Laminectomy with Laminar Reconstruction for Resection of Intradural Tumors at the Thoracolumbar Junction: A Technical Note

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■ OBJECTIVE: **To introduce a new laminar reconstruction technique to treat primary spinal cord tumors.**

■ METHODS: **Laminectomy and laminoplasty techniques have been used to treat intradural spinal tumors. The advantage of laminectomy is its superior exposure of the spinal cord, whereas the advantage of laminoplasty is the reconstruction of the dorsal roof of the spine. In this technical note, we present a technique that combines a full laminectomy to maximize exposure, with a reconstructive technique to repair the lamina. This technique restores the posterior ligamentous complex to preserve spinal biomechanics.**

■ RESULTS: **In this illustrative case, a 55-year-old woman with severe back pain radiating to the right lower extremity was found to have an intradural tumor at the T12-L1 spinal level. Given the transitional level of the spine and potentially high biomechanical stresses on the posterior support structures, we used a T12 laminectomy to resect the tumor, followed by reconstruction using miniplates. The patient tolerated the surgery well, without any complications. She was discharged home and was doing well during the 3 months follow-up visit. Appropriate patient consent was obtained.**

■ CONCLUSIONS: **Laminectomy and laminar reconstruction allow maximum visualization and manipulation of the tumor, followed by restoration of the dorsal roof of the spinal ring, and is an effective technique for treating spinal cord tumors.**

INTRODUCTION

Laminectomy is a common technique to expose the spinal cord for tumor resection.[1] Although it allows for excellent exposure, there are some disadvantages. First, it leaves the cord exposed, making revision operations at that level more difficult, because one has to dissect through the scar and make sure that there is no injury to the cord.[2] Second, if a fusion is necessary, it can be performed only via the facets in the cervical spine and facets and transverse processes in the thoracic and lumbar spines.[3] Third, at the cervicothoracic and thoracolumbar transition zones, there are biomechanical advantages to maintaining the dorsal arch, as well as the height of the spinous process.[4] For these reasons, some have favored laminoplasty or laminar reconstruction as an alternative to laminectomy for intradural tumor resection. Although laminoplasty was first described by Japanese orthopedic surgeons in the 1970s as a treatment for ossification of the posterior longitudinal ligament, many different modifications and variants of the technique have been described for use in primary spinal cord tumors.[5] The advantages of laminoplasty include the restoration of the posterior support complex, the spinal ring (when miniplates and grafts are used), and the dorsal roof of the spinal cord and prevention of associated complications, allowing for total resection of the intradural mass.[6] However, the most common laminoplasty techniques

Key words
- Extramedullary tumors
- Intradural tumors
- Laminoplasty
- Primary spinal cord tumors

Abbreviation and Acronym
MRI: Magnetic resonance imaging

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have limitations for visualization of tumors within the spinal canal, which is a significant limitation to their wide application in spinal neuro-oncology. We present a modification of the laminoplasty technique, wherein we perform a total laminectomy, then, after tumor resection, replace the lamina and reconstruct it with bilateral miniplates, which allows for full visualization of a traditional laminectomy with the reconstructive advantages of a laminoplasty. Such reconstruction aims to restore the biomechanics of the osteoligamentous posterior support complex, and, therefore, reduce the risk of postoperative instability and the risk of progressive kyphotic deformity and maintain the advantages of standard laminectomy. Laminar reconstruction also prevents the development of postoperative scarring between the dura mater and muscles.

METHODS

Surgical Technique

To perform the technique, the facet joints at the operated segment are isolated after subperiosteal dissection. The supraspinous and interspinous ligaments and ligamentum flavum are dissected above and below the operated segment. Using a high-speed drill at 30°–40° angle to the sagittal plane, a trough is cut on the lateral margin of the lamina bilaterally. This procedure allows sufficient visualization for intracanal manipulations comparable to traditional laminectomy, and the angled cut of the lamina prevents its subsequent intrusion into the spinal canal during its reconstruction and further accelerates the process of bone healing across the cancellous surfaces. Then, the laminectomy of the operated segment is completed by cutting across the posterior supporting complex of the adjacent supraspinous and interspinous ligaments, preserving them as well as the spinous process and lamina for subsequent reconstruction, rather than removing them with rongeurs (Figure 1).

After hemostasis, durotomy is performed, then, the dura mater is opened by bluntly tearing in the longitudinal direction using 2 forceps and fixed with holding sutures. Resection of the tumor under the operating microscope is performed. Then, the dura mater is closed with sutures. Two plates are then connected to the temporarily extracted bone-ligamentous block and fastened with 2 or 3 screws at the base of the spinous process. The extracted block is then repositioned and fixed with screws to the pars or to the base of the facet joint. Mutual reinforcement of independent plates with the same screws through the spinous process creates a unified biomechanical framework that mimics the biomechanics and distribution of support loads in the normal lamina. Then, the ligaments of the posterior support complex are reconstructed. The interspinous and supraspinous ligaments are sutured in layers using nonabsorbable 1–0 interrupted sutures.

RESULTS

History and Presentation

A 55-year-old woman with a medical history of obesity and hypertension presented with symptoms of progressive back pain radiating to the right lower extremity that was resistant to conservative treatment. Neurologic examination showed hypoesthesia in the L1, L2 dermatomes on the right. The patient had no motor deficit or bowel and bladder dysfunction.

Magnetic resonance imaging (MRI) showed an intradural extramedullary mass lesion at the level of T12-L1. T1 contrast study showed enhancement over the entire tumor volume. The location of the tumor on the right side as seen on the axial MRI within the proximity to the L1 and L2 spinal nerves correlated with the distribution of the pain and hypoesthesia. No other central nervous system lesions were detected (Figure 2).

Video

Video available at www.sciencedirect.com

Surgery

The operative plan called for a T12 laminectomy to resect an intradural extramedullary spinal tumor (Video 1). Given the transitional level of the spine and the potentially high biomechanical loads on the posterior support complex, the surgical treatment plan included a replacement and reconstruction of the lamina.

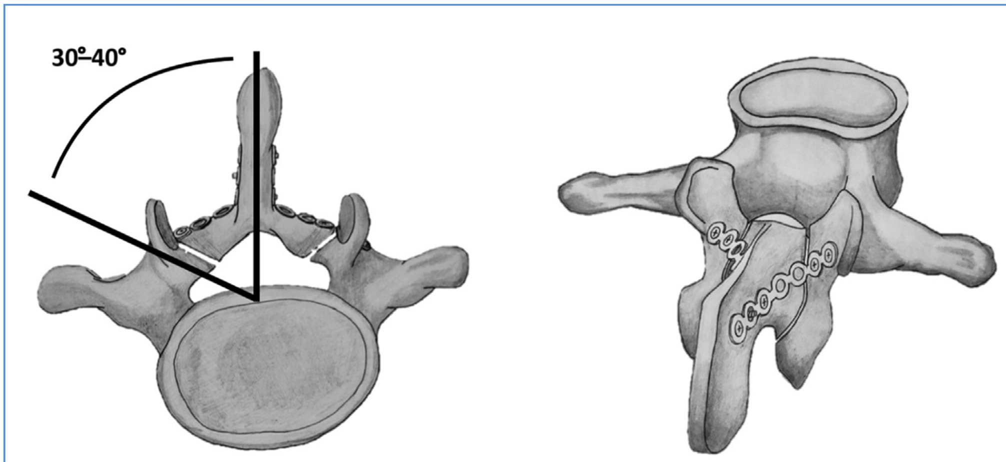

Figure 1. Cutting and mounting plates.

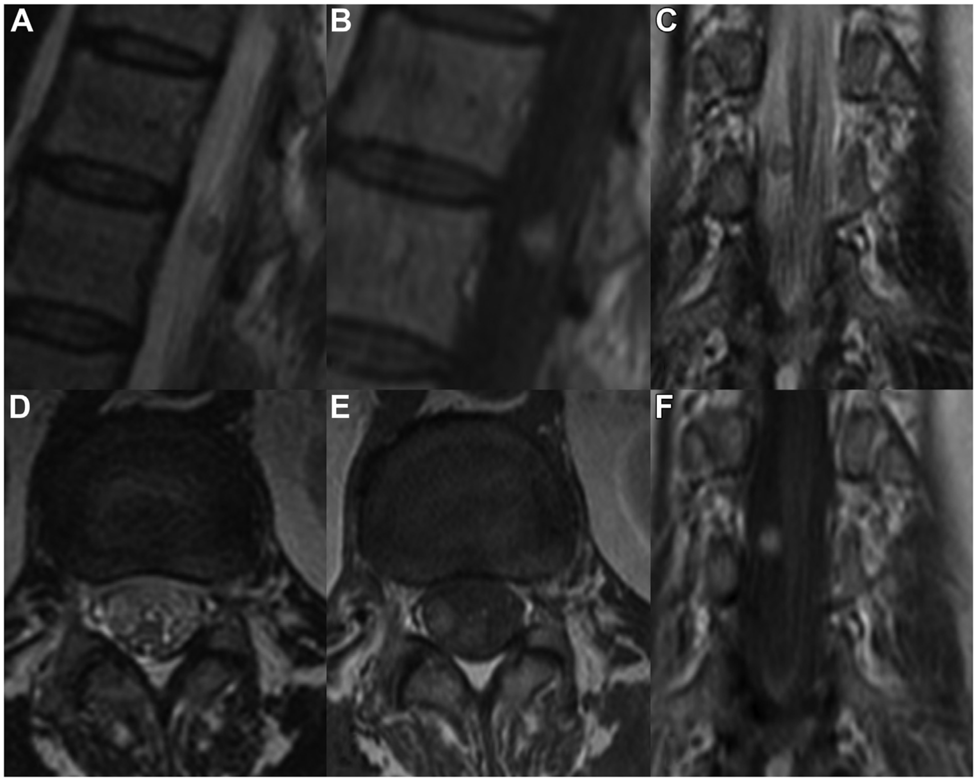

Figure 2. Preoperative magnetic resonance imaging showing an intradural extramedullary mass at T12-L1. (**A**) Sagittal T2-weighted image. (**B**) Sagittal T1-weighted postcontrast image. (**C**) Coronal T2-weighted image. (**D**) Axial T2-weighted image. (**E**) Axial T1-weighted postcontrast image. (**F**) Coronal T1-weighted postcontrast image.

Benefits of surgical intervention, as well as alternatives, including observation with serial imaging were offered, and the patient chose to proceed with the surgery. After induction of general anesthesia, the patient was positioned prone on the surgical table, with careful padding of all bony prominences. Standard intraoperative monitoring was used throughout the operation. A C-arm was used to navigate and confirm the level of interest.

A standard posterior midline incision was made and the T12 and L1 laminae were exposed. A trough was made bilaterally using a high-speed small cutting drill bit and completed with Kerrison rongeurs. The troughs were directed obliquely in the sagittal plane such that, when the lamina was replaced, the remaining lateral margins acted as bony blocks to intrusion of the lamina into the canal. The T12 lamina was then removed, with care to preserve the ligaments for subsequent reconstruction.

After achieving hemostasis, a single pull-up suture was placed and a linear durotomy was initiated using an insulin syringe needle and, then, the opening was enlarged longitudinally by bluntly pulling the edges apart with forceps. The dural edges were fixed to the surrounding muscles with 4—0 prolene sutures.

A tumor originating from the spinal nerve was identified. Using sharp arachnoidal dissection, the tumor was dissected along its perimeter. It was intimately adherent to and inseparable from one of the spinal nerves, which was coagulated at the proximal and distal ends of the tumor to prevent postoperative neuroma formation. The tumor was then resected in a single block. The dura mater was closed with a running suture.

The laminar reconstruction was then performed. We used 2 independent titanium miniplates fixed to the spinous process using 2.5-mm screws. The laminar bone—ligamentous complex with attached plates was secured back in place with 2 small screws on each side (Figure 3). The interspinous and supraspinous ligaments were repaired and the wound was closed in a standard multilayered fashion without drain.

Histologic Analysis

Pathologic assessment confirmed presumptive diagnosis, showing Antony A type schwannoma with Antony B type areas.

Postoperative Course

Postoperative MRI and computed tomography scans showed complete removal of the tumor and restoration of the posterior osteoligamentous complex without significant atrophy of the paraspinal muscles (Figure 4). Despite coagulation of the spinal nerve root, no postoperative neurologic deficit was observed. The patient had significant regression of pain and was discharged home on postoperative day 3. No additional therapy was required for the spinal intradural schwannoma. Further follow-up will include a lumbar MRI in 3 months.

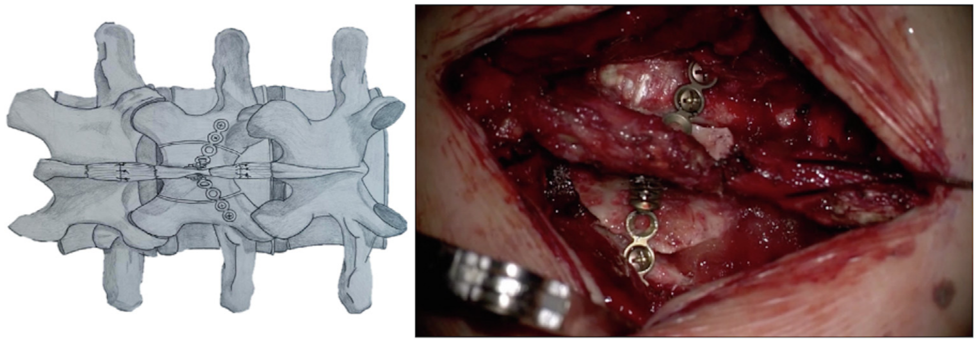

Figure 3. Schematic and intraoperative photographs of the laminoplasty.

DISCUSSION

We report a modification of a technique of temporary laminectomy, followed by laminar reconstruction, to expose and resect intradural tumors. This technique is similar to laminoplasty techniques but affords better visualization and exposure than the typical open-door laminoplasty. Previous reports have used unilateral plates and screws, as well as translaminar screws.[7-9] However, the unifying disadvantage of these techniques is the biomechanically fragile method of attaching metal plates, which may subsequently lead to migration of an unstable lamina into the spinal canal. In addition, previous methods described cutting the bone flap at a 90° angle to the sagittal plane, which can result in biomechanical instability, decreased fusion rates, and loss of range of motion.[10] Unlike the previously described techniques, in the presented technique, the lamina margin is cut at a 30° angle, which increases the bone contact surface area and reduces the risk of bone flap migration inside the spinal canal. Reinforcement of 2 independent plates with single screws through the spinous process creates a single biomechanical structure that mimics the biomechanics and load distribution in the normal lamina. In combination with interspinous and supraspinous ligaments repair, the posterior support complex is recreated and helps to prevent migration of bony structures into the spinal canal during postoperative mobilization.

Figure 4. Postoperative sagittal and axial magnetic resonance imaging and computed tomography images.

These techniques have been variously called laminoplasty or laminar reconstruction but, in essence, all refer to performing a laminectomy followed by reconstruction after the tumor resection and fixation using some type of instrumentation.[11-16]

The biomechanical advantages of laminectomy and laminar reconstruction as a method for accessing and reconstructing the spinal canal have been widely investigated. Jiang et al.[11] investigated the biomechanics of thoracolumbar laminar reconstruction in the treatment of spinal tumors. Compared with the laminectomy group, patients in the laminar reconstruction group showed better spinal range of motion (31.6° ± 12.0° vs. 21.7° ± 11.8°; $P = 0.013$), a smaller Cobb angle (9.6° ± 4.3° vs. 12.5° ± 5.3°; $P = 0.034$), a lower rate of cerebrospinal fluid leakage (4/14.8% vs. 11/47.8%; $P = 0.015$), and a shorter length of hospital stay (13.1 ± 1.8 vs. 15.1 ± 2.3 days; $P = 0.001$). Bone fusion was satisfactory in most patients in the laminar reconstruction group. The biomechanical advantages of laminar reconstruction have also been confirmed in other studies: in the study by Nong et al.,[12] laminar reconstruction showed better results, in terms of mechanical stability, compared with laminectomy, and Park et al.[13] reported that laminar reconstruction with translaminar screw fixation is safe and suitable for use in the thoracic and lumbar spines. There are few series of laminar reconstruction techniques used for primary spinal cord tumors in the literature.[14-16] The biomechanical advantages of laminoplasty have led researchers to focus more and more on comparative studies comparing its advantages with traditional laminectomy.[17,18] A meta-analysis of the effectiveness of laminoplasty versus laminectomy in the treatment of spinal tumors showed significant results in terms of effective recovery rate, blood loss, hospital stays, spinal deformity, and cerebrospinal fluid leak.[5] An extended meta-analysis, which included more clinical series, confirmed the previous findings: The laminectomy group showed a larger postoperative spinal deformity rate than the laminoplasty/laminar reconstruction group (odds ratio, 0.47). The laminoplasty/laminar reconstruction group had a shorter hospital stay (standardized mean differences, −0.68) than the laminectomy group. Both laminoplasty/laminar reconstruction and laminectomy have comparable operative times and total complications in the treatment of spinal tumors.[19]

One of the reasons why standard laminoplasty has not become widespread in tumor surgery, despite its biomechanical advantages, is limited visualization, making it technically difficult to perform tumor resection. This factor increases the risk of incomplete resection, as well as damage to neural structures. Our laminectomy followed by laminar reconstruction solves this problem, combining the advantages of traditional laminectomy with restoration of the posterior support complex.

With a full laminectomy, one can adequately visualize the tumor and the source of its growth and blood supply and control adjacent neural and vascular structures during surgical treatment. The laminar reconstruction then restores the natural biomechanics of the operated spine-motion segments. The miniplates allow for relatively rigid fixation, because they recreate the ring but do not cross a motion segment. This feature allows for early mobilization, comparable to those who undergo laminectomy alone.

CONCLUSIONS

Laminectomy and laminar reconstruction allow for maximal visualization and manipulation of the tumor, followed by restoration of the dorsal roof of the spinal ring, as well as the structures of the posterior osteoligamentous support complex.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Vadim A. Byvaltsev: Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Roman A. Polkin:** Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Andrei A. Kalinin:** Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Evgenii G. Belykh:** Conceptualization, Formal analysis, Writing – review & editing. **K. Daniel Riew:** Conceptualization, Formal analysis, Data curation, Writing – original draft, Writing – review & editing.

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