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Original Investigation

Laminoplasty with Miniplates for Posterior Approach in Thoracic and Lumbar Intraspinal Surgery

Torasik ve Lomber Intraspinal Patolojilere Cerrahi Yaklaşımda Titanyum Miniplaklarla Laminoplasti

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ABSTRACT

OBJECTIVE: A prospective clinical follow-up study of patients who underwent thoracolumbar intraspinal surgery with replacement of the posterior spinal arch and supporting elements is reported.

PATIENTS and METHODS: The surgical procedures of 45 patients who underwent intraspinal surgery with osteotomy and replacement of 122 spinal laminae using an air drill and mini-plates with repair of the supraspinous ligaments were analyzed. Data of a complete clinical and radiological follow-up examination were evaluated in 45 patients. Plain radiographs and computed tomography scans were analyzed for bony healing of the laminae and spinal alignment.

RESULTS: No complications due to the technique were observed. None of the patients had kyphosis and/or instability on static or dynamic plain x-ray films. There was no scar tissue invasion in the spinal canal based on MRI findings.

CONCLUSIONS: No patient required additional surgery because of progressive spinal instability. This technique is safe and well-suited to serve as a standard posterior approach to intraspinal pathologies and offers distinct advantages over laminectomy and repeat surgery.

KEYWORDS: Epidural fibrosis, Instability, Intradural tumor, Laminoplasty

ÖZ

AMAÇ: Torakolomber intraspinal patolojilere yaklaşımda, posterior spinal ark ve destek yapılarının tekrar yerine yerleştirilmesi ile yapılan prospektif klinik çalışmanın sonuçları bildirildi.

YÖNTEM ve GEREÇ: İntraspinal patolojilere ulaşmak için havalı tur kullanılarak çıkarılan 122 laminanın tekrar miniplaklarla yerine yerleştirilip, supraspinöz ligamentin de tamir edildiği 45 olgudaki cerrahi sonuçlar analiz edildi. Bu 45 olgudaki tüm klinik ve radyolojik takip sonuçları değerlendirildi. Direkt grafi ve bilgisayarlı tomografi kullanılarak laminadaki kemik iyileşmesi ve spinal dizilim değerlendirildi.

BULGULAR: Uygulanan tekniğe bağlı komplikasyon gözlenmedi. Dinamik ve statik düz grafilerde kifoz ve/veya instabilite tesbit edilmedi. Magnetik rezonans görüntülemelerde spinal kanalda skar dokusu invazyonu gözlenmedi.

SONUÇ: Progresif spinal instabilite nedeniyle hiç bir olguya ek bir cerrahi girişim uygulanmadı. Bu teknik, intraspinal patolojilere standart posterior yaklaşımda, emniyetli ve kolay uygulanabilir olup, rekürren cerrahi bile olsa laminektomiye belirgin üstünlükler sağlamaktadır.

ANAHTAR SÖZCÜKLER: Epidural fibrozis, İnstabilite, İntradural tümör, Laminoplasti

INTRODUCTION

The replacement of laminae after an intraspinal approach was first described by Raimondi et al. (27) in 1976. A variety of techniques using the reduction procedure for the removal of the spinal cord and cauda equina tumors were afterwards developed to prevent post-operative spinal deformities or avoid the formation of adhesions to surrounding tissues (3,4,6, 11,15,19,21,23,33). The physiologic roles of the vertebral arch, supraspinous ligament, and interspinal ligament include a tethering or tension constraint during anterior flexion, support for the dorsolumbar fascia and muscles in all body positions, and an extension block or restraint during extension. Laminectomy provides a sufficient operative exposure for the safe removal of a spinal tumor. However, several difficulties still exist, including an invasion of the hematoma and scar tissue into the spinal canal, and difficulty in repeat surgery (12,16). Barrier materials are foreign to the human body and carry a risk of infection. However, the lamina is an effective and safe mechanical barrier material. The replacement of a laminar flap using a titanium mini-plate and repairing the supraspinous ligament is safe, well-suited to serve as a standard posterior approach to intraspinal pathologies, and offers distinct advantages over laminectomy.

PATIENTS and METHODS

Between January 2000 and October 2007, 45 consecutive patients underwent spinal surgeries in which osteoplastic laminotomy with replacement of the laminar flap and fixation with mini-plates, and repair of the supraspinous ligament, was used. The surgical procedures of 45 patients who underwent intraspinal surgery with osteotomy and replacement of a total of 122 spinal laminae using an air drill and mini-plates were analyzed (Table I). After completing the surgical procedures in the interior of the spinal canal, the excised supraspinous ligament was connected with the upper part of the supraspinous ligament with PDS 1.O suture.

Data of a complete clinical and radiological follow-up examination were evaluated in 45 patients. Plain radiographs and computed tomography scans were analyzed for bony healing of the laminae and spinal alignment. A plain X-ray was obtained for each patient periodically after the surgery, and the surgeon checked the position of the screws and plates. Computed tomography was performed 2 months after surgery, and both examinations were continued until bony fusion was recognized. When callus formation of the replaced laminae was found and no displacement of the screws and plates was identified, the surgeon determined that bony fusion had been achieved. At the latest follow up, we examined the neurological findings, the presence of back pain, and checked the location of the plates, subluxation, and the instability of the affected spine by x-rays, and checked for any scar tissue invasion in the spinal canal or a recurrence of the tumor based on magnetic resonance imaging (MRI) findings and according to the patients' statements and follow-up findings.

RESULTS

No complications due to the technique were observed. No patients had kyphosis and/or instability on static or dynamic plain x-ray films done at 3, 6, and 12 months. Minor complications, such as cerebrospinal fluid collection and disturbed wound healing occurred within normal ranges. There were no cases of dural, nerve root, or spinal cord injuries attributable to laminotomy or laminar flap replacement. Eight (17.7%) patients complained of moderate-to-severe local pain at the time of follow-up examination and 6 patients stated impaired mobility of the spine at the surgical site. Six (13.3%) patients underwent secondary surgery and 2 (4.4%) patients underwent tertiary surgery because of tumor recurrence.

Bony healing was confirmed radiologically in 91% of the laminae. There was no scar tissue invasion in the spinal canal based on the MRI findings.

Representative case report (Case 9)

A 20-year-old man had an 8-month history of lower back pain and a 2-month history of progressive numbness and paraparesis in both legs. A MRI of his lumbar lesion revealed a huge intradural spinal tumor ranging widely from the 1st to the 5th lumbar spine (Figure 1A, B). At the time of surgery, the laminae from the 1st spine to the 5th lumbar spine were cut using a surgical drill. After removing the spinal tumor, the 4 excised laminae were replaced using titanium mini-plates with repair of the supraspinous ligaments. Due to the initial rigid fixation of the replaced laminae, the patient was allowed to walk wearing a soft brace in the first post-operative month. The post-operative diagnosis was a neurinoma.

Table I: Characteristics of the patients.

No	Age/sex	Diagnosis	Localisation	No of segment
1	32/F	Astrocytoma	Thoracic	3
2	48/F	Ependymoma	Lumbar	4
3	54/M	Dermoid	Lumbar	3
4	49/M	Ependymoma	Thoracolumbar	4
5	28/M	Dermoid	Lumbar	3
6	22/M	Dermoid	Lumbar	3
7	19/M	Astrocytoma	Thoracic	4
8	14/F	Lipoma	Lumbar	3
9	20/M	Neurinoma	Lumbar	4
10	32/M	Ependymoma	Thoracic	2
11	36/M	Neurinoma	Thoracic	2
12	38/F	Astrocytoma	Thoracic	2
13	48/M	Meningioma	Thoracic	2
14	56/M	Meningioma	Thoracic	2
15	64/F	Meningioma	Thoracic	2
16	45/F	Astrocytoma	Thoracic	3
17	55/M	Neurinoma	Thoracolumbar	3
18	52/F	Ependymoma	Lumbar	4
19	64/F	Meningioma	Thoracic	2
20	37/M	Ependymoma	Lumbar	3
21	15/M	Dermoid	Thoracolumbar	4
22	50/M	Ependymoma	Lumbar	4
23	43/F	Ependymoma	Thoracic	2
24	58/M	Neurinoma	Lumbar	2
25	36/M	Cavernous angioma	Thoracic	2
26	32/F	Syringomelia	Thoracic	3
27	68/M	Meningioma	Thoracic	2
28	46/F	Neurinoma	Thoracolumbar	3
29	54/M	Ependymoma	Lumbar	2
30	50/M	Meningioma	Thoracic	2
31	19/M	Astrocytoma	Thoracic	3
32	20/F	Neurinoma	Thoracolumbar	4
33	36/F	Ependymoma	Lumbar	2
34	58/M	Ependymoma	Lumbar	3
35	13/F	Lipoma	Lumbar	4
36	40/F	Neurinoma	Thoracic	2
37	31/M	Dermoid	Lumbar	4
38	52/M	Astrocytoma	Thoracic	2
39	58/F	Meningioma	Thoracic	2
40	35/F	Neurinoma	Lumbar	2
41	46/M	Cavernous angioma	Thoracic	1
42	57/F	Meningioma	Lumbar	2
43	42/M	Neurinoma	Thoracolumbar	3
44	48/F	Syringomelia	Thoracic	2
45	56/F	Ependymoma	Thoracolumbar	4

Figure 1: *Sagittal (**A**) and axial (**B**) T2 MRI revealing a huge intradural spinal tumor ranging widely from the first to the fifth lumbar spine.*

The post-operative third month dynamic lumbar x-rays showed no lumbar instability (Figure 2A,B) and a MRI performed 1 year post-operatively showed neither residual tumor nor recurrence. The spinal canal remained widely patent without any compromise caused by an epidural scar or other pathologies (Figure 3). Bony fusion of the excised laminae was recognized 3 months after surgery (Figure 4A, B).

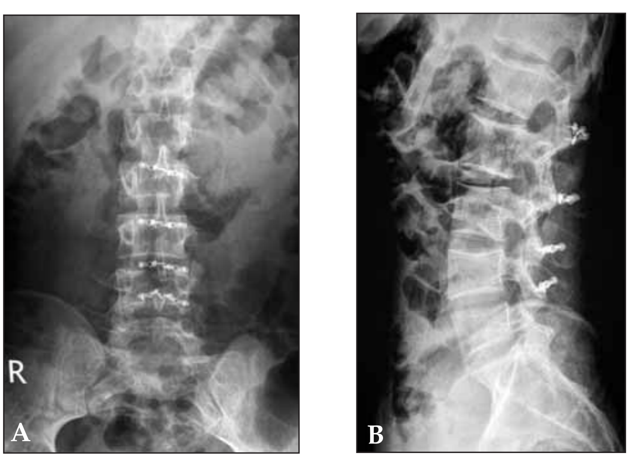

Figure 2: *Follow-up A-P (**A**) and dynamic (**B**) plain x-ray films showing no kyphosis and/or instability.*

DISCUSSION

In general, intradural lesions are best approached from the posterior or posterolateral aspect. More bone removal is not necessarily better. The goal of any procedure is to obtain adequate decompression and visualization for intervention and to maintain or, in some cases, to achieve spinal stability. However, the removal of too little bone can increase the risk of a

Figure 3: *Follow-up MRI, sagittal T1 with gadolinium, showing no residual or recurrent tumour or epidural scar formation after one year.*

Figure 4: *Postoperative sagittal (**A**) and axial (**B**) computed tomography showing bony fusion of excised laminae recognized at 3 months after surgery.*

dural tear, prevent recognition of a nerve root, or result in incomplete removal of the tumor.

The spine is a dynamic structure that continuously adapts to the movement and position of the body. In the setting of spinal pathology, and following surgery, the normal function of the spinal column may be significantly altered. This can lead to accelerated degeneration of some levels in the spine, as well as a failure of normal function in the muscles and ligaments that support the spine. Thus, the posterior arch of the spine (laminae and supraspinous ligaments) should be preserved in thoracolumbar intraspinal surgery.

The most common surgical procedure for exposing the spinal canal in the thoracic and lumbar spine has been a laminectomy. However, the disadvantages of laminectomy, such as spinal deformity, spinal instability, acceleration of spondylotic changes, constriction of the dura by epidural cicatrices and adhesions, and lack of posterior bony protection of the spinal cord are frequently quoted in the literature (10, 17,18,20,34,35), and result in recurrence of the pain syndrome and aggravation of a patient's state.

Several reports have given a high success rate after laminectomy (1,2,5,11,25,26). However the rates were decreased to < 60% at long-term follow-up (14, 22,25,29). Instability with resultant chronic pain syndrome has been suggested as a potential cause of a poor outcome. Mullin et al. (22) found 54% instability on dynamic lateral radiographs of patients who had decompressive laminectomy with long-term follow-up. Papagelopoulos et al. (25) reported that the incidence of spinal deformity after multilevel lumbar or thoracolumbar laminectomy occurred in 28% of patients ≤ 30 years of age. Iida et al. (10) reported that extensive laminectomy was likely to cause interspinal instability and that resection of the posterior elements of the spine exerted more effect on post-operative spinal instability than discectomy. Tsuji et al. (31) reported that the degree of improvement in low back pain and sensory disturbance was lower than that of other symptoms following extensive laminectomy.

The biomechanical roles of the supraspinous ligament, interspinous ligament, and the vertebral arch include a tethering or tension constraint during anterior flexion, support for the dorsolumbar fascia and muscles in all body positions, and an extension block or restraint during extension (9,24). In addition, many reports, including those published by Hotta (9) and Newman (24), have emphasized the importance of the supraspinous ligament and interspinal ligament in flexion stability. Sano et al. (28) and Joson et al. (13) reported a technique that conserves the supraspinous ligament in laminectomy, and Hirofuji et al. (8) reported a technique that reconstructs the supraspinous ligament and interspinal ligament using artificial ligaments. These methods can ensure control over anterior flexion. In this study, we only cut the upper part of the supraspinous ligament. After finishing the surgical procedures in the interior of the spinal canal, the excised supraspinous ligament was connected with the upper part of the supraspinous ligament with the PDS 1.O suture.

The literature contains a description of numerous methods of protection from sequelae of epidural fibrosis: fatty tissue, amniotic membrane, silicon membranes and plates made of silastic, irrigation of nervous structures by steroids, and non-steroid anti-inflammatory drugs. Their efficacy is rather low. Due to these circumstances, there appears to be a tendency to reduction of a traumatic character of surgical interventions with a subsequent spread of surgical techniques (10,17,18,20,34,35). However, the lamina is an effective and safe mechanical barrier material. The replacement of the laminar flap using the titanium mini-plate is safe, well-suited to serve as a standard posterior approach to intraspinal pathologies, and offers distinct advantages over laminectomy

On the other hand, this procedure is not suitable for dumb-bell tumors, which expand into multiple foramina and exhibit multi-directional eroding. In such cases, it is impossible to replace the laminae on the articular facets because the facets have been resected.

Various kinds of laminoplasty have been reported for thoracic and lumbar spine, spinal cord and cauda equina tumors (3,4,6,7,11,15,21,32). The use of mini-plates has some advantages over other techniques, such as fixation with drill holes and ties, thus achieving exact realignment of the vertebral arch, immediate stability of the construct, and saving of time.

Laminoplasty procedures may have some benefit, especially when treating a benign disease in young patients (27,30). Progressive post-laminectomy deformity associated with pain requires correction and stabilization by surgical fusion with bone grafting and instrumentation. Posterior bone grafting and instrumentation are usually difficult in these patients because of the small amount of bone surface posteriorly after wide laminectomy. Pseudarthrosis is likely to occur. Combined anterior and posterior approaches are the treatment of choice (18).

Thoracolumbar intraspinal surgery with replacement of the laminar flap using titanium mini-plates and repairing the supraspinous ligament is a minimally invasive procedure and has some potential advantages over laminectomy. These were as follows: 1) bony protection of the spinal canal is restored; 2) development of spinal instability and kyphosis is prevented; 3) replacement of the laminae together with the spinous process clearly provides a better cosmetic result after surgery; 4) epidural scar formation observed after laminectomy is avoided; 5) repeat surgery is easy and safe with preserved posterior anatomic landmarks; and 6) function of the paraspinal muscles is supported by reinsertion of the muscles to the laminae with replacement of the laminae.

CONCLUSION

Laminoplasty for thoracic and lumbar spine surgery enables surgeons to preserve the posterior arch of the spine while preventing invasion of the hematoma and scar tissue, post-operative instability, subluxation, and kyphotic deformities. Repeat surgery is easy and safe with this type of laminoplasty. Considering the overall gratifying as a result of laminoplasty with mini-plates, the authors recommend this technique as a valuable alternative to laminectomy for a posterior approach in intraspinal surgery independent of the patient's age, the location of the lesion, and the number of segments involved.

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