so piecemeal removal may be more suitable.

In conclusion, biportal endoscopic decompression, a MIS technique, offers the clinician an excellent option for managing patients with spinal stenosis. Our "butterfly" technique of *en bloc* flavum resection is a reproducible and efficient method and help early adopters overcome the steep learning curve.

Key Points

- *En Bloc* removal of the ligamentum flavum is an effective technique for decompressing the spinal canal.
- Visualizing the attachments of the flavum as a "butterfly" can aid in a successful *en bloc* removal.
- The benefits of this technique include providing a protective barrier for the dura, reducing epidural bleeding, and improving visualization.
- Another advantage is that inadvertent durotomy typically occurs later in the procedure, making it more manageable.
- A systematic approach is helpful in overcoming the steep learning curve associated with endoscopic surgery.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Conceptualization: CWP, JYLO. Writing: CWP, JYLO. Supervision: CWP. Final approval of the manuscript: all authors.

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