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Replacement of Vertebral Lamina (Laminoplasty) in Surgery for Lumbar Isthmic Spondylolisthesis. A Prospective Clinical Study

Lomber İstmik Spondilolistesizde Laminanın Yeniden Yerleştirilmesi (Laminoplasty) Cerrahisi: Bir Prospektif Klinik Çalışma

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ABSTRACT

BACKGROUND: The use of lamina as a graft for fusion in isthmic lumbar spondylolisthesis (LIS) is not known. In the present prospective clinical study, we used the laminoplasty technique and reported on its outcomes.

MATERIAL and METHOD: Twenty cases that have been operated in our clinic due to G1 and G2 ISL between February 2003 and December 2006 were clinically and radiologically examined. The clinical assessment of the patients was carried out with the Prolo Economic and Functional scale.

RESULTS: Both interbody fusion and laminoplasty procedures concerning 88 pedicles in total were performed on 20 cases of which 10 were at the L4-5 level, whereas 6 were at the L5-S1 level and 2 were at the L3-4-5 level. Five (25%) cases also had coexisting spinal stenosis. 19 (95%) patients had solid fusion but one (5%) had no solid fusion formation while having posterior fusion along with a clinical neurological examination result similar to the one obtained during the preoperative period. In conclusion, the anterior fusion rate was 95%. The most remarkable finding among the patients was the recovery observed at the 2nd month. The Prolo scale results of the cases were good and the follow-up time was 23.5 months.

CONCLUSION: The laminoplasty technique is a method which presents advantages in isthmic spondylolisthesis cases such as short duration of operation, absence of graft donor site complications, preservation of the osteoligamentous structures of the posterior column and a high probability of achievement of fusion through only a posterior approach at a single session; therefore, we believe it is an alternative surgical technique.

KEYWORDS: Laminoplasty, Lumbar spine, Isthmic spondylolisthesis, Spondylolysis

ÖZ

AMAÇ: Lomber istmik spondilolistesizde (LİS) daha önce laminanın füzyon amaçlı yeniden kullanılması tekniği bilinmemektedir. Biz lomber laminoplasti tekniğini bu çalışmada uyguladık.

YÖNTEM ve GEREÇ: Kliniğimizde Şubat 2003 - Aralık 2006 arasında opere edilen toplam Evre 1 ve 2 20 olgu prospektif olarak incelenmiştir. Olgular klinik ve radyolojik olarak incelenmiştir. Hastalar Prolo ekonomik ve fonksiyonel skala ile inceleme altına alınmıştır.

BULGULAR: Hem cisimler arası füzyon hemde laminoplasti işlemi ile totalde 88 pedikül içeren 20 olgu opere edilmiştir ki bunların 10 tanesi L4-5 seviyesi, 6'si L5-S1, ve 2'de L3-4-5 seviyesi idi. 5 olguya (%25) spinal stenosis eşlik ediyordu. 19 olguda (% 95) solid füzyon oluşmuştu, bir olguda (%5) posterior füzyon oluşumu varken cisimler arası füzyon oluşmamıştı ama nörolojik muayenesinde postoperatif dönemle aynı idi. Sonuçta füzyon oranı %95 idi. En dikkati çeken bulgu, olguların 2. ayda şikayetlerinin tamamının düzelmiş olması idi. Prolo skalasının sonucu da iyi bulundu ve olgular toplam 23.5 ay izlendiler.

SONUÇ: Posterior osseoligamentöz yapıları korunması, nöral dokuların korunması,tek seansta cerrahinin bitmesi,greft için dönor saha gerekmemesi, kısa operasyon süresi ve yüksek füzyon oranı ile istmik lomber spondilolistesiz tedavisinde laminoplasti tekniği alternatif cerrahi tekniktir.

ANAHTAR SÖZCÜKLER: Laminoplasti, Lombar omurga, İstmik spondilolistesis, Spondilolizis

INTRODUCTION

There are ongoing discussions about the surgical treatment of lumbar isthmic spondylolisthesis (LIS).

Symptomatic cases had better results after surgery than after conservative treatment (5,24,25). Conducting spinal fusion from both anterior and posterior aspects may provide the strongest fusion and reduction but increases the duration of surgery and morbidity as well (10). Simple decompressive operations have proven to be inadequate. Various authors have expressed different opinions on the timing and type of surgery as well as on whether reduction should be applied or not (1,6,21,24,31). Moreover, autograft or allograft usage for fusion has also been a focus for different opinions (6,13,16,21, 27,28). The autograft has its own advantages but also presents disadvantages such as donor site complications (30). In light of these data, the use of the laminoplasty technique in lumbar and cervical stenosis has been reported (23,24) but its use has not been reported in LIS previously. We therefore aimed to present this new technique and its outcomes in the present study.

PATIENTS and METODS

We clinically and radiologically examined 20 cases that had been operated in our clinic due to G1 and G2 ISL between February 2003 and December 2006. The clinical assessment of the patients was carried out with the Prolo Economic and Functional scale (Table I). The Prolo scale was used as the VAS and the Oswestry Index are only pain scales. Gender distribution was 13 (67%) females and 7 (33%) males. The youngest age was 22, whereas the oldest was 57 (mean age: 33.5). The most common symptoms were low back pain (90%), hip and foot pain (75%), and mechanical low back pain and reduced walking distance (65%). The walking distance was below 100m in 5 (25%) of the cases. Preoperative and postoperative standard anteroposterior, lateral, oblique, and standing flexion-extension radiograms were obtained from all the cases. Grading of subluxations was performed according to the Meyerding classification.

All the patients received medical treatment including bed rest, physiotherapy, and external brace treatment for an adequate time. Only the cases that did not respond to conservative treatment were scheduled for surgery.

Surgical technique: The same surgical treatment method was performed on all the patients. Following the exposure of midline muscles in the prone position, the posterior interspinous ligament bands were elevated to be sutured afterwards. Joint facet surfaces of the lamina were removed en-bloc by monopolar cautery to be put back afterwards (Figure 1). Laminoplasty was conducted with a high-speed drill (with piecemeal laminotomy). This device enables us to perform the procedure rapidly and easily. No dura or nerve root injury was observed during the procedure.

The procedure was carried out after retraction of sublaminar ligamentum flavum. The pressure on the nerve root at the same level or one level above which should be decompressed was removed via

Figure 1: *En-bloc excision following dissection of lamina*

Table I: Summary of prolo economic and functional scale

	Status	
Grade	Economic (activity)	functional (pain)
1	complete invalid (worse)	total incapacity (worse)
2	no gainful occupation	moderate-to-severe daily pain (no change)
3	working/active (but not at premorbid level)	low-level-daily pain (improved)
4	working/active (at previous level w/limitation)	occasional or episodic pain
5	working / active (at previous level w/o limitation)	no pain

Figure 2: *Drilling upper and lower end-plates until spongious tissue is exposed.*

Figure 3: *Implantation of bone chips into the disc space by packing*

foraminotomy. Following massive discectomy using high-speed drills, both upper and lower sides of the end-plate was drilled until observation of blood from the spongious tissue in order to facilitate the fusion (Figure 2). Thereafter, allograft bone chips were compressed from both sides to obtain compact tissue in the disc space (Figure 3). During this procedure, 15cc bone fragments were inserted from both sides and compressed into the disc space to make it compact. Facies articularis inferior of the space that underwent laminoplasty and the cartilages on the joint surface of the removed lamina were decorticated. Care was taken to align the articular surfaces properly during reimplantation. The lamina was placed under the rods firmly in order to avoid its dislocation and bone chips were placed onto the surface of the decorticated facet joint, thus providing a strong fixation including 3 columns. Finally, the interspinous ligaments were sutured. In the end, the midline posterior structures were rendered functional again (Figure 4A,B,C). Following the establishment of the vertebral alignment, the operation was ended by insertion of the pedicle screws (Figure 5).

Clinical and Neuroimaging follow-up

All patients were followed up clinically and radiologically at 1 week, and 3, 6 and 24 months.

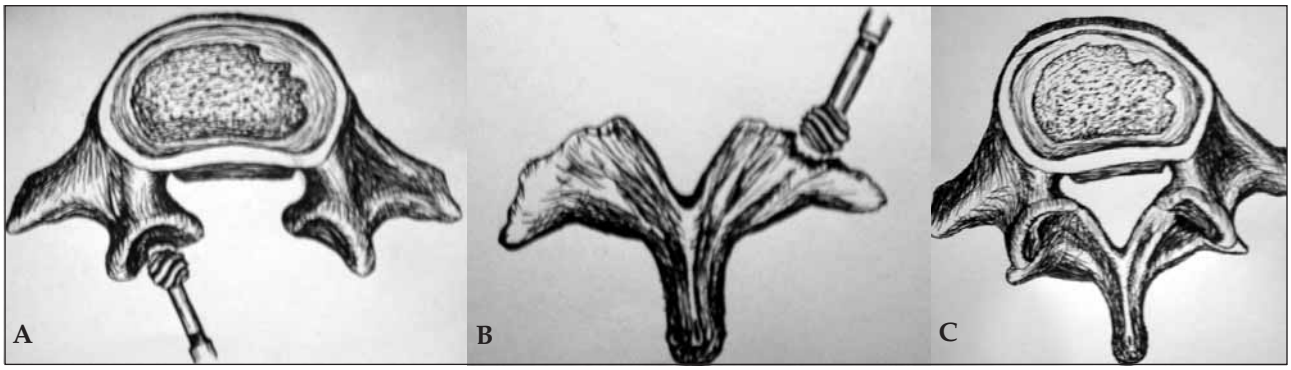

Figure 4: *Procedures applied on joint surfaces followed by tight replacement for fusion.**A**; Facies articularis inferior or the lamina is decorticated with drilling. **B**; Facies articularis superior or the lamina is decorticated with drilling. **C**; Reimplantation of lamina (laminoplasty).*

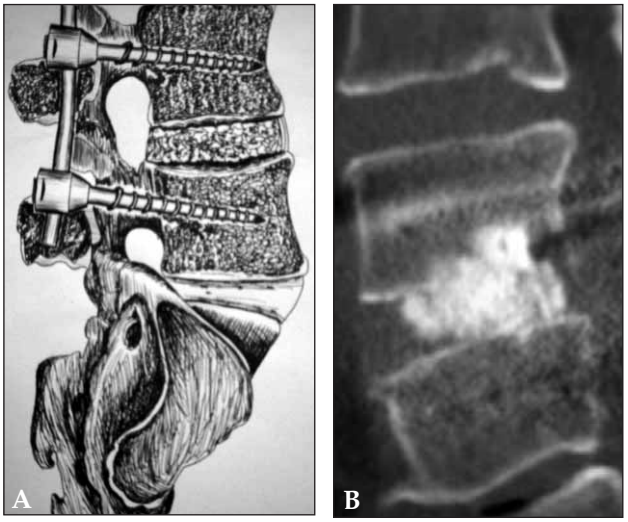

Figure 5: *Illustration (**A**) and image (**B**) show termination of the anterior and posterior fusion with posterior pedicle fixation.*

Clinical follow-ups were performed with the Prolo scale and radiological follow-ups by direct radiography via fine-cut bone-window CT with coronal and sagittal reconstructions (Figure 6A,B). Sagittal (A) and axial (B) reconstructions were included in the evaluation for postoperative fusion assessment with CT (6 months, Figure 7). MRI was performed 2 months postoperatively in all cases to assess neural decompression.

RESULTS

In total, 20 patients with a mean age of 33.5 were operated. Neurological examination revealed no postoperative difference. Generally, the symptoms and complaints of the patients occurred at the 2nd month and that was found to be a remarkable finding. None of the cases displayed postoperative neurological deficit. The straight leg raising test gave

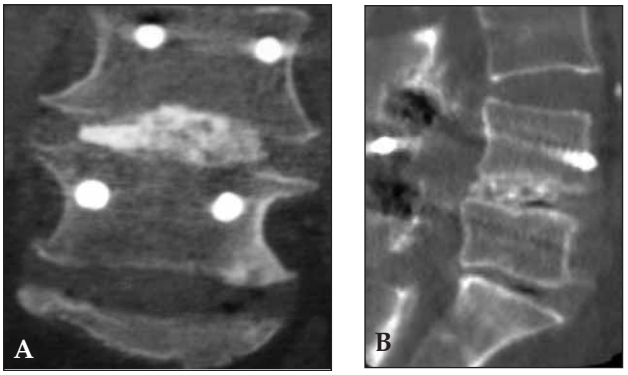

Figure 6: *IImages with coronal (**A**) and sagittal (**B**) reconstructions of the lumbar spine with fine-cut bone-window CT.*

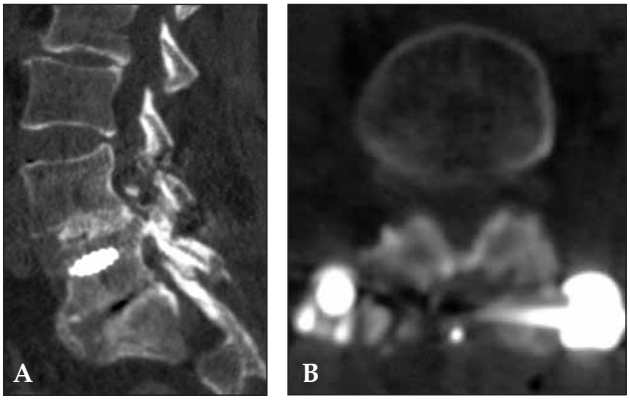

Figure 7: *Sagittal (**A**) and axial (**B**) reconstruction CTs in the postoperative period (6 month).*

a positive result in 11 cases. 6 cases exhibited reflex changes. Neurological and radiological tests of the patients were recorded prior to the operation. 3 (10%) cases showed no angulation, whereas 11 patients had G1 listhesis (55%) and 7 (35%) patients had Grade 2 listhesis. A summary of the clinical, cost-related, and radiological results in the pre-surgery period are presented (Table II). In total, 88 pedicle screws were inserted in 20 patients. In 4 cases, 6 pedicle screws were placed which involved the L3-4-5 spaces in 2 cases and L4-L5-S1 spaces in 2 cases. The reason for those insertions was G2 ISL. The PLIF technique was performed only at the listhetic level. For instance, L4-L5 interbody fusion was conducted in the L3-L4-L5 listhetic case. Laminoplasty was performed for posterior fusion.

Spinal stenosis accompanied the spondylolisthesis in 5 (25%) cases. The PLIF procedure failed in 1 case due to pseudoarthrosis (Figure 8 A,B,C). However, posterior fusion was a complete success (8). This case had no complaints arising from the pseudoarthrosis. In other words, it was a clinical success whereas a radiological failure. Complete fusion was achieved in all cases except one; bone fusion occurred at the intervertebral level as well as in the posterior laminar arcus. Fusion rate was 95% among the patients. Four cases were chronic smokers who consumed 1 pack/day. Sagittal plane rotations and displacements were calculated based on the disc space. The final radiological follow-up period was 23.5 months. Sagittal plane rotation, disc space, and disc space height were measured; the preoperative and postoperative values are shown in (Table III). Pre- and post-surgery sagittal plane displacement, sagittal plane rotation and disc space height

Table II: Summary of pre-and postoperative neurologic deficit rate and Prolo score

	Preop	Postop	12. mo	24. mo	Change
Motor deficit	None	None	None	None	0
Sensory deficit	12	6	4	4	50
Economic score	2.9	4.1	4.3	4.3	57
Functional score	3.2	3.9	4.5	4.8	54

differences were statistically significant ($p<0.05$). The only observed complication was a dura tear in 2 cases. No infection was found. The mean duration of surgery was 2.4 hours. The mean volume of blood loss was 320 cc. None of the cases displayed adjacent segment disease during the follow-up period due to PLIF (mean duration: 23.5 months). Long-term results will be followed-up with MRI.

DISCUSSION

Surgical approaches in lumbar ISL are various and there is an ongoing discussion on determining the most effective one. Many methods have been defined following simple decompression and reduction such as posterior or posterolateral fusion (4,33), fixation alongside PLIF with reduction (20), 360° circumferential fusion with reduction (33), simple decompression without fusion (16), stabilization and posterior reduction via minimal laminectomy (17,19,33), and reduction and stabilization without laminectomy (2,3,21). The target of surgery is to decompress the neural structures and stabilize the vertebral column. Vertebral column stabilization methods are used for the fusion of the unstable vertebral segment. Gill underscored the method of posterior decompression in patients with symptoms associated with nerve root compression (12). The same study reported painful radiculopathy in low-grade spondylolisthesis and underscored a disadvantage brought by application of destabilization.

Booth and Herkowitz conducted a prospective, randomized study and reported worse outcome for patients who were subjected to only laminectomy as compared with the patients who received arthrodesis (4,15).

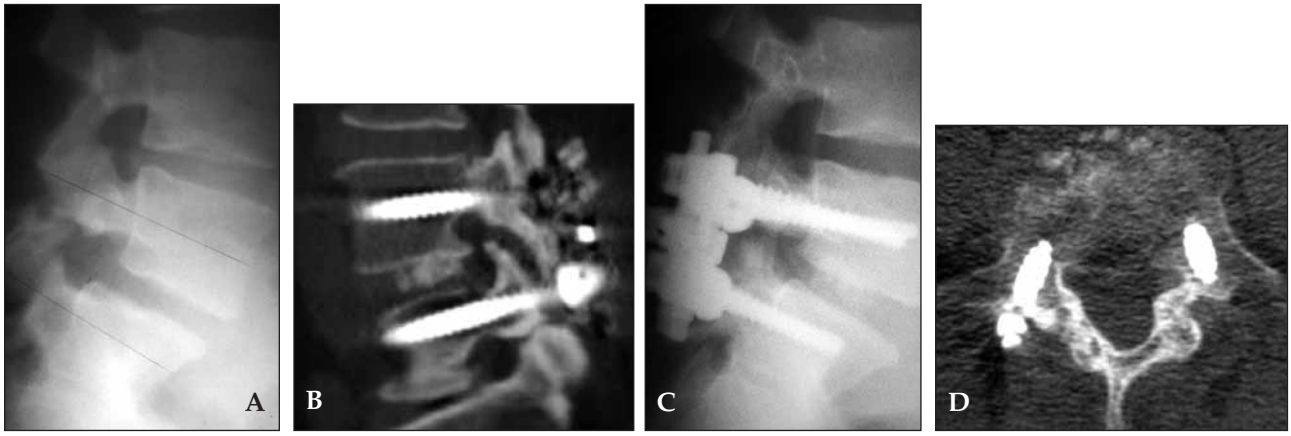

Figure 8: *Complete posterior fusion occurred while anterior fusion was not observed in one case.* ***A****; Preoperative direct lateral X-ray,* ***B****; postoperative direct lateral X-ray,* ***C****; Pseudoarthrosis is demonstrated by direct lateral X-ray in the late postoperative (12 month) period.* ***D****; Posterior fusion was found to have developed in this case.*

Table III: Summary of measurements determined in 20 patients with ISL

Measurement	Preop	Postop	P Value
Sagittal-plane displacement (%)	31.56±7.9	3.5±2.1	<0.05
Sagittal-plane rotation (°)	12.44±2.9	8.25±2.1	<0.05
Disc space height (%)	19.5±2.4	25.5±3.1	<0.05

Swan et al. (32) conducted a comparative study on low-grade ISL cases and achieved better results in patients that were subjected to posterior + anterior fusion surgery as compared with those who received only posterior fusion. However, this success rate was accompanied by a long and difficult operation technique with a high hemorrhage level. In contrast, the surgical technique we use enables establishment of a compact support tissue with allograft bone chips in the anterior portion without causing any donor site morbidity and helps achievement of fusion in the physiological column posterior aspect by laminoplasty, along with preserving the strength of the entire vertebral column by pedicle screws. This procedure can be performed just like any other PLIF procedure carried out without requirement of an anterior approach. Adequate foraminotomy and spinal canal decompression can also be conducted. To our knowledge, no study has described this technique based on performing PLIF with bone chips while preserving the lamina and interspinous ligaments that establish the integrity of posterior column in lumbar spondylolisthesis in the literature.

Our aim in applying this technique was to preserve anatomic structures such as the dural sac and nerve roots. Following the achievement of compact tissue, the posterior lamina is reimplemented for posterior fusion. All our cases exhibited intervertebral bone fusion and posterior laminar arcus fusion.

Matsudaira et al. (23) defined a technique that included no anterior fusion for repositioning to preserve the posterior components in spondylolisthesis and found it to be easy to apply while having a high success rate (6,9,11-14,21,24,27-31).

Pedicle screws fixate the distal segment and maintain immobilization that helps fusion. The insert-and-rotate posterior lumbar interbody fusion (PLIF), described by Jaslow in 1946, can be performed safely and effectively by surgeons in a single session.

Interbody fusion has been compared with posterolateral fusion previously and the Fraser PLIF technique has been reported to achieve better fusion (10). Various intervertebral implants have been employed for PLIF and fusion results were found to be about 72% and 87% (22,36).

Many surgeons criticize the PLIF technique regarding complications such as epidural fibrosis, nerve root scarring and excessive nerve root retraction; moreover, safe instruments are needed because it is frequently required to remove the supportive structures of vertebral column. Many methods with minimal morbidity have recently been developed while staying loyal to the standard PLIF technique (3). Most of these methods are reported to have a high neural damage risk. However, we observed no complications during our operations.

In the current study, no metallic implant was present in the fusion site and free allograft chips were compressed. The surface space was adequately large for fusion.

The intervertebral cage can take a limited number of graft chips. Thankfully, uninstrumented PLIF has less morbidity and a lower price compared to instrumented (without an intervertebral cage but with pedicle screws) PLIF.

The optimal target is to place the bone graft by applying maximum compression on the bone fusion bed. We observed no complications such as graft displacement or stenosis. Discussions on the use of allograft vs. autograft to restore fusion still continue. The fusion rate varies between 75-95% when an allograft is employed in ILS (7,19,32). In our surgical series, this rate was 95% for fusion while the clinical success rate was 100%. Autograft usage in spinal operations may lead to donor site complications. The major complication rate may rise up to 8.6%. The other major complications were as follows: 2.5% infection, 0.8% prolonged wound leak, 3.3% large hematomas, 3.8% reoperation, 2.5% pain that can be prolonged up to 6 months, and 1.2% loss of sensation. Even if the same surgical incision is used for graft harvest, the complication rate can be as high as 17.9% (36). In our series, no donor complication associated with allograft was found. The duration of surgery was short and the fusion rate was higher (95%).

Cutting lamina facilitates the surgery. Reduction is performed following insertion of the pedicle screw and the lamina is again compressed between the rods before the procedure is finalized by suturing the interspinous ligaments.

Another advantage of this technique is neural preservation. Adhesion of fibrous scar tissue, dural band nerve tissue, and paraspinal muscle tissue have been observed following failed low back syndrome surgery requiring reoperation. Scar formation and band formation are particularly the underlying causes of postoperative pain and low back discomfort (5,22). Collection of blood in the paravertebral muscles after laminectomy leads to formation of scar tissue. We

therefore believe that reimplantation of free lamina prevents scar formation by inhibiting blood collection in the paravertebral muscle. This theory has been verified on laboratory animals (5,35). Another advantage is that it facilitates performing revision surgery.

CT has replaced linear tomography in anatomical evaluation of the bone comprising the fusion mass. Vertebral bone structures and fusion in graft and lamina may be evaluated by restructuring of the 3D structure of the vertebral column. Novel CT technologies allow subtraction of the metallic instrument resulting in less artifact. We used coronal and sagittal tomographies on all our patients.

MRI may be useful in evaluation of post-op complications such as asymptomatic infection and abscess, and may help in assessment of progression of adjacent segment disease. We applied MRI in all our cases but did not suggest MRI to our patients because they displayed no pathology during the follow-up period.

To our knowledge, this is the first study on the technique involving the establishment of fusion by reimplantation of lamina.

We consider the laminoplasty technique in ISL cases as an alternative surgical technique presenting advantages such as preservation of the osteoligamentous structures of the posterior column, conclusion of the operation in a single session, absence of graft donor site complications, and high fusion rates.

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