EXPERIMENTAL STUDY

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The effect of expansive open-door laminoplasty on spinal canal diameter: an experimental study on rabbits

Massoud FATEH[1], Baransel SAYGI[2], Özgür KARAMAN[2], Murat BEZER[3]

[1]Department of Orthopedics and Traumatology, Acıbadem Hospital, İstanbul, Turkey;
[2]Department of Orthopedics and Traumatology, Fatih Sultan Mehmet Training and Research Hospital, İstanbul, Turkey;
[3]Department of Orthopedics and Traumatology, Faculty of Medicine, Marmara Univesity, İstanbul, Turkey

Objective: The aim of this experimental study was to evaluate the effect of expansive open-door laminoplasty with simple suture fixation on spinal canal diameter in a rabbit model.

Methods: Twenty white New Zealand rabbits were operated on with C4-C7 Hirabayashi open-door laminoplasty. The spinal canal diameter was evaluated radiologically on preoperative day 1 and postoperative days 1 and 42.

Results: The mean spinal canal diameter was 6.42 mm preoperatively, 8.04 mm on postoperative day 1 and 8.02 mm at day 42. There was a significant difference between the mean preoperative and postoperative day 1 spinal canal diameter ($p<0.001$). There was no significant difference between the mean spinal canal diameter at postoperative day 1 and 42 ($p>0.05$).

Conclusion: Our results suggest that the open-door laminoplasty with simple suture fixation is an effective method to expand the spinal canal diameter. No recurrent narrowing is expected in short term.

Key words: Expansion; laminoplasty; myelopathy; reclosure; spinal canal.

Cervical myelopathy is caused by spinal cord compression which can be due to congenital or degenerative spinal stenosis or ossification posterior longitudinal ligament. Surgery is the treatment of choice in severe or progressive myelopathy. The primary goal is to decompress the spinal cord while maintaining the stability of the cervical spine.[1-4] Anterior or posterior approaches may be used during surgical treatment. Laminectomy, laminoplasty and laminectomy with fusion are the posterior decompression techniques. Expansive open-door laminoplasty, which was first described by Hirabayashi in 1978, was developed as an alternative to laminectomy in an attempt to prevent postoperative spinal instability and postlaminectomy kyphosis.[5-8]

The main concern in laminoplasty is expanding the spinal canal effectively and permanently.[9-11] To maintain the expansion of the spinal canal in open-door laminoplasty, many techniques, such as bone grefting, miniplate fixation, suture anchors, screws with or without spacer interposition, have been proposed.[9-16] Although these techniques increase the complexity and cost of surgery, many studies showed that they are not superior to simpler techniques.[9-11,17]

Correspondence: Baransel Saygı, MD. Fatih Sultan Mehmet Eğitim ve Araştırma Hastanesi Ortopedi ve Travmatoloji Kliniği, E5 Karayolu Üzeri, İçerenköy, Ataşehir, 34752, İstanbul, Turkey.
Tel: +90 216 - 578 30 00 e-mail: baranselsaygi@yahoo.com

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The aim of this experimental study was to evaluate the effect of expansive open-door laminoplasty with suture fixation on spinal canal diameter in a rabbit model.

Materials and methods

After Institutional animal care and use committee approval, 20 (11 male and 9 female) white New Zealand rabbits (mean age: 23.85±1.26 months, weight: 3325± 361 g) were operated on with Hirabayashi open-door laminoplasty between C4 through to C7.[18] The anteroposterior spinal canal diameter of the animals were measured on computerized tomography (CT) images on preoperative day 1 and postoperative days 1, and 42 under sedation.

A standard Hirabayashi open-door laminoplasty was performed in prone position under general anesthesia with endotracheal intubation. The laminae, from C3 to C7, were exposed through a posterior midline incision by dissection of paravertebral muscles bilaterally. Laminae medial to facet joints were cut on the left side at C4-C7 levels with high speed burr. These hinged laminae were opened like a door from left to right and to prevent the closure of laminar door nonabsorbable sutures were placed through the drilled holes at the base of spinous processes and secured laterally to facet joint capsules (Fig. 1). Fat graft was placed over the exposed dura. Following surgery the animals were put back to their cages and the return of the normal spinal cord function was confirmed.

To measure the anteroposterior diameter of the spinal canal, first a horizontal line was drawn between the transverse foramens. Then a perpendicular line to this first line was drawn from the deepest point of vertebra corpus to the anterior margin of lamina in spinal canal. Length of this perpendicular line was accepted as sagittal diameter of spinal canal (Fig. 2).

During CT scan the middle C5 vertebra was centralized. Based on the vertebral corpus height (VCH) measured on sagittal images, the slice thickness was adjusted to obtain 10 axial CT sections. The anteroposterior diameter was measured on each of 10 axial (Fig. 3) and the mean of sections for each animal were calculated separately for determined days.

ANOVA and Student-Newman-Keuls tests were used in statistical analysis.

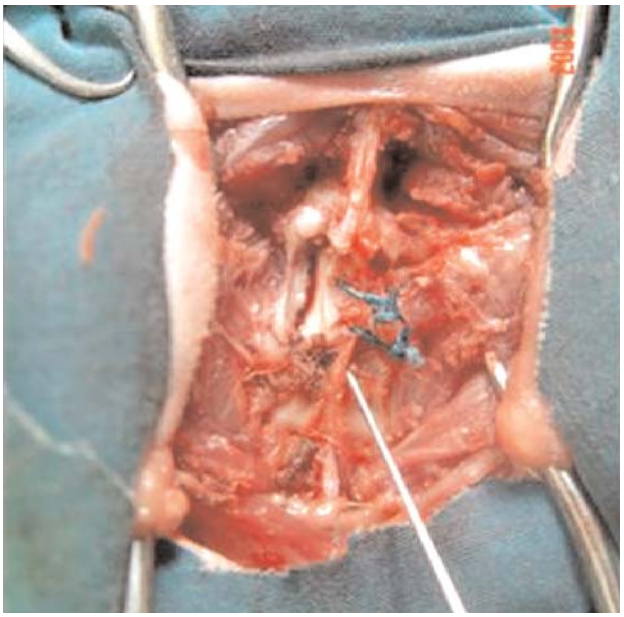

Fig. 1. Elevated lamina is secured to the facet joint capsule with nonabsorbable sutures. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

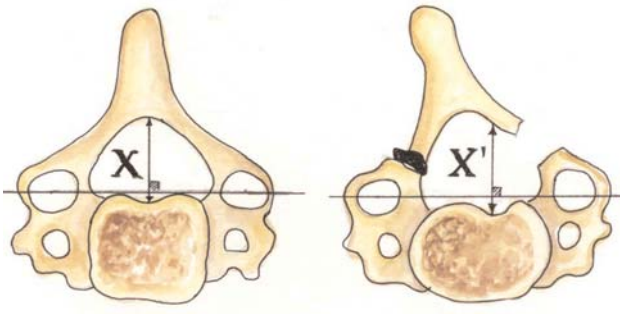

Fig. 2. Spinal canal diameter was measured on a line perpendicular to the axis of the transverse foramens. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

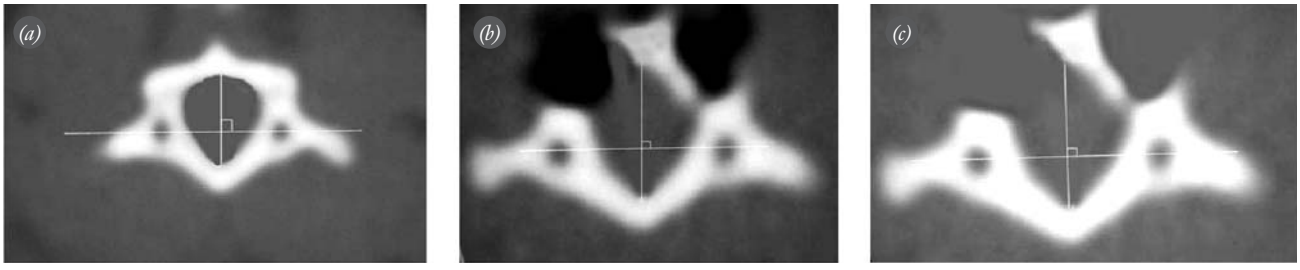

Fig. 3. Measurement of anteroposterior spinal canal diameter on axial CT scans. **(a)** Preoperative measurement, **(b)** measurement on postoperative day 1, **(c)** measurement on postoperative day 42.

Results

The mean spinal canal diameter was 6.42±0.48 (range: 5.66 to 7.46) mm preoperatively, 8.04±0.62 (range: 7.10 to 9.93) on postoperative day 1 and 8.02±0.63 (range: 7.09 to 9.91) mm on postoperative day 42 (Table 1) (Fig. 4).

The mean spinal canal diameter at postoperative day 1 were significantly larger than the mean preoperative spinal canal diameter ($p<0.001$). On the other hand, there was no significant difference between the mean spinal canal diameter at postoperative day 1 and day 42 ($p>0.05$), which suggested no significant narrowing of the canal in short term follow-up (Tables 2 and 3).

Discussion

Cervical laminoplasty was developed in Japan in 1970s as an alternative to laminonectomy. The original method of expansive laminoplasty was described in 1977 by Hirabayashi.[5] However, the reclosure of opened lamina with exacerbation of neurologic symptoms had been reported by Hirabayashi himself.[17-19] Then he modified its retention suture around the base of spinous processes.[10] This open-door laminoplasty, which is simple and safe, has gained immediate and wide spread acceptance.[8]

The key point in a successful laminoplasty is expansion of the spinal canal and its maintenance. Although satisfactory results of revised classical open-door laminoplasty had been gathered and its reclosure hasn't been shown radiologically,[10,20-22] many new techniques, mostly hardware assisted, have been introduced for maintaining canal expansion.[4,10,20,21,23] Lee et al. and Itoh et al. reported bone grafting on the open-door side.[9,12,13] O'Brien and his colleagues described to use titanium miniplates.[24] On the other hand, Shaffrey et al. used allograft in addition to O'Brien's technique.[14] Some authors preferred materials such as ceramics,[13,15] titanium[9,11] and hydroxyapatite[16] for preserving expansion. Although those techniques may provide secure fixation of elevated lamina, they are often complex, technically difficult, and they increase operative time, blood loss and as a result chance of iatrogenic injury.[9,24]

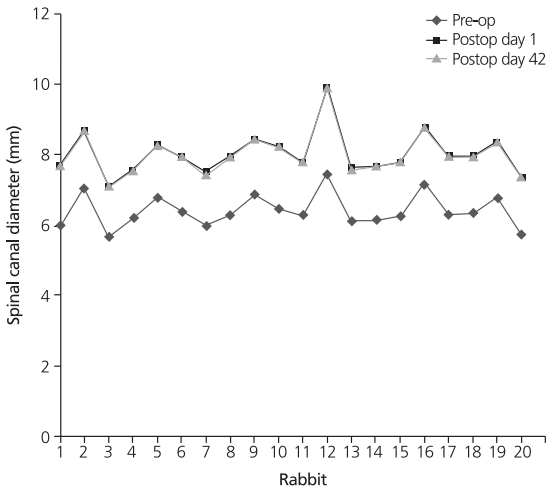

Fig. 4. Preoperative and postoperative spinal canal diameters of the rabbits.

Table 1. Spinal canal diameter (mm) as measured preoperatively, at postoperative day 1 and day 42.

	Pre-op	Post-op day 1	Post-op day 42	C5 VBH
R1	5.99	7.69	7.68	19
R2	7.09	8.70	8.68	19
R3	5.66	7.10	7.09	16
R4	6.19	7.56	7.55	18
R5	6.80	8.29	8.27	20
R6	6.40	7.95	7.94	19
R7	5.98	7.53	7.41	18
R8	6.29	7.95	7.93	19
R9	6.89	8.46	8.45	18
R10	6.45	8.25	8.24	19
R11	6.28	7.79	7.78	19
R12	7.46	9.93	9.91	19
R13	6.11	7.65	7.56	19
R14	6.14	7.67	7.66	19
R15	6.27	7.79	7.78	18
R16	7.16	8.80	8.78	20
R17	6.29	7.95	7.93	19
R18	6.34	7.95	7.93	18
R19	6.77	8.36	8.35	19
R20	5.73	7.36	7.33	19
Mean±SD	6.42±0.48	8.04±0.62	8.02±0.63	18.7

Table 2. Table illustrating descriptive statistics of the series.

Parameters	Pre-op	Post-op day 1	Post-op day 42
Number of animals	20	20	20
Mean	6.42	8.04	8.02
Standard deviation	0.48	0.62	0.63
Minimum	5.66	7.10	7.09
Maximum	7.46	9.93	9.91
Confidence interval (95%)	6.19	7.75	7.72

Table 3. Comparison of the mean spinal canal diameters.

Comparison	Mean difference	q	p
Preop-postop 1 day	-1.62	56.22	<0.001
Preop-postop 42 day	-1.60	55.39	<0.001
Postop 1-postop 42 day	-0.02	0.83	>0.05

Open-door laminoplasty that is superior to some other techniques regarding enlargement of sagittal diameter and complication rate have been shown in clinical studies also.[25,26] Yang et al. claimed that in classic procedure, loosened sutures may result in dislodgement and reclosure of the lifted lamina.[26] On the other hand, this could be overcomed mainly by bone healing and/or by uncomplicated secure fixation.[7,9,18,26]

In the present study, the elevation of the lamina is provided by revised form of classical open-door laminoplasty procedure. This study is unique in that maintenance and reclosure of expanded lamina were evaluated prospectively by radiological measurements in an animal model which was described by Fields et al.[18]

The current study demonstrated that classical open-door laminoplasty technique is effective in expansion of lamina and its prevention against reclosure in an experimental model. The Hirabayashi technique is simpler, safer, cheaper than and as effective as the more complex techniques.

It can be postulated from the data of the current study that open-door laminoplasty procedure is sufficient and has no need to be made more complicated. However, there is a need for future clinical studies to compare clinically and radiologically the different laminoplasty techniques.

Conflicts of Interest: No conflicts declared.

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