

Laminoplasty for Cervical Cord Injury without Bone Injury

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Abstract

Cervical Spinal Cord Injury (SCI) without bone injury occurs in cervical spondylosis, ossification of the posterior longitudinal ligament, disc herniation, and other conditions caused by hyperextension. Controversy remains as to the treatment of this type of injury. The purpose of this study was to evaluate the clinical results of laminoplasty for the treatment of SCI without radiographic evidence of trauma.

Seventeen patients who underwent laminoplasty for the treatment of SCI without radiographic evidence of trauma were included in this study. Preoperative neurologic deficits improved by at least 1 grade on the Frankel scale in 12 patients (71%) after surgery. None of the patients' neurologic deficits worsened after surgery. A significant improvement was seen in patients who underwent surgery within 2 days of injury, compared with patients who underwent elective surgery ($p = 0.044$). The results of this study suggest that cervical spinal cord decompression by laminoplasty is an effective surgical treatment for cervical SCI without bone injury.

Keywords: Cervical spinal cord injury; Without bone injury; Laminoplasty; Surgical results

Introduction

The National Spinal Cord Injury Statistical Center at the University of Alabama in Birmingham, USA, reported an annual incidence of 11,000 new cases of traumatic spinal cord injury (SCI), or 40 per 1 million of the population, with a prevalence of 250,000 cases [1]. SCI often results in significant and catastrophic dysfunction and disability. Instability of the cervical spine caused by traumatic force often requires internal fixation for stabilization.

Sometimes, SCI can occur without radiographic evidence of trauma. Acute SCI without radiographic evidence of trauma occurs in cervical spondylosis, Ossification of the Posterior Longitudinal Ligament (OPLL), disc herniation, and other conditions [2]. Hyperextension is the most common mechanism underlying cervical SCI without radiographic evidence of trauma [3]. The syndrome of acute central cord injury, which was described by Schneider [4], is often seen in this injury; this is characterized by greater motor impairment of the upper compared with the lower extremities, bladder dysfunction, and variable sensory loss below the level of injury. Controversy remains as to the treatment of SCI without radiographic evidence of trauma.

We have performed laminoplasty for the treatment of SCI without radiographic evidence of trauma. Patients whose neurologic deficits persist, those whose neurologic recoveries reach a plateau, or those whose neurologic deficits worsened during follow-up are also candidates for this surgery. The purpose of this study was to evaluate the clinical results of laminoplasty for the treatment of SCI without radiographic evidence of trauma.

Materials and Methods

After approval from the investigational review board of our hospital, 17 patients (14 men and 3 women, with a mean age of 59.3 ± 14.3 years) who underwent laminoplasty for the treatment of cervical SCI without radiographic evidence of trauma between September 2006 and January 2012 were included in this study. The modes of trauma were as follows: falls from standing in 5 patients, falls from a height in 9 patients, impact of a heavy object in 1 patient, and traffic accidents in 2 patients. Of the 17 patients, 4 had OPLL of the cervical spine. The

affected levels of cervical SCI were as follows: C3–4 in 4 patients, C4–5 in 7, and C5–6 in 6 (Table 1).

Our surgical indication for cervical SCI without evidence of trauma was persistent neurologic deficits that reached a plateau in recovery and the existence of spinal compression, which occurred before trauma. The patients whose neurologic deficits worsened during follow-up also were candidates for surgery. We performed expansive open-door laminoplasty [5] in the affected spinal cord levels with or without the adjacent vertebral levels. A hydroxyapatite spacer was placed between the opened laminae. Patients began rehabilitation as soon as possible after surgery, without a neck collar.

Clinical results were evaluated by using the Frankel classification system. Frankel classifications A, B, and C include individuals with little or no useful muscle power below the injury site, while Frankel classifications D and E include individuals that have useful or full recovery of the muscles below the injury site [6]. We further evaluated the patients by dividing them into 2 groups based on whether the surgery was performed within 2 days of the injury or after 3 days.

The sagittal diameter of the cervical spinal canal was measured by using preoperative sagittal reconstruction computed tomography. The space available for the spinal cord was measured in patients with OPLL. Surgical time and blood loss volume were also assessed. The data were analyzed by using the Fisher's exact probability test or the Mann-Whitney U test using SPSS software (IBM Corporation, Armonk, NY). The level of significance was set at $p < 0.05$.

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Case No.	Age at surgery, (y)	Sex	Level of injury	Range of laminoplasty	Disease	Mode of trauma	Injury surgical interval (days)
1	58	M	C3-4	C3-C7	CSM	FFH	0
2	58	M	C5-6	C3-C7	CSM	RTA	8
3	67	M	C5-6	C3-C6	OPLL	FFH	0
4	70	M	C4-5	C3-C6	OPLL	FFS	11
5	55	M	C5-6	C4-C7	CSM	FFH	0
6	65	F	C4-5	C3-C7	CSM	FFH	3
7	76	M	C4-5	C3-C6	OPLL	RTA	2
8	44	M	C3-4	C3-C5	OPLL	IOHO	0
9	25	M	C4-5	C3-C6	CSM	FFS	8
10	70	F	C4-5	C4-C6	CSM	FFH	16
11	68	F	C5-6	C4-C7	CSM	FFS	19
12	49	M	C4-5	C3-C6	CSM	FFS	6
13	65	M	C5-6	C3-C6	CSM	FFH	2
14	34	M	C5-6	C3-C7	CSM	FFH	1
15	58	M	C3-4	C3-C6	CSM	FFH	3
16	71	M	C3-4	C3-C6	CSM	FFS	4
17	75	M	C4-5	C3-C6	CSM	FFH	8
Mean	59.3						5.4

Abbreviations: CSM- Cervical Spondylotic Myelopathy; FFH, fall from height; FFS, fall from standing; IOHO, impact of a heavy object; OPLL, ossification of the posterior longitudinal ligament; RTA, road traffic accident.

Table 1: Patient profiles and details of surgical procedures.

Frankel grade	Arrival at the hospital	Preoperative					Final follow-up				
		A	B	C	D	E	A	B	C	D	E
A	2	2					1	1			
B	5		2	3					4	1	
C	8			7	1				1	4	3
D	2				2						2
E											

Table 2: Changes in neurologic status according to the Frankel classification system.

Results

The mean follow-up period was 11.8 ± 15.3 months (range, 1–55 months). The mean time from injury to surgery was 5.4 ± 5.7 days (range 0–19 days). Seven patients (41%) underwent surgery within 2 days of injury. The mean sagittal diameter of the cervical spinal canal was 9.5 ± 2.0 mm (range, 6–13 mm). The mean number of laminoplasty levels was 3.1 intervertebral levels (range, 2–4 levels): C3–5 in 1 patient, C4–6 in 1, C3–6 in 9, C4–7 in 2, and C3–7 in 4. The average surgical time was 97 min (range 48–159 min). The average blood loss volume was 118 mL (range 0–300 mL).

According to the Frankel classification system, upon arrival at the hospital, grade A was observed in 2 patients, grade B in 5, grade C in 8, and grade D in 2. Preoperatively, grade A was observed in 2 patients, grade B in 2, grade C in 10, and grade D in 3. Immediately after surgery, grade A was observed in 1 patient, grade B in 2, grade C in 8, grade D in 4, and grade E in 2. At the final follow-up, grade A was observed in 1 patient, grade B in 1, grade C in 5, grade D in 5, and grade E in 5. Preoperative neurologic deficits improved by at least 1 grade on the Frankel scale in 12 patients (70.6%) at the final follow-up. None of the patients' neurologic deficits worsened after surgery (Table 2). Seven of

10 patients (70%) who had neurologic deficits classified as Frankel C preoperatively improved to ambulatory status (Frankel D or E) at final follow-up. Neurologic deficits improved in 100% of the patients who underwent surgery within 2 days of injury and in 50% of those who underwent surgery after 3 or more days (Table 3). The patients who underwent surgery within 2 days improved significantly, compared with those who underwent elective surgery ($p = 0.044$). The follow-up periods were not significantly different between the 2 groups ($p = 0.61$).

Discussion

The incidence of unstable injuries to the cervical spine is about 30 per 1 million of the population, per year. The treatments for cervical SCI with spinal instability have been almost decided. Surgical treatment allows decompression of the spinal canal, when indicated, stabilization of the spinal column, and early mobilization. However, controversy remains regarding the treatment of cervical SCI without radiographic evidence of trauma [4,7-11]. We performed surgical spinal decompression by laminoplasty when patients' neurologic recovery was insufficient and when spinal cord compression occurred due to spondylosis, OPLL, or another condition. A total of 70.6% of the patients in our study demonstrated that their neurologic deficits

Preop/postop Frankel grade	A	B	C	D	E
A	-	1 (1) ^a	-	-	-
B	-	-	2 (1,2)	-	-
C	-	-	-	3 (1,7,8)	1 (29)
D	-	-	-	-	-
E	-	-	-	-	-

(a) Patients group who underwent surgery within 2 days of injury

Preop/postop Frankel grade	A	B	C	D	E
A	-	1 (1) ^a	-	-	-
B	-	-	2 (1,2)	-	-
C	-	-	-	3 (1,7,8)	1 (29)
D	-	-	-	-	-
E	-	-	-	-	-

^a() = follow-up duration

Preop/Postop Frankel grade	A	B	C	D	E
A	1 (2) ^a	-	-	-	-
B	-	-	-	-	-
C	-	-	3 (1,1,1)	1 (55)	2 (15)
D	-	-	-	1 (1)	2 (12,24)
E	-	-	-	-	-

^a() = follow-up duration

Table 3: Clinical evaluation of Frankel classification pre- and postoperatively divided by surgical timing.

were improved at the final follow-up. No patients in this study showed worsened neurologic deficits after surgery, as assessed by the Frankel classification system.

There are some reports on the importance of the timing of the surgical procedure for cervical SCI without radiographic evidence of trauma [12-14]. These reports have conflicting results, however. Kawano and colleagues [15] reported that, in patients with SCI, without bone or disc injury, whose ASIA impairment score is A, B, or C, surgical treatment within 3 to 14 days (mean, 8.2 days) of injury was not superior to conservative treatment. However, the investigators did not evaluate the effectiveness of surgery when performed within 2 days injury. Some surgeons have suggested that they can obtain a greater improvement in paralysis if such patients undergo decompression surgery within 24 or 48 hours of injury [16]. In our study, the conditions of patients who underwent surgery for cervical SCI without bone injury within 2 days of injury improved significantly, compared with the elective surgery group, though the sample was small. Furthermore, in 3 patients who underwent surgery more than 3 days after injury, neurologic deficits remained stable as Frankel C before surgery and at the final follow-up; however, their follow-up duration was only 1 month. It is possible that their neurologic status would have improved if the follow-up duration was longer. Laminoplasty for cervical SCI without fractures within 2 days of injury may achieve more neurologic improvement, particularly in patients classified as Frankel C.

SCI without radiographic evidence of trauma often occurs in cervical spondylosis, OPLL, and disc herniation. In our study, the mean

sagittal diameter of the cervical spinal canal was 9.5 mm. Therefore, all patients underwent laminoplasty for cervical spinal canal stenosis.

The limitation of this study is that, in our hospital, doctors in the emergency department perform perioperative management, including the decision to transfer patients to other hospitals. Therefore, it is sometimes difficult to follow-up with patients for a long enough period to evaluate neurologic recovery. Other limitations of this study include the lack of a control group, small sample size, variety of preoperative neurologic status, and its retrospective design. Furthermore, in our hospital, the doctors in the emergency department are involved in management make decisions regarding patient transfer to other hospitals. Our hospital willingly started accepting SCI patients as soon as an emergency department was established. Because the emergency department had been established only a short time before this study was initiated, the sample population included only patients and no controls; furthermore, the sample size was small. Despite these limitations, our results indicate that spinal cord decompression by laminoplasty of the cervical spine can improve neurologic deficit in patients with cervical SCI without bone injury.

Conclusion

The patients who underwent surgery within 2 days of injury improved significantly, compared with those who underwent elective surgery. Based on our results, we conclude that cervical spinal cord decompression by laminoplasty is an effective surgical treatment for cervical spinal cord injury without bone injury.

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