

Bone-to-bone ligament preserving laminoplasty technique for reconstruction of laminae

ABSTRACT

Introduction: Laminoplasty is a method used in spinal intradural tumor surgery to reduce the possibility of iatrogenic deformity. In classic laminoplasty, the interspinous, supraspinous, and ligamentum flavum integrity may be impaired, thereby creating a risk of deformity despite the laminoplasty. The aim of this study was to review the outcomes of bone-to-bone ligament preserving laminoplasty (BLP laminoplasty) technique.

Materials and Methods: The data of 14 cases who underwent BLP laminoplasty for intradural spinal tumor between 2017 and 2019 were reviewed. Through examination of preoperative and postoperative computed tomography images and flexion-extension lateral X-rays, the fusion and kyphotic changes were evaluated in the laminae. An axial Visual Analog Scale (VAS) was used to evaluate clinical satisfaction.

Results: The cases comprised 10 females and 4 males, with a mean age of 39.2 years (range, 16–52 years). The masses were intramedullary in six cases and extramedullary in eight. Lumbar region localization was most frequent. Ependymoma was determined in 8 cases, schwannoma in 4, and meningioma in 2. Laminoplasty was applied at 43 levels (10 thoracic and 33 lumbar). No complications were observed, and fusion was obtained in all the cases at the end of 1 year. No segmental kyphotic changes were determined. In the clinical evaluation, the VAS scores improved from 3.4 ± 2.0 preoperatively to 1.8 ± 2.1 postoperatively.

Conclusion: BLP laminoplasty is a safe technique which preserves posterior ligamentous integrity. Furthermore, the use of ultrasonic bone scalpel provides a narrower gap between laminae and other bones, preventing dislocation, and allowing for more fusion, and consequently preventing kyphosis.

Keywords: Laminectomy, laminoplasty, laminotomy

INTRODUCTION

The diagnosis of spinal intramedullary tumors has become easier with the recent improvements in imaging technologies. The main purpose is total resection with aggressive surgical interventions in light of new microsurgical techniques. One of the most important risks in this type of surgery is iatrogenic deformity seen during the postoperative follow-up. The minimally invasive surgery, laminectomy, and laminoplasty techniques were developed to prevent iatrogenic deformity.^[1,2] Despite all these techniques, the risk of deformity continues, especially in pediatric cases.^[3-5]

Iatrogenic deformity may occur for many reasons, such as aggressive bone resection, posterior ligamentous complex injury, and radiotherapy. Many laminoplasty techniques

have been described to decrease the risk of deformity.^[6,7] In order to minimize the risk of iatrogenic spinal deformity, a new technique (bone-to-bone ligament preserving [BLP] laminoplasty technique) was described and used in our cases. The aim of this study was to review the results of BLP laminoplasty.

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Technical note

The patient was positioned prone on a radiolucent operating table. Intra-operative neuromonitoring was performed, and the signals of the neuromonitor were followed up during the operation. After the determination of the vertebral level of the tumor location by fluoroscopy, a midline skin incision was made. The paravertebral muscles were released on both sides, preserving the interspinous ligament, including the upper and lower vertebrae of the lamina level where the tumor was located. The incision was made carefully to prevent any damage to the facet joints and capsule. An appropriate sized retractor was then placed. The target laminae were cut obliquely at the lateral borders without damaging the facet integrity, at 10 mm on cervical area and 20 mm in the thoracic and lumbar areas. The proximal and distal laminae were cut in the transverse plane and the spinous process was cut in the vertical plane as far as the middle of the spinal process. The laminae were excised together with the ligamentum flavum and interspinous ligament. The appropriate amount of the bone was left behind for suturing of the residual spinous process following spinous process excision. After the tumor operation, the laminae were fixed with mini-plates or micro-end of ultrasonic bone scalped (UBS) or fixation on holes opened with a high-speed drill with nonabsorbable sutures [Figure 1].

MATERIALS AND METHODS

Evaluation was made of 14 cases of intradural spinal tumor cases, which were operated on using the BLP laminoplasty technique between 2017 and 2019. The primary lesion, level of vertebrae, preoperative and postoperative magnetic resonance imaging scan, and computed tomography scan (CTs) of all the cases were examined.

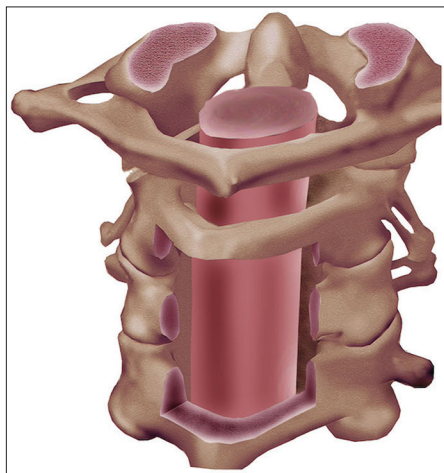


Figure 1: New laminoplasty technique is illustration image in the cervical spine

Clinical and radiological assessment

The fusion rates and kyphotic changes on the laminae were reviewed in the early postoperative period, then at 6 and 12 months in all cases with flexion-extension lateral X-rays and CT scan. The Visual Analog Scale (VAS) was used to evaluate clinical satisfaction.

RESULTS

The 14 cases comprised 10 females and 4 males, with a mean age of 39.2 years (Range: 16–52 years). All the cases had a spinal intradural tumor, six intramedullary and eight extramedullary. Of all the lesions, two were in the thoracic area and the others were in the lumbar area. Ependymoma was determined in eight cases, schwannoma in four and meningioma in two. A total of 43 pieces of laminoplasty were performed, 10 of which were thoracic and 33 were lumbar. No complications occurred secondary to laminoplasty. The laminae used on laminoplasty levels were examined with postoperative CT. The mean follow-up duration was 14.9 ± 4.4 months. Fusion was seen in eight cases in the 6th month and all the cases were fused in the 12th month [Figure 2].

No segmental kyphotic changes were seen in any cases, all of which resulted in fusion. The mean preoperative segmental kyphosis angle was 15.4 ± 5.7 , early postoperative 15.0 ± 4.9 , and late postoperative 13.9 ± 6.2 ($P > 0.05$). The dorsalgia/lumbalgia VAS evaluation was 3.4 ± 2.0 immediately postoperatively, 2.3 ± 1.8 at 6 months and 1.8 ± 2.1 at 12 months ($P < 0.05$) [Table 1].



Figure 2: Patient No: 4 Lumbar schwannoma, performed L2–L3 laminoplasty (a) Immediately postoperative sagittal image of computerized tomography, blue arrow is laminoplasty line (b) Postoperative 12th month sagittal image of computerized tomography, white arrow is laminoplasty line with fusion

DISCUSSION

This study showed that the BLP laminoplasty technique prevents iatrogenic deformity and results in successful fusion in the laminoplasty incision line. The technique was also seen to be safe and more comfortable for repeated surgery if necessary.

There are many approaches for accessing intradural spinal tumors. Hemilaminectomy is a good choice for intradural extramedullary tumors, but total laminectomy and laminoplasty is the most preferred technique for intramedullary tumors. Both techniques have *pros and cons*. Laminectomy can be accompanied by significant osseous ligament injury. Progressive iatrogenic deformity occurs in laminectomy patients with intradural tumors at the rate of 10% in the adult population and at 16%–100% in the pediatric population.^[7,8] Theoretically, the main cause of this deformity is instability due to injury of the facet joint capsule and posterior ligamentous capsule. Instability may be decreased with surgical instruments but these materials may cause imaging artefacts, especially in patients who need close follow-up in the postoperative period. This led to the development of the laminoplasty technique by Raimondi *et al.* to decrease and eradicate the risk of iatrogenic deformity.

Previous studies have shown that laminoplasty decreases the risk of iatrogenic deformity and CSF fistula and makes repeated operations more comfortable.^[9]

However, although the risk of iatrogenic deformity decreases with laminoplasty, it may not be totally eradicated. McGirt *et al.*^[10] showed that laminoplasty decreases the postoperative deformity risk but does not totally prevent it

in a study of 238 spinal tumor cases. Ratliff and Cooper^[11] reported postoperative spinal deformity at the high rate of 35% in a meta-analysis in 2003. It is assumed that deformity may be caused by many factors, including osseoligamentous injury, surgical laminoplasty technique, failure of fusion, and failure of reconstruction. Laminoplasty is of importance. It is usually performed with a high-speed drill or fine Kerrison curette. This technique may result in significant bony loss and wide gaps at the edges. It is difficult to decrease this gap to <2–3 mm. However, in laminoplasty applied with UBS, the gap is 0.5–1.0 mm.^[12] As laminae wing freely, even when fixated, when there is a wide gap, this may result in delayed fusion.

The decreased gap resulted in satisfactory bony replacement and decreased displacement and thereby better fusion.^[13] UBS also significantly decreases the operation duration, as three levels of laminoplasty take 1–2 min with UBS, whereas this procedure will take 10–15 min with other instruments.

BLP laminoplasty with UBS appears to reduce the risk of deformity in laminoplasty, while preserving the integrity of ligamentous structures.

None of the conventional methods preserve the interspinous ligament and ligamentum flavum, which are responsible for the posterior tension band. However, the method described in this study preserves the integrity of the supraspinous, interspinous, and yellow ligaments.

Previous studies about the thoracolumbar posterior ligamentous complex have shown that preserving supraspinous and interspinous ligamentous structures are the most important factor in the range of motion.^[14-16,17]

Table 1: Patient characteristics ([+/-]: Parsiel fusion)

| Patient number | Age (years; sex) | Tumor and laminoplasty level | Pathology | Follow-up duration (months) | Cobb angle | | | Fusion | |
|----------------|------------------|------------------------------|------------|-----------------------------|--------------|---------------------|--------------------|---------|------|
| | | | | | Preoperative | Early postoperative | Late postoperative | Laminae | Spin |
| 1 | 39; female | T7-8-9 | Ependymoma | 18 | 11.2 | 10.3 | 13.2 | + | + |
| 2 | 16; female | T12-L4 | Ependymoma | 27 | 13.4 | 17.3 | 0.5 | + | + |
| 3 | 36; female | L2-3-4 | Ependymoma | 19 | 17.5 | 16.4 | 18.7 | + | +/- |
| 4 | 34; female | L2-3 | Schwannoma | 12 | 16.9 | 18 | 11.5 | +/- | + |
| 5 | 26; female | T12-L1 | Ependymoma | 17 | 13.5 | 12.6 | 13.0 | + | + |
| 6 | 51; male | T3-4 | Meningioma | 11 | 0.5 | 3.9 | 2.2 | + | + |
| 7 | 43; female | L1-2 | Ependymoma | 13 | 12.4 | 11.2 | 12.7 | + | + |
| 8 | 52; female | L2 | Schwannoma | 14 | 17.7 | 13.2 | 16.7 | +/- | + |
| 9 | 26; male | L2 | Ependymoma | 9 | 16.3 | 16.0 | 14.3 | + | + |
| 10 | 47; female | L2 | Ependymoma | 15 | 22.5 | 20 | 16.7 | + | +/- |
| 11 | 52; female | L2-3-4 | Meningioma | 13 | 20.4 | 18.5 | 21.0 | + | + |
| 12 | 34; male | L4-L5 | Ependymoma | 16 | 24.2 | 24.5 | 23.4 | +/- | + |
| 13 | 45; male | L2-4 | Schwannoma | 12 | 15.2 | 14.2 | 16.3 | + | +/- |
| 14 | 49; male | L2-3 | Schwannoma | 13 | 14.3 | 14.6 | 14.5 | + | + |

CONCLUSION

BLP laminoplasty is a safe technique, which preserves posterior ligamentous integrity. Furthermore, the use of UBS provides a narrower gap between laminae and other bones, thereby preventing dislocation and allowing more fusion and consequently, preventing kyphosis.

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Conflicts of interest

There are no conflicts of interest.

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