

Clinical relationship between cervical spinal canal stenosis and traumatic cervical spinal cord injury without major fracture or dislocation

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Abstract

Purpose The purpose of the study was to evaluate the clinical relationship between cervical spinal canal stenosis (CSCS) and incidence of traumatic cervical spinal cord injury (CSCI) without major fracture or dislocation, and to discuss the clinical management of traumatic CSCI.

Methods Forty-seven patients with traumatic CSCI without major fracture or dislocation (30 out of 47 subjects; 63.83 %, had an injury at the C3–4 segment) and 607 healthy volunteers were measured the sagittal cerebrospinal fluid (CSF) column diameter at five pedicle and five intervertebral disc levels using T2-weighted midsagittal magnetic resonance imaging. We defined the sagittal CSF column diameter of less than 8 mm as CSCS based on the previous paper. We evaluated the relative and absolute risks for the incidence of traumatic CSCI related with CSCS.

Results Using data from the Spinal Injury Network of Fukuoka, Japan, the relative risk for the incidence of traumatic CSCI at the C3–4 segment with CSCS was calculated as 124.5:1. Moreover, the absolute risk for the incidence of traumatic CSCI at the C3–4 segment with CSCS was calculated as 0.00017.

Conclusions In our results, the relative risk for the incidence of traumatic CSCI with CSCS was 124.5 times higher than that for the incidence without CSCS. However, only 0.017 % of subjects with CSCS may be able to avoid developing traumatic CSCI if they undergo decompression surgery before trauma. Our results suggest that prophylactic surgical management for CSCS might not significantly affect the incidence of traumatic CSCI.

Keywords Cervical spinal canal stenosis · Traumatic cervical spinal cord injury without major fracture or dislocation · MRI · Relative risk · Absolute risk · Prophylactic surgical management

Introduction

Traumatic cervical spinal cord injury (CSCI) without major fracture or dislocation often is described as CSCI without radiographic abnormality (SCIWORA) [1–3] or CSCI without radiologic evidence of trauma (SCIWORET) [4–6]. Most patients are elderly and have radiographic abnormalities such as osteophytes, disc bulging/herniation, hypertrophy of the ligamentum flavum, or ossification of the posterior longitudinal ligament, and may present with tetraplegia caused by hyperextension injury, predominantly at the C3–4 segment, with cord compression as a result of a stenotic spondylotic canal [1, 5, 7–9]. The reported incidence of cervical SCIWORA/SCIWORET ranges from approximately 10–16 % in North America and India [1, 5], and it is the most common (47 %) cervical cord injury in Japan [5]. Moreover, the incidence of cervical SCIWORA/SCIWORET is increasing dramatically in Japanese aging society.

A broad definition of cervical SCIWORA/SCIWORET includes disc injury, anterior vertebral body tip or spinous

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process fracture, or other ligamentous injury. We defined CSCI with or without those injuries but without fracture dislocation and spinal canal bony injury such as tear drop fracture or facet fracture as traumatic CSCI without major fracture or dislocation. Traumatic CSCI can occur with or without cervical spinal canal stenosis (CSCS) or cervical cord compression. The biomechanical etiology of traumatic CSCI is still a matter of discussion, and its relationship with CSCS is one of the most controversial issues in the clinical management of traumatic CSCI.

In this study, we measured the sagittal diameter of the cerebrospinal fluid (CSF) column in patients with traumatic CSCI without major fracture or dislocation and in healthy individuals using T2-weighted midsagittal magnetic resonance imaging (MRI). The aims of the current study were to evaluate the clinical relationship between CSCS and incidence of traumatic CSCI, and to discuss the clinical management of traumatic CSCI without major fracture or dislocation.

Materials and methods

Study population

Seventy-two subjects with traumatic CSCI without major fracture or dislocation were treated in our facility from 2006 to 2010. All patients underwent functional plain radiography, computed tomography (CT), MRI, and neurologic examination by a spine surgeon at the time of admission. Of these, a total of 47 subjects (43 men, 4 women; average age, 68 years [range, 51–89 years]) were included in the study based on the criteria below. The subjects who were admitted in our facility within 48 h following trauma, and had an evidence of cervical cord injury with cervical cord intensity change on T2-weighted MRI. Moreover, the following subjects were excluded from the study: patients with multiple segmental cervical cord injury, complaints of cervical myelopathy, such as numbness in the limbs, finger fine motion or gait disturbances, before trauma, apparent herniated disc at the injured segment, severe instability on functional radiographs, or ankylosing spondylitis. Thirty subjects out of 47 subjects had an injury at the C3–4 segment, 10 out of 47 subjects at the C4–5, 6 out of 47 subjects at the C5–6, and 1 out of 47 subjects at the C6–7.

Six hundred seven healthy volunteers (301 men, 306 women; average age, 64.2 years [range, 50–79 years]) were enrolled as control subjects in the study. The exclusion criteria included a history of brain or spinal surgery, comorbid neurologic disease such as cerebral infarction and neuropathy, symptoms related to sensory or motor disorders (numbness, clumsiness, motor weakness, and gait

disturbances) or having severe neck pain. Pregnant women and individuals who received workmen's compensation or presented with symptoms after a motor vehicle accident were also excluded.

Institutional review board approval was granted and informed consent was obtained from all patients and healthy volunteers.

Measurement of sagittal diameter of CSF column

We used a T2-weighted midsagittal MR image to measure the sagittal diameter of the CSF column at five pedicle levels (C3, C4, C5, C6, and C7) and five intervertebral disc levels (C2–3, C3–4, C4–5, C5–6, and C6–7) in all the CSCI patients and control subjects. We defined the sagittal diameter of the CSF column at a given pedicle level as the sagittal cervical canal diameter [10–13]. The sagittal diameter of the spinal cord is nearly constant in adults, averaging approximately 8 mm from C3 to C7 [14]. Therefore, we defined the sagittal CSF column diameter at any intervertebral disc level measuring <8 mm as CSCS.

Statistical analysis

Mann–Whitney *U* test was used for statistical analyses. A *P* value of <0.05 was considered statistically significant. Analysis of variance (ANOVA) was used to calculate the relative and absolute risks for the incidence of traumatic CSCI without major fracture or dislocation related with CSCS.

Results

There was no significant difference in age between the subject with traumatic CSCI and healthy volunteers.

The average values of the sagittal CSF column diameter at five pedicle and five intervertebral disc levels for the subjects with traumatic CSCI without major fracture or dislocation and the healthy volunteers are shown in Tables 1 and 2. The sagittal diameter of the CSF column at all the pedicle and intervertebral disc levels in the subjects with traumatic CSCI without major fracture or dislocation was significantly narrower, compared with that of the healthy volunteers.

Our published paper, using data from the Spinal Injury Network of Fukuoka, Japan, reported the general incidence rate of spinal cord injuries in Fukuoka prefecture to be 33.77 per million [15]. In that report, traumatic CSCI without major fracture or dislocation accounted for 58.1 % of all the spinal cord injuries. According to our data, traumatic CSCI at the C3–4 segment accounted for 63.83 % (30/47) of all the traumatic CSCIs without

Table 1 The sagittal cervical CSF column diameters at five pedicle levels

	No.	Pedicle level (mm)				
		C3	C4	C5	C6	C7
CSCI	47	8.3 ± 1.4 ***	8.2 ± 1.3 ***	8.3 ± 1.8 ***	8.7 ± 1.7 ***	10.4 ± 1.3 ***
HV	606	11.4 ± 1.2	11.2 ± 1.3	11.1 ± 1.4	11.1 ± 1.4	12.0 ± 1.2

CSCI traumatic cervical spinal cord injury without major fracture or dislocation, HV healthy volunteers

Compared with CSCI and HV * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 2 The sagittal cervical CSF column diameters at five intervertebral disc levels

	No.	Intervertebral disc level (mm)				
		C2-3	C3-4	C4-5	C5-6	C6-7
CSCI	47	9.0 ± 1.3 ***	6.3 ± 1.9 ***	6.4 ± 1.9 ***	6.5 ± 1.8 ***	7.6 ± 1.8 ***
HV	606	11.6 ± 1.3	10.5 ± 1.5	10.1 ± 1.7	9.5 ± 1.7	9.8 ± 1.5

CSCI traumatic cervical spinal cord injury without major fracture or dislocation, HV healthy volunteers

Compared with CSCI and HV * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

fracture or dislocation. Based on these results, the incidence rate of traumatic CSCI without major fracture or dislocation at the C3–4 segment is 12.52 per million ($33.77 \times 0.581 \times 0.6383$).

In our subjects with traumatic CSCI without major fracture or dislocation at the C3–4 segment, 27 out of 30 (90 %) had a sagittal CSF column diameter of <8 mm, while 3 had a diameter of >8 mm at this segment. In the healthy volunteers, 41 out of 607 (6.75 %) had a sagittal CSF column diameter of <8 mm, while 566 subjects had a diameter of >8 mm at the C3–4 segment.

Table 3 shows the relationship between the C3–4 segmental sagittal CSF column diameter and traumatic CSCI without major fracture or dislocation at the C3–4 segment and healthy volunteers. The percentage of incidence of traumatic CSCI without major fracture or dislocation at the C3–4 segment with a sagittal CSF column diameter of <8 mm at this segment was 11.27/67510.42. The percentage of incidence of traumatic CSCI without major fracture or dislocation at the C3–4 segment with a sagittal CSF column diameter of >8 mm at this segment was 1.25/932489.58. The relative risk for the incidence of traumatic CSCI without major fracture or dislocation at the C3–4 segment with a sagittal CSF column diameter of <8 mm at this segment was calculated as $(11.27/67510.42):(1.25/932489.58) = 124.5:1$. On the other hand, the absolute risk for the incidence of traumatic CSCI without major fracture or dislocation at the C3–4 segment with a sagittal CSF column diameter of <8 mm at this segment was calculated as $(11.27/67510.42) - (1.25/932489.58) = 0.00017$.

Table 3 The relationship between the C3-4 segmental CSF column sagittal diameter and traumatic CSCI without major fracture or dislocation at C3-4 segment and healthy volunteers

	No.	CSF column diameter	
		<8 mm	>8 mm
C3-4 CSCI	12.52	11.27	1.25
HV	999,987.48	67,499.15	932,488.33
Total	1,000,000	67,510.42	932,489.58

CSCI traumatic cervical spinal cord injury without major fracture or dislocation, HV healthy volunteers

Discussion

A congenitally narrow cervical spinal canal has been established as an important risk factor for the development of cervical spondylotic myelopathy [10, 11, 16, 17]. In our results, the sagittal diameter of the cervical spinal canal at all of the pedicle levels in the subjects with traumatic CSCI without major fracture or dislocation was significantly narrower, compared with that of the healthy volunteers. This result suggests that a congenitally narrow cervical spinal canal might be an important risk factor not only for the development of cervical spondylotic changes, but also for the occurrence of traumatic CSCI.

Numerous controversies exist with regard to the clinical management of traumatic CSCI. Some authors recommended surgical treatment for traumatic CSCI without major fracture or dislocation with cervical cord

compression at the injured segment [18–21]. La Rosa and colleagues [19], in particular, reported that early decompression surgery within 24 h of trauma had a significantly better outcome, compared with late surgical management. On the other hand, Kawano and colleagues [22] reported that surgical treatment was not found to be superior to conservative treatment for traumatic CSCI without major fracture or dislocation with spinal cord compression in the acute phase. Moreover, Itoh and colleagues [23] reported that there was no significant difference in neurologic improvement between surgical and conservative management of traumatic CSCI without major fracture or dislocation, and, further, a higher frequency of postoperative complications was observed in the subjects who were treated surgically.

To the best of our knowledge, there are no published reports on the prophylactic management of CSCS for the prevention of traumatic CSCI. In our study, the relative risk for the incidence of traumatic CSCI without major fracture or dislocation with CSCS was 124.5 times higher than that for the incidence without CSCS. However, the absolute risk for the incidence of traumatic CSCI without major fracture or dislocation with CSCS was 0.00017 (0.017 %). This data indicate that 0.017 % of subjects with CSCS may be able to avoid developing traumatic CSCI if they undergo decompression surgery before trauma. Our results suggest that prophylactic surgical management, such as decompression, for CSCS might not significantly affect the incidence of traumatic CSCI.

Nevertheless, some questions remain unanswered even after the current study. We did not discuss the degree of neurologic recovery after trauma between the subjects with CSCS and those without CSCS. Therefore, the current investigation can only serve as a pilot study for further research using a larger population, which may help to resolve several issues not addressed in this study, and to further clarify the clinical management of traumatic CSCI without major fracture or dislocation.

Conflict of interest None.

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