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Video Article

Full-Endoscopic J-Shaped Transforaminal L5 Nerve Decompression in Bertolotti Syndrome

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This case report and video demonstrate the technique of full-endoscopic J-shaped transforaminal L5 exiting nerve decompression in Bertolotti syndrome. Bertolotti syndrome, characterized by a congenital lumbosacral transitional vertebra, often results in mechanical lower back pain and nerve root compression. A 69-year-old male presented with progressive radiating pain in the right leg and tingling in the L5 dermatome. Lumbar spine MRI revealed a right foraminal disc herniation at the L5–S1 level, with calcification and foraminal stenosis. The patient was also diagnosed with Castellvi type I Bertolotti syndrome, featuring a large L5 transverse process and a high iliac crest. These anatomical variations complicated the transforaminal approach, creating a narrow safety zone for conventional methods. The approach began with docking on the L5 transverse process. Endoscopic drilling was performed in a J-shaped configuration to partially resect the transverse process and alar wing, facilitating endoscope insertion into Kambin's triangle. Foraminal decompression was achieved by removing the tip of the superior articular process (SAP), thereby decompressing the L5 exiting nerve root. Full-endoscopic spine surgery offers a safe and effective alternative to traditional open techniques for L5 nerve decompression in Bertolotti syndrome. This video presentation illustrates the intraoperative endoscopic approach, detailing the decompression techniques and highlighting the minimally invasive advantages of this method.

Keywords: Bertolotti syndrome, Full-endoscopic transforaminal approach, Minimally invasive spine surgery, L5 exiting nerve root

INTRODUCTION

Bertolotti syndrome, characterized by a congenital lumbosacral transitional vertebra (LSTV), is a well-recognized cause of mechanical lower back pain and radiculopathy. This condition frequently leads to compression of the L5 exiting nerve roots, resulting in significant morbidity and a diminished quality of life. Despite advancements in surgical techniques, managing Bertolotti syndrome remains challenging due to the complex anatomical variations associated with the condition.

The enlarged transverse process of the lumbar vertebra and the proximity of the iliac crest are key anatomical features that often obstruct surgical access, particularly in endoscopic minimally invasive procedures. These anatomical challenges highlight the need for the development of innovative surgical approaches that ensure effective nerve root decompression while minimizing surgical trauma.

This study explores a novel full-endoscopic transforaminal decompression technique tailored for the management of Bertolotti's syndrome. The surgical approach involves the meticulous removal of the superior articular process (SAP) and adjacent soft tissue contributing to nerve root impingement, with a focus on preserving surrounding anatomical structures. By partially resecting the L5 transverse process and alar wing, the

technique provides access to Kambin's triangle, facilitating targeted decompression of the L5 exiting nerve roots. This report outlines the methodology and rationale for this approach, addressing the unique challenges posed by Bertolotti syndrome and demonstrating its potential as an effective treatment option for patients with this condition.

CASE REPORT

1. Patient History and Preoperative Investigations

The patient is a 69-year-old male with several notable comorbidities, including coronary heart disease, managed with a stent placement 5 years ago, hypertension, type 2 diabetes, and a history of posterior lumbar interbody fusion at the L3–4–5 level performed 7 years ago. He presented to the outpatient clinic with rapidly progressive radiating pain in the right leg, accompanied by tingling sensations in the L5 dermatome.

Lumbar spine magnetic resonance imaging (MRI) revealed a right foraminal disc herniation at the L5–S1 level, characterized by narrowing of the L5–S1 disc space and the presence of right foraminal and lateral recess stenosis. Additionally, Castellvi type I Bertolotti syndrome was identified through plain radiographs and computed tomography (CT) imaging, with evidence of right L5–S1 disc calcification.

After thorough consideration of the surgical risks associated with his comorbidities, the patient opted to undergo full-endoscopic transforaminal foraminotomy at the L5–S1 level under local anesthesia.

Written informed consent was obtained from the patient as a mandatory requirement.

2. Surgical Approach and Procedure

1) Patient positioning and preoperative planning

The patient was positioned prone on the operating table and appropriately prepared for the procedure. Preoperative acquisition was performed using C-arm fluoroscopic imaging to assess the target anatomy. The L5–S1 foraminal space was identified, and a line was drawn marking the entry point into the L5–S1 foramen area, located above the iliac crest. The puncture point was then marked approximately 8 cm laterally from the midline to guide the insertion.

All procedures were conducted under local anesthesia, utilizing a mixture of 10 mL of 2% lidocaine and epinephrine. After accurately inserting an 18G spinal needle into the designated target location at the notch of the SAP, a 1-cm skin incision was made. A 0.8 mm guide wire was inserted through the 18G spinal needle, and a cannula dilator was then advanced over the guide wire to expand the paraspinal muscles.

2) Surgical technique: decompression process

The endoscope (RIWOspine, Richard WOLF, Knittlingen, Germany) was introduced through the working cannula. Due to the large size of the L5 transverse process in Bertolotti syndrome, direct access was not feasible. Therefore, the working sleeve was docked between the L5 transverse process and the alar. To facilitate endoscope entry into the foramen, the caudal and basal parts of the transverse process were drilled to expand the access space.

The superior articular process (SAP) notch was identified by drilling in the caudal direction along the isthmus and inferior articular process (IAP). The drilling trajectory began at the transverse process, directed downward toward the IAP, and continued towards the SAP notch and alar in a caudal direction. Upon locating the SAP notch, it served as a landmark for the initiation of drilling to decompress the nerve root. This step was followed by drilling toward the disc space and the tip of the SAP in a cranial direction, creating a "J" shaped pathway.

Once in position, further drilling of the SAP notch created a safe working zone, while cranial drilling allowed access to the tip of the SAP. After discectomy and removal of soft tissue, the L5 exiting nerve root was visualized. Decompression was performed by extensively drilling the SAP to decompress the pedicle area, ensuring patency of the foraminal and extraforaminal regions along the L5 nerve root. Complete decompression of the exiting nerve root was achieved.

Subsequently, the cephalic portion of the intervertebral foramen was fully exposed, allowing for effective decompression of the exiting nerve root. Decompression was deemed complete once the compressed lumbar spinal nerve roots were fully visualized, allowing for unhindered mobilization of the nerve roots using a flexible probe.

By inserting the radiofrequency tip or curved probe, the anteroposterior C-arm image can be used to confirm that the tip passes under the pedicle and enters the spinal canal without resistance.

DISCUSSION

1. Bertolotti Syndrome and Its Association with Low Back Pain and Radiculopathy

Bertolotti first described the association between an enlarged transverse process and transitional vertebrae as a cause of low

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back pain in 1917.[1] Low back pain is a prevalent condition with multifactorial etiology, affecting approximately 80% of adults at some point in their lives.[2,3] In patients with Bertolotti syndrome, the condition often leads to mechanical lower back pain and radiculopathy, especially when the L5 nerve root is impinged due to congenital anatomical changes.

2. Conservative and Surgical Management of Bertolotti Syndrome

For patients with refractory Bertolotti syndrome, treatment often begins with local injections of anesthetics and/or corticosteroids, which may be followed by radiofrequency treatment. If conservative treatments fail, surgical options, such as decompression or fusion, may be considered.[4] Surgical reports have shown that decompression or fusion at the affected site can provide relief.[5,6] While lumbosacral intervertebral fusion has been shown to be as effective as decompression, it carries certain disadvantages, including reduced lumbosacral mobility and increased invasiveness.

3. Radicular Symptoms and LSTV

Recent studies have highlighted the association between lumbosacral transitional vertebrae (LSTV) and radicular symptoms, often conceptualized as "far-out syndrome."[7-11] In this context, the impingement of the L5 nerve root is attributed to degenerative spurring related to LSTV, rather than to disc bulging. L5 radiculopathy is a common clinical presentation, particularly when stenosis is observed at the L4–5 level in the canal or lateral recess, or at L5–S1 foramen.[12] Radiological evaluations using MRI and reconstructed CT images of the extraforaminal zone are crucial in identifying these extraforaminal lesions.[13]

4. Castellvi Type II LSTV and Its Implications

In the context of an aging population, Castellvi type II LSTV may increasingly be recognized as a significant cause of radiculopathy. This condition is characterized by advanced spondylosis resulting from the decreased distance between the L5 transverse process and the sacral ala, often attributed to reduced disc height following pseudoarticulation at the contact surfaces due to cumulative loading over the years. The bony spur formed within the articulation can compress the L5 nerve root at the extraforaminal zone, leading to clinical symptoms.[14] The L5 nerve root is frequently involved in lumbar foraminal stenosis.[15]

Degenerative Changes and Spinal Instability

The development of LSTV may represent a compensatory response to inadequate load-bearing capacity of the sacrum or spinal instability, often exacerbated by weakened iliolumbar ligaments.[16] In patients with degenerative spinal scoliosis, abnormal stress on the spine can reduce the intervertebral space height, leading to a narrowing of the foramina. Pedicular kinking on the concave side of the scoliosis may result in significant root tethering at the foramina, necessitating partial pedicle excision along with foraminotomy to achieve adequate root decompression.[13]

5. Far-out Syndrome and Its Mechanisms

Wiltse et al.[11] first described spinal nerve compression occurring far laterally, between the transverse process and sacral ala, coining the term "far-out syndrome." Various anatomical studies have proposed mechanisms underlying this syndrome.[8,13,16-18] Nathan et al.[16] discovered that the L5 nerve could become entrapped within the "lumbosacral tunnel," formed by the L5 vertebral body, sacral ala, and lumbosacral ligament. Similarly, Matsumoto et al.[19] identified osteophytes on the L5–S1 vertebral bodies as a primary cause of extraforaminal entrapment of the L5 nerve within the lumbosacral tunnel.

6. Challenges in Diagnosing and Managing Far-out Syndrome

The far-out syndrome occurring below a transitional vertebra was first reported by Abe et al.[7] This syndrome differs from other pathologies in that the intervertebral level immediately below a transitional vertebra tends to be more stable, offering better protection against mechanical stress and showing a lower propensity for degenerative changes.[20] Therefore, conditions such as disc herniation, spinal stenosis, and nerve root canal stenosis are more prevalent at the intervertebral disc immediately above a transitional vertebra.[20-22]

Pseudoarticulation or fusion between the transverse process of L5 and the sacral ala can lead to extraforaminal entrapment of the L5 nerve root, often manifesting as radicular pain in the buttock and leg.[23,24] Radiological diagnosis of symptomatic extraforaminal entrapment is challenging, as conventional axial and sagittal MRI images often fail to provide sufficient detail to accurately diagnose far-out syndrome.[25-27]

Previous studies have documented favorable clinical outcomes following microscopic decompressive surgeries. More recently, fully endoscopic approaches have been implemented for the surgical treatment of foraminal lesions.[28]

7. Full-Endoscopic Transforaminal Approach for Far-Out Syndrome in Bertolotti Syndrome

We implemented a full-endoscopic transforaminal approach for decompressive surgery in cases of far-out syndrome. In patients with Bertolotti syndrome, particularly Castellvi type II, the anatomical configuration poses unique challenges: a high-positioned iliac crest and an enlarged L5 transverse process complicate direct access to Kambin's triangle using an endoscope.

To facilitate entry, docking was performed at the L5 transverse process, followed by drilling of its caudal aspect to expand the entry zone. The endoscope was maneuvered in a 'J' orientation, with sequential drilling of the isthmus, inferior articular process (IAP), and superior articular process (SAP) notch, enabling access to Kambin's triangle.

8. Importance of Entry Point Selection

Proper selection of the entry point is critical for procedural success. Generally, the entry point should be within 8 cm of the midline. However, if the L5 transverse process exceeds 1.5 cm in size or the iliac crest is positioned cranially relative to the L4–5 disc level, the entry point should be set closer to the midline (5–8 cm). Setting the entry point too cranial or lateral increases the thickness of the transverse process that must be traversed, prolonging bone removal time and complicating surgical adjustments.

9. Decompression Technique

Once in position, further drilling of the SAP notch establishes a safe working zone, while cranial drilling provides access to the tip of the SAP. After discectomy and soft tissue removal, the L5 exiting nerve root is visualized. Decompression is achieved by extensive drilling of the SAP to decompress the pedicle area, confirming patency of the foraminal and extraforaminal regions along the L5 nerve root. Complete decompression of the exiting nerve root is thus accomplished.

Endoscopic bony decompression targeted the hypertrophic SAP, ventral isthmus, and inferior superior pedicle. The surface of the SAP was initially exposed, with the extent of resection determined by the severity of foraminal stenosis. Resection depth varied based on the degree of compression toward the pedicle area.

During the procedure, the ligamentum flavum and foraminal ligaments were adequately exposed. Bone decompression is critical to ensuring effective soft tissue decompression, fully relieving neural structures from compression.

10. J-Shaped Transforaminal Approach vs. Paraspinal Approach

The J-shaped transforaminal approach shares similarities with the paraspinal approach, yet distinct differences exist: The J-shaped transforaminal approach is performed through the intervertebral foramen, using the SAP notch as a landmark. This approach is particularly suited for uniportal (full) endoscopic surgery and can be applied to a variety of disc herniations.

The paraspinal approach is primarily used in biportal endoscopic surgery and is most effective for foraminal or extraforaminal lesions. Its relatively wider surgical field makes it advantageous for more complex procedures.

On the other hand, the J-shaped transforaminal approach is considered a much more minimally invasive technique. It can be

Table 1. Comparison between J-shaped transforaminla approach and paraspinal approach

Approach method	J-shaped transforaminal approach	Paraspinal approach
Approach path	Through intervertebral foramen by endoscope	Through side of the spine (isthmus), larger incision
Surgical technique	Minimally invasive Mainly full endoscopic (uniportal)	More invasive larger incisions and muscle dissection Mainly Biportal endoscopic
Primary use	Various discectomy Foraminal exiting nerve decompression	Far lateral Herniated discs, Foraminal decompression Exiting nerve root decompression
Advantages	Less invasive, faster recovery, less blood loss	Broader view Better for complex or large-scale procedures
Disadvantages	Requires advanced skill (more difficult) Limited field of view	Larger incision, more muscle disruption Longer recovery
Starting target point	Notch of superior articular process (SAP)	Tip of SAP (Isthmus)
Range of bone work	T-process → notch of SAP → Tip of SAP → decompression exiting nerve root (J-shaped)	Isthmus → Tip of SAP → decomp exiting nerve root
Anesthesia	Local or epidural → real-time neuro-monitoring	General or epidural

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performed under local anesthesia, allowing for real-time neuromonitoring during the procedure (Table 1).

This video and case report serves as a valuable educational tool for surgeons interested in mastering fully endoscopic lumbar spine surgery. It emphasizes the importance of preoperative planning, intraoperative navigation, and demonstrates the key procedural steps in detail.

In conclusion, clinically symptomatic Bertolotti syndrome with extraforaminal stenosis is rare but can present with significant neurological manifestations. While traditional surgical approaches yield acceptable outcomes, they are often invasive. The full-endoscopic transforaminal L5 nerve decompression technique offers a safe and effective alternative, minimizing surgical trauma while achieving successful decompression.

NOTES

Video File: The video file for this article is available at https://doi.org/10.14245/ns.2449112.556.

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