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ORIGINAL ARTICLE

Outcome of decompression surgery for cervical spinal cord injury without bone and disc injury in patients with spinal cord compression: a multicenter prospective study

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Study design: A multicenter prospective study comparing the neurological outcome of patients treated by surgical intervention versus conservative treatment for cervical spinal cord injury (CSCI) without bone and disc injury.
Objective: To evaluate the neurological outcome of decompression surgery for CSCI without bone and disc injury in patients with spinal cord compression with incomplete paralysis (AIS B, C).
Setting: The Japan LHWO Spinal Injuries Center and the other 10 labor accident hospitals in Japan.
Methods: Thirty-four patients with AIS B, C and cervical spinal cord compression were classified into either a surgical treatment group or a conservative treatment group. The 34 patients enrolled were equally divided between the groups. Patients with AIS B, C and mild spinal compression were enrolled into another group.
Results: The neurological outcome of surgical treatment and conservative treatment for AIS B, C with spinal cord compression was found to be closely similar. In addition, the neurological outcome was also similar to that observed after conservative treatment for AIS B, C in patients presenting with mild spinal cord compression.
Conclusions: Surgical treatment was not found to be superior to conservative treatment for CSCI patients without bone and disc injury suffering from spinal cord compression in the acute phase.
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Keywords: cervical spinal cord injury; spinal cord compression; spinal cord injury without bone and disc injury; decompression surgery; prospective study

Introduction

Cervical spinal cord injury (CSCI) without bone and disc injury tends to be caused by a hyperextension force to the neck.[1] This type of injury has been increasing as the elderly population is dramatically increasing in Japan. Hyperextension force causes a pinching effect to the cervical spinal cord. Although the patients experience only a minor or moderate impact, CSCI is associated with various grades of paralysis.[2]

There are various problems associated with CSCI without bone and disc injury. The terminology regarding this type of injury remains confusing whereas, in addition, treatment with either surgery or conservative measures remains controversial.[3–18]

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Such cervical cord injury has previously been called 'Adult SCIWORA (Spinal cord injury without radiographic abnormality in adults,[10] or Spinal cord injury without radiological abnormality in adults[19])'. However, this term is incorrect because the terminology 'SCIWORA (Spinal cord injury without radiographic abnormality)' was created before the development of computed tomography and magnetic resonance imaging (MRI), and only for children.[20] Furthermore, many radiological abnormalities are observed in elderly subjects, mainly degenerative changes such as osteophytes, disc bulging, hypertrophy of ligamentum flavum, and OPLL. For such injury, various terms exist, and even today, there is no standardized terminology. The term 'Cervical spinal cord injury (CSCI) without bone and disc injury' has been adopted for this injury, because radiographical abnormalities, such as degenerative changes, do exist but no specific injury is present.

The treatment with either surgery or conservative measures for acute CSCI without bone and disc injury remains

controversial.[3–18] This injury does not usually require surgery for the reconstruction of the spinal column but instead may require decompression for the narrowed spinal canal with laminoplasty, to achieve an improvement in the paralysis. Some surgeons have reported an improvement of paralysis, following decompression of the spinal cord, whereas others have concluded that the fate of an injured spinal cord cannot change by decompression surgery, as such spinal cord compression may have existed before the injury even though such patients had been asymptomatic. This indicates that the symptoms were therefore not caused by the compression itself.

However, many problems remain to be discussed regarding the optimal treatment of such cases, and so far there has been no study that compared the improvements in paralysis obtained by either conservative or surgical treatments.[6,14,16] Precisely, what specifically is the difference in the recovery potential in regard to various grades of spinal cord compression? Addressing these problems is therefore the purpose of this multicentric prospective study.

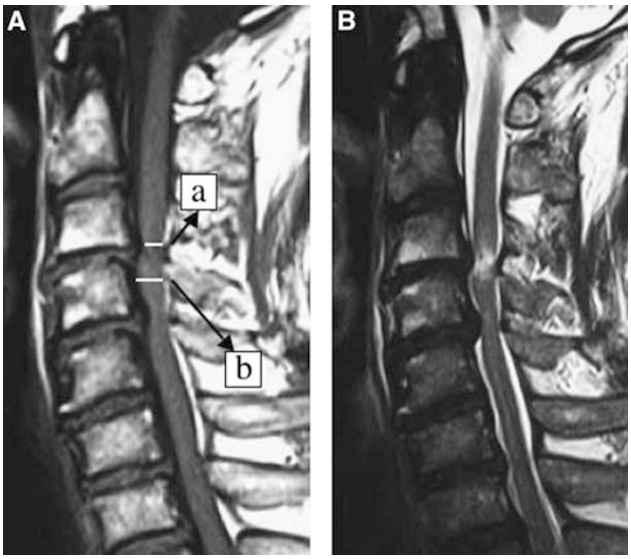

Figure 1 Conservative treatment case. (**A**, T1-weighted image) (**a**) Cervical spinal cord compressed by an osteophyte and ligament flavum. (**b**) Intact cervical spinal cord. Compression rate was 27%. (**B**, T2-weighted image) High intensity area at C3/4.

Patients and methods

Before beginning this investigation, the study was approved by the Ethics Committees of all the hospitals participating in the trial. Two hundred and three patients with acute CSCI without bone and disc injury were treated at 11 hospitals (study group) in Japan from September 2000 to December 2002. Patients whose paralysis was classified as either ASIA impairment scale (AIS) B or C were selected to investigate the improvement in their paralysis. For obvious reasons, the neurological state before injury could not be accurately established. However, all patients selected had been walkers who had at least an AIS D or better before injury. Patients with either AIS A or D were excluded from the study for the following reasons: many patients with AIS A showed a very poor general condition. As a result, surgical treatment was thought to have a negative influence on their general condition.

The rate of spinal cord compression was measured by sagittal view MRI (Figure 1). A high intensity area in the cervical cord on T2-weighted MRI images was determined to be the injured level of the cervical spinal cord. The spinal cord diameter was measured at both the noncompression level and the injured level on T1-weighted MRI images, and was calculated by the following equation:

$$(B - A)/B * 100\%$$

where A is the diameter of the cervical cord at the noncompression level and B is the diameter of the cervical cord at the injured level.

A rate of 20% was defined as a cut-off point for the spinal cord compression rate. The cut-off point was artificially set at 20%, because no previous research or clinical data about neurological impairment and spinal cord compression exist in the literature. All members of the study group observed many MRI films in which the cervical spinal cord was compressed with various rates of compression. A 20% compression rate is a point at which many of them judged the spinal cord to be compressed and therefore considered decompression surgery to be needed. Therefore, the cut-off point for the spinal cord compression rate was determined to be 20%.

The method of treatment (surgical or conservative) was selected by the day of injury instead of conducting a randomized trial. If the CSCI occurred on an odd numbered day, then the patient was treated by decompression surgery. If the spinal cord was compressed by the anterior elements and single level stenosis, then anterior decompression (and fusion) was selected. Multilevel laminoplasty was selected if the spinal cord was compressed by posterior or circumferential elements, or multilevel stenosis. MRI studies were conducted after surgery in all of the surgically treated cases. The patients were treated conservatively if the CSCI occurred on an even numbered day. The patients treated conservatively were placed in a cervical collar for 4 to 6 weeks. The patients were informed that both treatments have been used to treat their condition, but the optimal treatment had not been standardized. In addition, they were told that similar outcomes had been observed with both treatments. All patients gave their informed consent to undergo the treatments.

The group treated surgically included 17 patients as did the group treated conservatively. Finally, 34 patients were enrolled in this study to compare the improvement in paralysis obtained by either surgical or conservative treatments. To compare, the surgical group (group I) and the conservative group (group II) was thought to demonstrate the effect of decompression surgery. In addition, 20 patients with spinal cord compression $<20\%$ and ASIA B, C (group III) were followed up to demonstrate the difference in the recovery potential according to the grade of spinal cord compression (Figure 2). The patients in group III were treated the same as the patients in group II.

Table 1 summarizes the number of patients, the mean age at the time of injury, the mean rate of spinal cord compression, and the number of AIS B or C in each group. Tables 2 to 4 show the detailed data in each group concerning the compression factor, the compression rate, the ASIA motor score at admission, and the level of vertebral injury.

The mean period from injury to operation was 8.2 days (range 3–14). Sixteen cases were treated by laminoplasty, and only one case by anterior decompression and spinal fusion. Spinal cord decompression was confirmed by MRI in all cases (Figure 3).

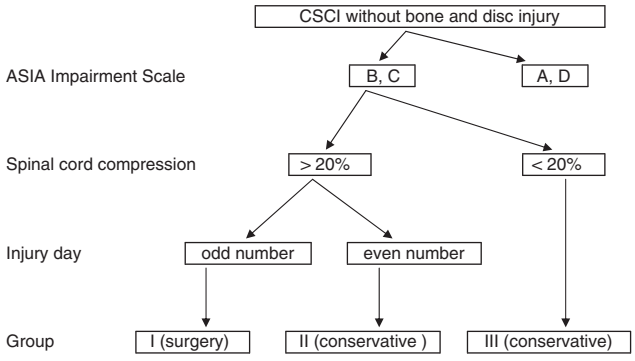

Figure 2 Patient selection.

Table 1 Case summary

	GI (surgery)	*GII (conservative)*	*GIII (mild compression)*
Case (M:F)	17 (11:6)	17 (15:2)	20 (18:2)
Age (years)	61.4 (39–72)	64.6 (39–75)	61.3 (33–75)
Compression rate (%)	28.7 (20–50)	28.7 (21–40)	10.2 (0–18)
AIS			
B	3	5	4
C	14	12	16

The patients were followed for a year (from the point of admission to 2 weeks, 3 months, 6 months and 1 year) after injury regarding the ASIA motor score (range from 0 to 100). The sensory function is difficult to assess correctly in the acute phase. Although the sensory function was evaluated, no sensory score has yet been adopted. This was analyzed using an analysis of variance.

Results

Changes in the ASIA motor scores were investigated from admission to 1 year after the injury in each group. The mean ASIA motor scores were 25.1 points (surgical group), 27.1 (conservative group), at the time of admission, 41.0 (surgical group), 42.5 (conservative group), at 2 weeks after injury, 61.8 (surgical group), 61.2 (conservative group), at 3 months after injury, 64.2 (surgical group), 63.0 (conservative group), at 6 months after injury, and 65.1 (surgical group), 64.1 (conservative group), at 1 year after injury. The two groups showed almost the same course in their recovery process.

In addition, the mean ASIA motor score of group III was 25.0 at the time of admission, 38.3 at 2 weeks after injury, 60.8 at 3 months after injury, 64.0 at 6 months after injury, and 64.9 at 1 year after injury. All groups (surgical group, conservative group and mild compression group) followed almost the same course in their recovery process (Figure 4). Therefore, there were no significant differences in the improvement of paralysis among the surgical treatment and conservative treatment groups, or among the cases in which the spinal cord compression persisted and the cases of mild compression in the cervical spinal cord.

Discussion

Whether surgical decompression for CSCI without bone and disc injury has better outcome than conservative treatment remains controversial. In the case of CSCI without bone and

Table 2 Case summary (group I, surgical treatment case)

	OPLL	*Osteophyte*	*Disc*	*Ligamentum flavum*	*Compression rate (%)*	*Motor score (admission)*	*Level*
1–1			+	+	50	65	C3/4
1–2			+		50	42	C3/4
1–3		+			26	35	C3/4
1–4			+		30	8	C3/4
1–5		+		+	20	25	C3/4
1–6	+				25	40	C4/5
1–7		+		+	23	22	C3/4
1–8		+		+	23	24	C3/4
1–9		+			22	8	C3/4
1–10		+		+	28	24	C3/4
1–11		+			25	0	C3/4
1–12	+				20	22	C3/4
1–13			+		25	8	C3/4
1–14			+	+	42	18	C4/5
1–15		+			20	67	C5/6
1–16	+				50	5	C4/5
1–17		+			30	14	C3/4

Table 3 Case summary (group II, conservative treatment case)

	OPLL	*Osteophyte*	*Disc*	*Ligamentum flavum*	*Compression rate (%)*	*Motor score (admission)*	*Level*
2–1			+		38	6	C4/5
2–2		+		+	27	30	C3/4
2–3	+				21	9	C3/4
2–4	+				32	0	C3/4
2–5	+				22	52	C4/5
2–6		+		+	23	45	C4/5
2–7		+			27	48	C4/5
2–8		+			25	0	C4/5
2–9	+				30	8	C4/5
2–10		+			37	26	C3/4
2–11		+			30	58	C5/6
2–12		+		+	35	66	C3/4
2–13	+				40	16	C5/6
2–14			+		25	4	C3/4
2–15			+		29	22	C3/4
2–16		+			21	8	C5/6
2–17		+			25	62	C3/4

Table 4 Case summary (group III, mild compression and conservative treatment case)

	OPLL	*Osteophyte*	*Disc*	*Ligamentum flavum*	*Compression rate (%)*	*Motor score (admission)*	*Level*
3–1			+	+	18	29	C5/6
3–2					0	22	C3/4
3–3	+				13	50	C5/6
3–4	+				9	54	C3/4
3–5			+		10	4	C3/4
3–6					0	7	C3/4
3–7			+		10	57	C5/6
3–8					0	0	C3/4
3–9		+			10	44	C4/5
3–10			+		16	0	C3/4
3–11		+			10	8	C3/4
3–12			+		12	35	C4/5
3–13	+				18	38	C3/4
3–14			+	+	12	19	C4/5
3–15			+	+	15	22	C4/5
3–16			+		16	18	C4/5
3–17			+	+	10	34	C3/4
3–18			+		5	8	C3/4
3–19		+			5	17	C3/4
3–20		+			15	34	C3/4

disc injury, the patients whose spinal cord is not compressed by degenerative changes do not need decompression surgery. However, it is disputable that the patients whose spinal cord is compressed by degenerative changes need decompression surgery to help the recovery from paralysis.

In the past, we routinely treated such patients with decompression surgery especially for cases of CSCI without bone and disc injury suffering spinal cord compression, but not all patients could be treated surgically due to various reasons. However, some recoveries from paralysis were observed even in the cases treated conservatively. If decompression surgery is conducted to help the patients to recover from the paralysis, then the improvement ratio of the patients treated surgically must be superior to that of the patients treated conservatively.

Chen *et al*.[16] reported surgical decompression to be associated with an immediate neurologic improvement and a better long-term neurologic outcome than for nonoperative treatment. Song *et al*.[15] and Uribe *et al*.[17] reported a good outcome of surgical treatment, but these reports were not compared with conservative treatment. In contrast, Pollard *et al*.[12] reported that no evidence was found to support surgical decompression in stenotic patients without any fracture.

This study showed no difference between the surgical treatment and the conservative treatment groups regarding the improvement of paralysis. These findings indicate that there is no effect of surgical treatment (decompression surgery) for the improvement of paralysis in the CSCI without bone and disc injury. This finding suggests that no

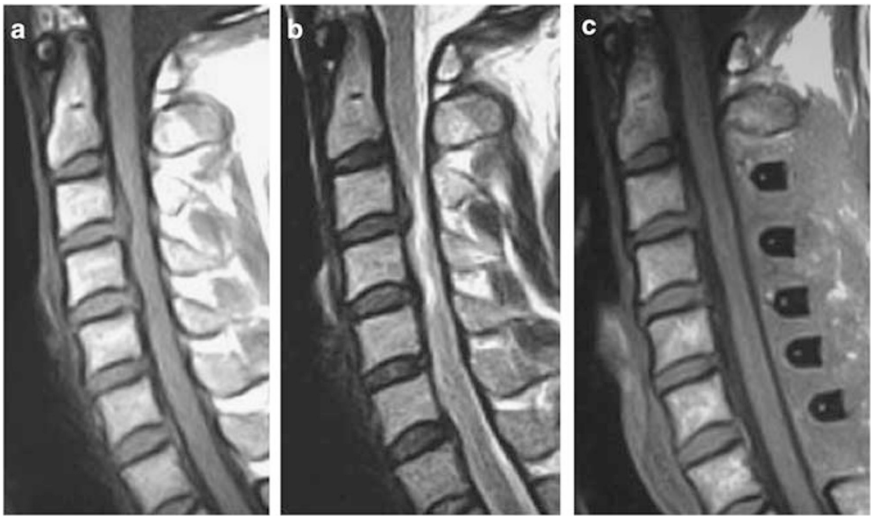

Figure 3 Surgical treatment case. (**a**, T1—weighted image) Cervical spinal cord compressed by a disc. Compression rate was 50%. (**b**, T2-weighted image) High intensity area at C3/4. (**c**, after surgery) Good decompression after laminoplasty.

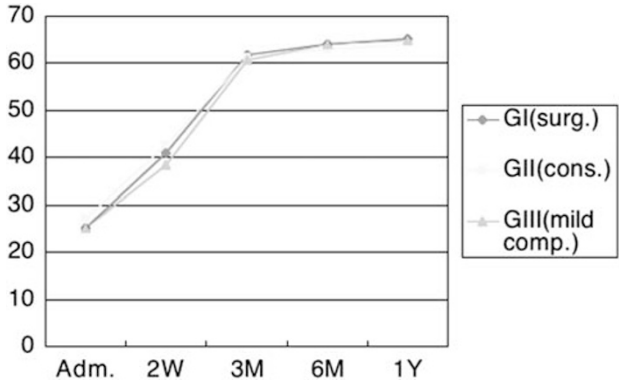

Figure 4 Changes in the mean ASIA motor scores from admission to 1 year after injury in each group. All groups (group I: surgical treatment; group II: conservative treatment; group III: light compression and conservative treatment) followed almost the same course in their recovery process.

improvement of paralysis was obtained by decompression surgery, because the patients with CSCI without bone and disc injury with spinal cord compression recovered from AIS B to AIS D through conservative treatment.

In addition, the result that no significant difference between group II and group III was observed with regard to the change of the ASIA motor score is considered to be a very interesting finding. This result suggests that the improvement in paralysis in such patients is influenced by the grade of paralysis at the time of injury, whereas it is not influenced by the rate of spinal cord compression.[21] These findings indicate that there may be no effect of immediate surgical treatment (decompression surgery) regarding an improvement of paralysis in the CSCI without bone and disc injury.

However, the compressed cervical spinal cord may have a greater recovery potential if decompression surgery is performed during the very acute phase. Some surgeons have suggested that they could obtain a greater improvement of paralysis if such patients can undergo decompression surgery within 24 or 48 h after injury.[14] Unfortunately, this question could not be answered based on the findings of this study. This, therefore, remains as one limitation of this study, as it was also in other similar clinical studies.

Conclusion

In the cases of CSCI without bone and disc injury, bone and disc injury do not exist while, at the same time, various radiological abnormalities (degeneration, spinal cord compression) do exist.

In cases of CSCI without bone and disc injury, the improvement of paralysis was found to be the same in the surgical treatment group and the conservative treatment group. Surgical treatment within 3 to 14 days after injury is not superior to conservative treatment for CSCI without bone and disc injury. Further study may therefore be required to investigate the effect of decompression surgery in the very acute phase by a randomized clinical trial; however, obtaining an appropriate number of subjects for such a study may be very difficult.

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