ORIGINAL ARTICLE

Our technique of midsagittal splitting laminoplasty for compressive cervical myelopathy and its short-term results

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ABSTRACT

Objective: The aim of this study was to discuss the technique of midsagittal splitting laminoplasty and to compare its short-term follow-up results with laminectomy in cases of compressive cervical spinal cord myelopathy.

Materials and Methods: Exclusion criteria were as follows: Intramedullary compressive lesions, kyphotic cervical spine, previous spinal surgeries, and defective anterior vertebral column. Twenty patients (10 each of laminoplasty and laminectomy groups) were prospectively studied from 2005 to 2008. After clinico-radiological assessment, laminoplasty or laminectomy was performed in patients aged <50 years and >50 years, respectively. The laminoplasty was performed by splitting the excised lamina in midline up to the tip of spinous process. Follow-up was done by neurosurgical cervical spine scoring, Nurick's grading, and the final outcome was determined by Odom's criteria.

Results: The mean operative time and blood loss in laminoplasty and laminectomy was 100 ± 0.87 (range 90-140 min), 80 ± 0.67 (range 75-100 min) $P = 0.04$; and 65 ± 0.07 (range 60-90 ml) and 68 ± 0.61 (range 65-80 ml) $P = 0.09$, respectively. There were no intraoperative accidents, and no postoperative neurological deterioration/recurrence of symptoms. One patient who underwent laminectomy alone developed progressive kyphosis of the spine, whereas one having rheumatoid arthritis and long symptom duration didn't improve. 85% (17/20 patients) had sustained excellent to fair outcome (improvement by at least one Nurick's grade).

Conclusions: The technique used by us was simple, effective, and inexpensive. There was no minimal postoperative morbidity, although long-term results are awaited.

Key words: Cervical spondylitis, compressive spinal myelopathy, laminectomy, laminoplasty

Introduction

Cervical canal stenosis may be developmental, traumatic, secondary to multisegmental cervical spondylosis, or due to ossification of the posterior longitudinal ligament.[1,2] The cervical spondylitis is a common cause of compressive spinal myelopathy (CSM).[3] The laminoplasty provides adequate decompression of the spinal canal and, at the same time, reduces instability by preserving and reconstructing posterior vertebral elements of the spine [Table 1].[3-6] The stability of posterior vertebral elements also prevents the kyphosis and swan-neck deformity in long term.[3-7] Here, we performed a newer technique of laminoplasty to expand the antero-posterior diameter of cervical spine canal. The technique and its short-term follow-up results were compared to laminectomy.

Materials and Methods

All patients having cervical spondylitis as the cause of CSM were prospectively analyzed from January 2005 to January 2008 at the university hospital. We excluded patients who previously underwent any kind of cervical spine surgery, patients having intramedullary lesion as the cause of myelopathy, associated kyphotic deformity of the cervical spine, or defective anterior column of cervical vertebra (due to trauma, tuberculosis, and or malignancy). The ethical approval

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was taken from the ethical committee of the university along with informed written consent from the patients.

The patient's neck was first immobilized by application of hard cervicalcollar. Clinical examination, neurosurgical cervical spine scoring (NCSS), Nurick's grading, X-ray cervical spine (antero-posterior and lateral views), and magnetic resonance imaging (MRI) of cervical spine were done [Tables 2 and 3]. The comorbid conditions (diabetes mellitus, rheumatoid arthritis, and hypertension) were managed simultaneously. The patients were divided into two groups according to the age, one who underwent laminoplasty (age <50 years), and other who underwent laminectomy alone (age >50 years). The demographic data, imaging findings, NCSS, and Nurick's grades were analyzed in the follow-up. The final outcome was determined by Odom's criteria [Table 4].

Operative procedure
The surgery was done under general anesthesia. The patients positioned prone and the head was supported on a horseshoe-shaped pad in the neutral position. Midline longitudinal incision was made from two vertebras above to

the two vertebras below of the diseased vertebras. Following exposure of appropriate lamina, the spinous processes of diseased vertebras along with one healthy vertebra above and below were tried to excised enblock with their spino-ligamentous complex. The lateral portion of laminas left *in situ* adjacent to the facet joint were drilled deeply to form gutters via the microspeed power system, having a 1.4 mm diamond shape burr (Aesculap B/BRAUN, Germany) [Figures 1 and 2]. The inside table of excised lamina was splited in midline up to the tip of spinous process. This portion serves the basis for the enlargement of cervical canal. A tunnel extending into the inferior articular process was made bilaterally on the excised lamina via the microspeed power system. Another tunnel was created into the corresponding portion of lamina left *in situ*. The excised lamina after splitting in midline was replaced to their position and secured via silk (2, 0) round body needle suture/22 gauge stainless steel wire passing into

Table 1: Indications and contraindications of laminoplasty[3]

Indications	Contraindications
Compressive myelopathy and radiculopathy due to cervical spondylosis, prolapse intervertebral disc/ossified posterior longitudinal ligament/thickened or calcified ligamentum flavum	Loss of anterior vertebral column because of tumor, trauma, or infection
Prolapse cervical disc with predominantly radicular symptoms	Isolated radiculopathy
Tumors, infective lesions, or communicated fractures involving the posterior vertebral elements and impinging into the spinal canal	Focal anterior compression of spinal cord
To gain surgical access to intraspinal pathology like tumors, infective granulation, abscess, or syringomyelia	Established kyphosis
In extended laminectomy (including c2 and sometimes c1): As subsequent hyperlordosis cause posterior migration of spinal cord, hence tension on nerve root and blood vessel	
In young patients, as predisposition to kyphosis is high	

Table 2: Nurick's classification of disability

Grade 0	Root signs and symptoms. But no evidence of cord involvement
Grade I	Signs of cord involvement. But normal gait
Grade II	Mild gait involved, but able to be employed
Grade III	Gait abnormality prevents employment, but ambulant without support
Grade IV	Able to ambulate with assistance
Grade V	Chair-bound or bedridden

Table 3: Neurosurgical cervical spine scoring

Lower extremity motor function

  Total disability: Chair bound or bedridden

  Severe disability: Needs support in walking on flat, and unstable to ascend or descend stairways

  Moderate disability: Difficulty in walking on flat, and needs support in ascending or descending stairways

  Mild disability: No difficulty in walking on flat, but mild difficulty in ascending or descending stairways

  Normal: Normal walking, with or without abnormal reflexes

Upper extremity motor function

  Total disability: Totally unable to perform daily activities

  Severe disability: Severe difficulty in daily activities with motor weakness

  Moderate disability: Moderate difficulty in daily activities with hand and/or finger clumsiness

  Mild disability: No difficulty in daily activities, but mild hand and/or finger clumsiness

  Normal: Normal daily activities, with or without abnormal

Sensory function and/or pain

  Severe disturbance: Severe difficulty in daily activities with incapacitating sensory disturbance and/or pain

  Moderate disturbance: Moderate difficulty in daily activities with sensory disturbance and/or pain

  Mild disturbance: Normal daily activities, but mild sensory disturbance and/or pain

  Normal: Neither sensory disturbance nor pain

Table 4: Odom's criteria for final outcome

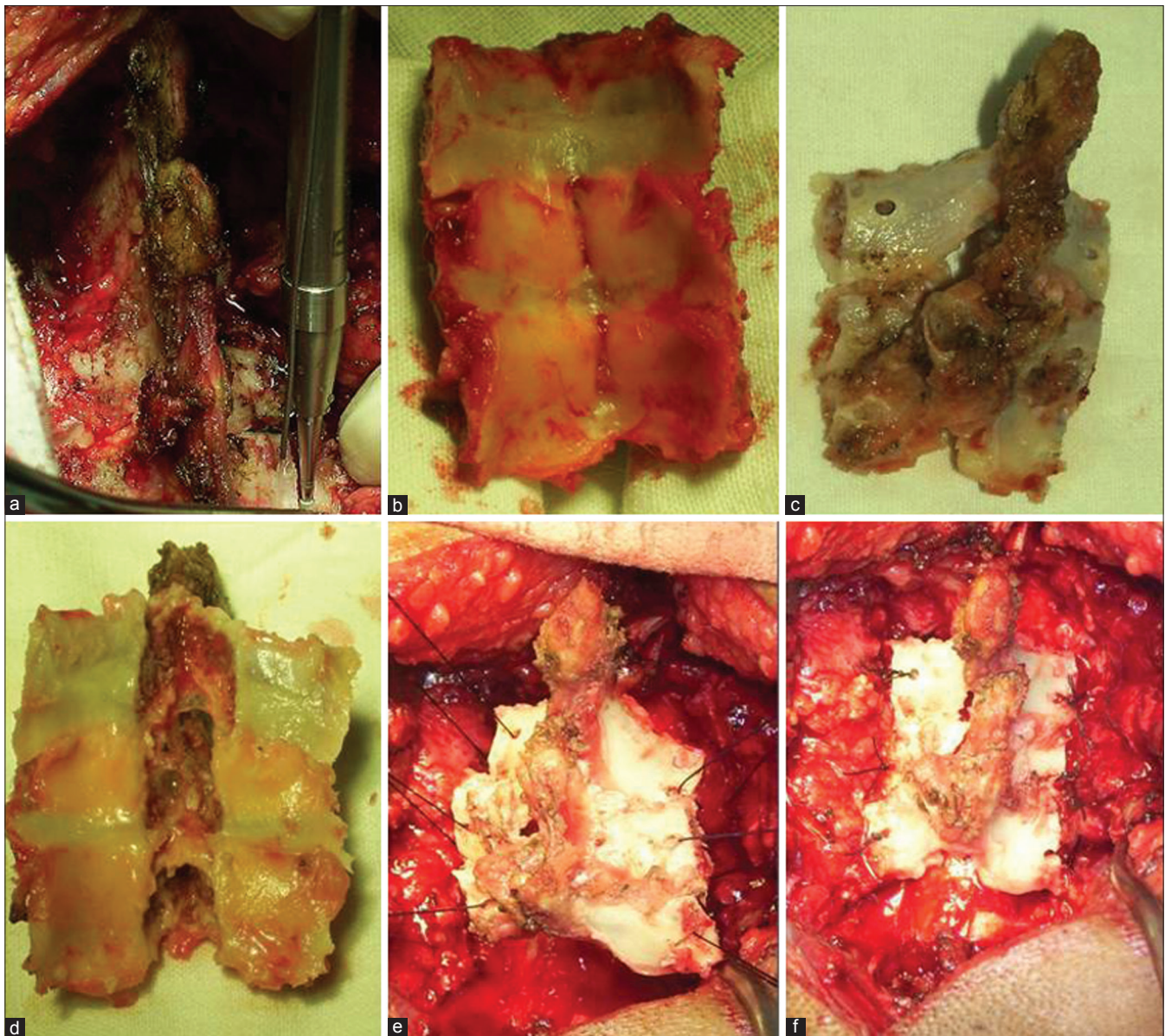| Outcome	Definition
Excellent	All preoperative symptoms relieved; abnormal findings improved
Good	Minimal persistence of preoperative symptoms; abnormal findings unchanged or improved
Fair	Definite relief of some preoperative symptoms; other symptoms unchanged or slightly improved
Poor	Symptoms and signs unchanged or exacerbated

Figure 1: (a) Exposed diseased cervical vertebras. (b) Laminas were excised enblock with a spino-ligamentous complex. (c) Tunnels were drilled into adjacent laminas on either side. (d) Midline saggital splitting of the inner table of lamina up to the tip of spinous process. (e) Splitted laminas were repositioned with a nonabsorbable suture. (f) Completed laminoplasty

the tunnels created on adjacent laminas. If enblock excision of laminas was not successful, individual lamina excised and repositioned after midline splitting, as described above. Thus, antero-posterior diameter of the reconstructed neocanal was increased [Figure 3]. Suction drain was placed and wound closed in three layers via absorbable sutures. The compressive dressing was done. During surgery average blood loss, time of operation, and intraoperative accidents (excessive bleeding, fracture of lamina during excision and/or during drilling, injury to spinal cord and/or nerve roots, failed laminoplasty due to any reason) were noticed.

In the postoperative period, intravenous antibiotics amoxicillin clavulanic acid 1.2 gm 6 hourly and amikacin 500 mg 12 hourly was administered for 5 days. The patients were ambulated from bed on the next day of surgery with application of a hard cervical collar. We have not used any other external orthosis for neck immobilization. The patients were discharged on the sixth to eighth postoperative day with proper advice and follow-up. The patients were advised to wear a hard cervical collar for 3-4 weeks following surgery. The patients were reexamined in follow up at outdoor visits at 3 months interval for at least 2 years.

Statistics

The data were analyzed through SPSS software, version 17.0. The continuous variables were expressed as mean values and ranges (minimum to maximum), as well as in percentages. The

Figure 2: (a) The inner table of individual lamina was splitted by either chesal and hammer, or (b, c) via microspeed power burr. (d) Individual lamina splitted in the midline. (e) Splitted laminas were repositioned with steel wires
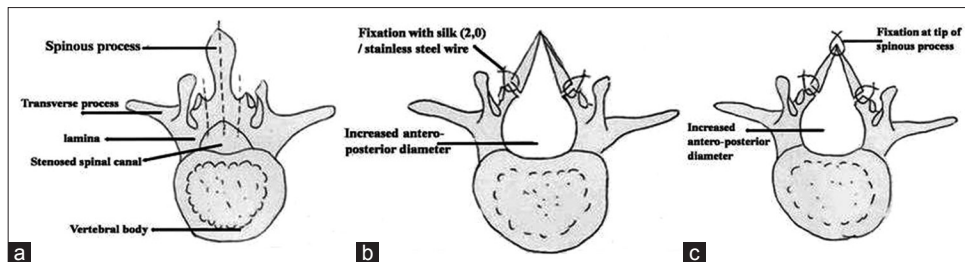

Figure 3: Pictoreal diagram showing basis of the technique (dotted line denotes line of laminectomy). (a) Preoperative narrow antero-posterior spinal diameter. (b) Increased antero-posterior diameter of the spinal canal after laminoplasty

analysis was performed using the Pearson χ^2 for categorical variables and Student's *t*-test for continuous variables. The non-parametric analysis was done with the Wilcoxon signed rank test. The $P <0.05$ was considered as significant while <0.005 as highly significant.

Results

A total of 25 patients having CSM were admitted at the department of university hospital over a 3 year period. Five patients were excluded from the study (kyphotic deformity

in one, previous spinal surgery in two, cervical spinal cord tumor in one, and intradural neurofibroma in one). The mean age at surgery was 58 ± 0.24 years (ranged 45-67 years). The male to female ratio was 19:1. The mean symptom duration was 18 ± 0.04 months (ranged 4-36 months). Three patients had diabetes mellitus. All patients had mixed sensory-motor symptomatology. The paraparasis was the most common presentation (65%, 13/20 patients) followed by monoparasis (20%, 4/20 patients) and quadriparasis (15%, 3/20 patients). Cervical mechanical changes (restricted neck movements and cervical pain) were present in 55% (11/20 patients) of patients. Muscle wasting was present in 15% (3/20) patients, which was related to their long symptom duration ($P = 0.05$). 35% (7/20) of patients had bladder and bowel involvement. 65% (13/20) of patients could not perform their jobs (Nurick's grade III).

On radiological assessment C_5-C_6-C_7 vertebras were most commonly involved. All patients showed radiological changes of spondylitis in X-ray cervical spine and 90.4% (19/20) of these changes disappeared at the end of 2 years of follow-up [Figure 4]. It was observed that if patients had a symptom duration of less than 5 months, there were no changes in the intensity of spinal cord on either T_1- or T_2-weighted MRI images ($P = 0.08$). However, as the duration of symptoms increased, the signal intensity of spinal cord in MRI images also increased (suggestive of dysplastic changes). The first noticeable change on MRI is on T_2-weighted MRI images, and these images are also more sensitive for predicting outcome. The patients having signal changes on only T_2-weighted images (85%, 17/20 patients) had better outcome in the postoperative period compared to those having altered signal on both T_1- and T_2-weighted MRI images ($P = 0.04$). One patient who underwent laminectomy alone had developed kyphosis after 6 months of surgery, which further progressed in the follow-up.
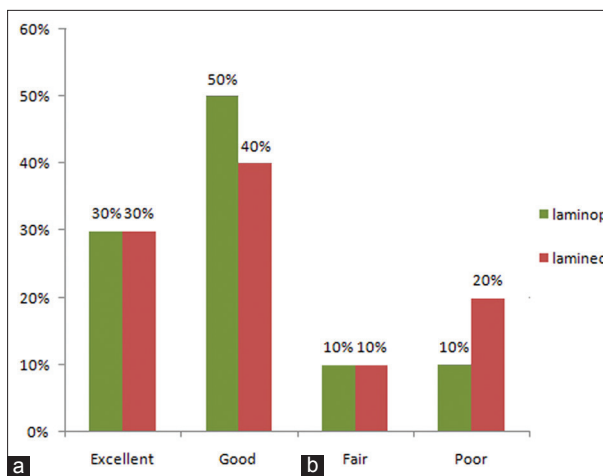

Figure 4: (a) Preoperative X-ray: Lateral view of cervical spine showing loss of cervical lordosis, anterior and posterior osteophytosis suggestive of cervical spondylosis. (b) Postoperative X-ray showing loss of posterior osteophytes and slight regain of lordosis

The laminoplasty/laminectomy was done from C_4 to C_7 in most of the cases. In six patients, the laminoplasty was done enblock, while in four it was done by repositioning of individual lamina. In authors' opinion, it takes longer time with the later technique, but had not affected the final outcome. The mean operative time in laminoplasty and laminectomy was 100 ± 0.87 (range $90 - 140$ min) and 80 ± 0.67 (range 75-100 min) $P = 0.04$. The average blood loss in laminoplasty and laminectomy was 65 ± 0.07 ml (range 60-90 ml) and 68 ± 0.61 (range 65-80 ml) $P = 0.09$.

There were no intraoperative accidents. The most common complication in the postoperative period was cerebrospinal fluid leak 15% (3/20 patients) followed by wound infection 10% (2/20 patients). Both the above complications were managed conservatively by prolonged use of intravenous antibiotics, regular dressings, and strict control of blood sugar in diabetic patients.

The follow-up was done at outdoor visits, questionnaires by mail, or on telephone calls. The symptom that improved earliest was radicular pain. The range of neck movements improved in both groups and compared between both laminectomy and laminoplasty groups.

On comparing Nurick's grade at the end of 2 years, it was found that within the laminoplasty group: One patient having grade V improved to grade IV and lost to follow-up at 1 year. Seven patients having grade IV of which five improved to grade III, one to grade II, and one did not improved at 6 months. All these patients improved further to one grade of Nurick's at the end of 2 years. Two patients of grade III improved to grade II at 6 months and further to grade I after 2 years. Among the laminectomy group, two patients of grade V improved to grade IV. One patient had lost to follow-up at 1 year, while the second patient remained in grade IV at 1 year of follow-up. Out of six patients having grade IV Nurick's, three had improved to grade III, two to grade II, while one remained in grade IV at 6 months of follow-up. These five patients had further improved to grade I at 2 years. The patient, who had not improved in follow-up after 6 months, had lost to follow-up. Out of two patients having grade III Nurick's, one improved to grade II at 6 months and grade I at 2 year. One patient deteriorated in the postoperative period up to Nurick's grade I, who acquired kyphotic deformity of the neck [Table 5].

In both groups, the mean NCSS scoring improved significantly in the postoperative period (non-parametric analysis with the Wilcoxon signed rank test) [Table 6]. In 2 years of follow-up, neither patient deteriorated nor had recurrence of symptoms, except one who developed progressive kyphosis of cervical spine after laminectomy alone. One patient having both diabetes mellitus and rheumatoid arthritis along with the long duration of symptoms did not improve at all. The final outcome based on Odom's criteria is shown in Figure 5.

Table 5: Preoperative and follow up Nurick's grades

Grades	Preoperative		Postoperative (6 months)		Postoperative (2 years)	
	Lamin-oplasty	Lamin-ectomy	Lamin-oplasty	Lamin-ectomy	Lamin-oplasty	Lamin-ectomy
I	0	0	-	-	3	1
II	0	0	3	2	3	5
III	2	2	5	5	3	0
IV	7	6	2	2	-	1
V	1	2	-	1	-	1
Total	10	10	10	10	9 (1 Pt. lost to follow-up)	8 (2 Pt. lost to follow-up)

Table 6: Comparison of NCSS scores at the end of 2 years

	Laminoplasty			Laminectomy		
	Preoperative	Postoperative	*P* value	Preoperative	Postoperative	*P* value
Lower extremity motor	2.8±0.9	4.8±0.9	0.03*	2.8±0.2	4.2±0.7	0.03*
Upper extremity motor	3.4±0.2	4.6±0.2	0.04*	3.3±0.4	4.1±2	0.04*
Sensory	2.8±0.4	3.8±8	0.03*	2.6±0.2	3.0±0.1	0.03*

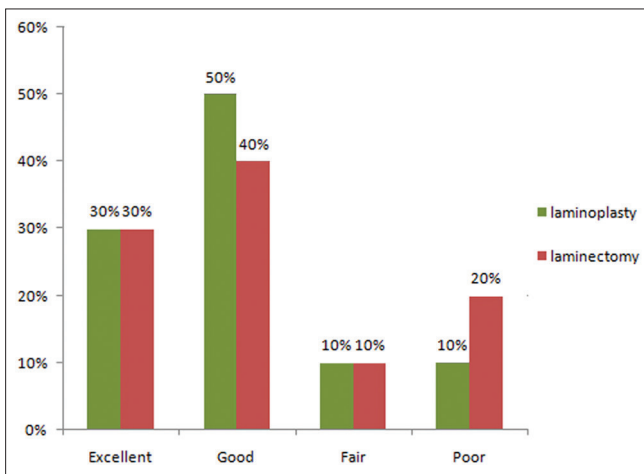*Significant; NCSS – Neurosurgical cervical spine scoring

Figure 5: Outcome at the end of 2 years (Odoms' criteria) in both laminoplasty and laminectomy groups

Discussion

Stookey advocated the removal of cartilaginous nodules of degenerate disk material for cervical spondylotic myelopathy.[8,9] Cervical spondylosis with multiple osteophytes better responds by extensive posterior decompression compared to limited laminectomy, so Aboulker *et al.* introduced total laminectomy from C-1 to D-1.[8-10] However, after laminectomy spinal deformity has been reported in 10-15% of the cases.[11,12] As in elder patients with poor muscular tone lack of cervical spine support lead to the development of cervical instability and kyphosis.[13] The laminoplasty is the procedure of choice in CSM, especially when multiple vertebras involve in young age.[14-16] In laminoplasty, the dura is covered by the bone; thus, restrangulation by the postlaminectomy membrane does not occur.[18,28,29] But laminoplasty does not have good

results in aged >65 years, myelopathy of >2 year duration, spinal canal stenosis of >60%, and kyphotic cervical spine curvature.[17,18]

Omaya and Hattori *et al.* described expansive lamina Z plasty.[7,17,19] Since then, several modifications such as use of wires, iliac bone graft, rib allografts, ceramic/apatite beads, mid-longitudinal bone graft, tension band laminoplasty, vascularized pedicled laminoplasty, vascularized pedicle on supraspinous, interspinous, and interlaminor ligaments, expensive midline T-saw laminoplasty, CG-Clip-assisted laminoplasty, etc., have been described.[20-26] All these procedures were technically demanding and cause some economic burden to the patients. But the technique described by us was not expensive.

We observed that it takes about 5 months for the CSM to produce signal changes in the spinal cord on MRI. The preoperative MRI may help to predict the postoperative outcome of surgery as signal changes on both T_1- and T_2-weighted MRI images showed poor outcome compared to the signal changes on T_2-weighted MRI images only.[3,6]

We had used Nurick's grade because of its simplicity (gait disturbances) which can be obtained by mail or telephonic questionnaire.[27] NCSS scoring provides objective assessment of sensory — motor functions.[3] Odom's criteria are the simplest and most widely used for outcome assessment.[3,27] Based on Odom's criteria, 85% (17/20) of patients had sustained excellent to fair results (improvement by at least one Nurick's grade), despite initial advanced disease (Nurick's Grade IV/V).

Our technique increased the diameter of spinal canal which enhances neurological recovery because of canal

Table 7: Conclusions drawn from our study

The operative procedure used in our study was cost effective as it needs no expensive material (avoids unnecessary economical burden to patients), technically easier, equally effective to prevent postoperative instability of spine. The range of postoperative neck movement was comparable to laminectomy

There was no use of graft material in our technique, hence there were no complications like graft failure and donor site morbidity, etc., There was no need for long postoperative bed rest which is usually needed to secure graft stability

The technique used by us has less operative time, operative blood loss in comparison to other type of laminoplasties, but the long term results are comparable

No patient detreriorated in follow-up by this new technique

After laminectomy, there is risk of vertebral coloum to be further deformed on long term, which may lead to further damage of the spinal cord. But, laminoplasty prevents spinal instability and there was no further deterioration due to surgery itself

enlargement and improvement in the circulation of the spinal cord and nerve roots.[18,28,29] The re-stenosis of the spinal canal is supposed to be the most common complication of our technique, but the authors did not encounter it in any patients till date; however, long-term results are still awaited. Other complications reported in the literature, like transient C5-6 root paresis, severe neck pain with or without paresthesias, and under riding of the lamina at the hinged side had not occurred in any of our patients.[13] The technique is cost effective (need no expansive material), simple, effective to prevent postoperative instability, but technically demanding. There were no risk of graft failure, donor site morbidity, and neurological deterioration [Table 7]. There was no need for prolonged bed rest to secure graft stability. The technique needed less operative time, less blood loss contrary to what had been reported in the literature, but with comparable results.[3]

To conclude midsaggital splitting, the laminoplasty technique was effective for the treatment of CSM, although long-term results of the technique is still awaited.

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