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Original Article

Efficacy of posterior decompression and vertebral fusion for treatment of patients with unstable cervical spine fracture with diffuse idiopathic skeletal hyperostosis

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Abstract: Objective: To investigate the efficacy of posterior decompression and vertebral fusion in the treatment of unstable cervical spine fracture with diffuse idiopathic skeletal hyperostosis (DISH), and evaluate the factors affecting neurological prognosis. Methods: From October 2006 to April 2016, 38 patients underwent posterior decompression and vertebral fusion surgery for unstable cervical spine fracture with diffuse idiopathic skeletal hyperostosis (DISH). Demographics, injury characteristics, surgery profiles, efficacy (neurological function changes evaluated as changes of American Spinal Injury Association (ASIA) grades after surgery) and complications of patients were collected. For patients with complete motor paralysis (ASIA-A/B), we also investigated the relationship between neurological improvements (from ASIA-A/B to ASIA-C or-D) and the elapsed time from injury to surgery by Pearson's correlation analysis. Results: All patients underwent posterior fusion with an average of 4.5±2.5 instrumented vertebrae (range, 2-7) with 6 patients required secondary halo-vest fixation. 13 improved more than one ASIA grade after treatment, 24 did not improve, and one deteriorated. 8 patients developed severe postsurgical pulmonary complications and 4 of these died. In the 18 ASIA-A/B cases (complete motor paralysis), the time of 8 hours or less from injury to surgery was correlated with neurological function improvement from ASIA A/B to C/D ($r=0.669$, $P=0.003$). Conclusion: About one third of the patients with unstable cervical spine fracture with diffuse idiopathic skeletal hyperostosis (DISH) benefited from posterior decompression and vertebral fusion. Patients with complete motor paralysis after a cervical fracture with DISH may recover to partial paralysis if surgically treated within 8 hours of injury.

Keywords: Diffuse idiopathic skeletal hyperostosis, posterior decompression, vertebral fusion, unstable cervical spine fracture

Introduction

Diffuse idiopathic skeletal hyperostosis (DISH) is a non-inflammatory disease in which the spinal longitudinal ligaments and enthesis become ossified over time, decreasing mobility in the affected segment [1]. DISH can be diagnosed by the presence of flowing ossification of the anterior longitudinal ligament over at least 4 consecutive vertebrae in lateral-view spine radiographs [2]. DISH is more common in people over 50 years of age, and its overall prevalence is greater than 10% in subjects that are 70 years and older [3, 4]. In DISH, multilevel bony vertebral fusions produce long lever arms, creating an environment in which even low-energy trauma can cause fractures with an increased risk of neurological injury [5]. Delayed detection of fractures in the ankylosing spine is sometimes an issue with DISH, either because of misdiagnosis or the patient's failure to seek medical attention promptly [6]. In general, surgery is recommended for 3-column injuries in the ankylosed spine because conservative treatments have not proven effective [7-11]. This study presents a series of patients with cervical-spine ankylosis due to DISH who presented at our center with a spinal fracture. All patients were treated surgically by posterior decompression and fixation. We present the results with special attention to surgical outcomes and complications.

Table 1. Basic information of patients with DISH and unstable cervical fractures

Characteristic	Value
Male/Female (cases)	35/3
Age (years)	71.8±8.8
Fracture location (Cases)	
C3-C4	2
C4-C5	10
C5-C6	12
C6-C7	11
C7-T1	3
Fracture type (Cases)	
Type 1	20
Type 2	8
Type 3	10
Mechanism of injury (Cases)	
Fall at ground	20
Motor-vehicle collision	8
Fall from a height	6
Falling on stairs	4
Time from injury to diagnosis (days)	3.1±7.8

Materials and methods

A retrospective review at Hokkaido Spinal-Cord Injury Center was conducted to identify patients who presented with DISH and fractures of the cervical spine and who were treated surgically between October 2006 and April 2016. These patients were identified by searching spinal x-rays and computed tomography images, and details were obtained from medical records and surgery notes. When DISH was identified, we examined the corresponding imaging studies and medical records for the presence of a cervical spinal fracture.

Evaluation of patient and injury characteristics

The following patient variables were assessed: patient demographics, injury variables such as the mechanism of injury and the fracture type; preoperative neurological status using the American Spinal Injury Association (ASIA) grade; treatment variables such as time to treatment, surgical technique, and delay of diagnosis, and post-treatment variables such as morbidity, mortality, additional surgery, and ASIA grade at final follow-up.

Cervical fractures caused by a distraction force were classified into 3 types. Based on whether the fracture through the anterior spinal column involved the intervertebral disc (type 1), the vertebral body (type 2), or both the body and the disc (type 3).

Evaluation of neurological function

Patients were assessed for neurological function by the ASIA spinal injury grade at the time of their initial assessment in emergency room of our center and at their last follow-up.

Complications

Patients' medical records were reviewed for perioperative complications related to the injury. We also looked for delayed diagnosis, which we defined as a lack of documentation of a fracture within 24 hours of the patient's initial assessment, for any decline in neurological function, and death. Decline in neurological function was defined as an obvious worsening of the patient's ASIA grade from the time of the initial examination to the most recent follow-up.

Statistics and level of significance

Means and standard deviations were computed for continuous variables which were analyzed with independent-samples t test. Cross-tabulation tables were applied along with Fisher's 2-tailed exact tests and Pearson's χ^2 test for dichotomous outcomes. For all analyses, Mac statistical analysis add-in software for Microsoft Excel was applied. The relationship of the elapsed time from injury to surgery with neurological prognosis was tested by Pearson correlation analysis. A *P* value less than 0.05 indicated statistically significant.

Results

Patient and fracture characteristics

Our review of medical records and radiographs identified 38 patients (35 males and 3 females) with DISH and unstable cervical fractures. The mean age was 71.8±8.8 years (mean ± SD; range, 53-92 years). The fractures were located in C3-4 in 2 cases, C4-5 in 10, C5-6 in 12, C6-7 in 11, and C7-T1 in 3. The most common fracture type, a fracture through the disc space (type 1), occurred in 20 patients (52.6%); fractures through the vertebral body (type 2) occurred in 8 patients (21.1%), and fractures

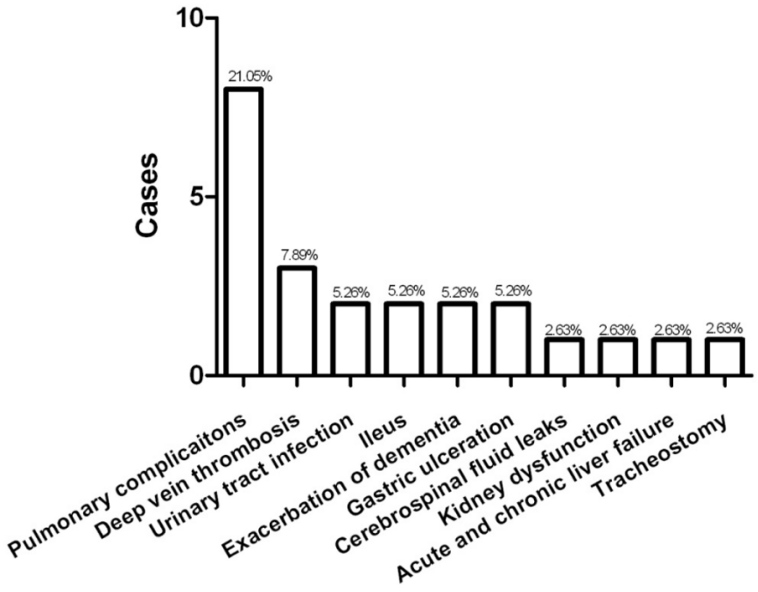

Figure 1. Perioperative medical complications associated with cervical fractures with DISH.

Table 2. Comparison of difference of ASIA grades between the types of fracture

Injury classification	Neurological status by ASIA grade				
	A	B	C	D	E
Type 1 (n=20)	9	1	5	3	2
Type 2 (n=8)	2	1	0	3	2
Type 3 (n=10)	3	2	2	2	1
X^2	6.674				
P	0.572				

through both the disc and vertebral body (type 3) occurred in 10 patients (26.3%). The most common mechanism of injury was a fall at ground level in 20 patients (52.6%), followed by motor-vehicle collision in 8 (21.1%), a fall from a height in 6 (15.8%), and fall on stairs in 4 (10.5%). The average time from injury to diagnosis of the spinal fracture was 3.1±7.8 days (range, 0--45) including 9 cases (23.7%) of delayed diagnosis (**Table 1**).

Treatment data and complications

All patients were treated by posterior decompression and instrumented fusion. The average number of instrumented vertebrae was 4.5±2.5 (range, 2-7). Within 2 months after surgery, 6 patients (15.8%) required additional halo-vest fixation because instrumentation screws had loosened.

Figure 1 lists perioperative medical complications, including 8 patients (21.1%) with severe postoperative pulmonary complications requiring ventilator support and 4 patients (10.5%) who died within 3 months after injury. The average age at the time of death was 72.5±11.0 years, which was not much older than the total study population (t=0.136, P=0.894). All of the patients who died or had severe pulmonary disorders were ASIA-A on admission.

Neurological function changes

ASIA grades were documented for all patients at the time of admission. There were 33 patients (86.8%) with a spinal-cord injury (18 with complete and 15 with partial paralysis). The patients' ASIA grades upon admission were as follows: 14 ASIA-A (36.8%), 4 ASIA-B (10.5%), 7 ASIA-C (18.4%), 8 ASIA-D (21.1%), and 5 ASIA-E (13.2%). Statistical analysis showed no significant difference of ASIA grades between the types of fracture (**Table 2**). The ASIA grade at admission was used as the baseline in all patients. At the last recorded examination, 13 patients (34.2%) had improved at least one ASIA grade; 24 patients (63.2%) had no change; one patient (2.6%) had neurological deterioration due to disuse atrophy syndrome (**Table 3**).

Factors affecting neurological prognosis

Table 4 shows that of 11 cases that were assessed as ASIA-A/B at admission and had an elapsed time from injury to surgery greater than 8 hours (range, 8.5 to 9 days), there was no neurological recovery (complete motor paralysis was unchanged, ASIA-A/B) at the final follow-up. On the other hand, in 7 ASIA-A/B cases with an elapsed time from injury to surgery of 8 hours or less (average 5.4±2.3 hours, range 1-7.8), 4 patients (57.1%) recovered from complete to partial motor paralysis (from ASIA-A/B to ASIA-C or -D) (**Table 4**). Statistical analysis revealed that the elapsed time from injury to surgery was significantly correlated with the neurological prognosis (r=0.669, P=0.003, Pearson's correlation analysis).

Table 3. Neurological outcome by ASIA spinal injury grade at admission and final follow-up (n, %)

Neurological status	Before surgery	After surgery	χ^2	P
A	14 (36.84)	11 (28.95)	3.081	0.544
B	4 (10.53)	3 (7.89)		
C	7 (18.42)	4 (10.53)		
D	8 (21.05)	14 (36.84)		
E	5 (13.16)	6 (15.79)		

Of the remaining, 20 patients with partial motor paralysis on admission (ASIA-C/D), only one patient had functional neurological deterioration at final follow-up, and this deterioration was due to disuse syndrome. For these patients, there was no statistical correlation between neurological prognosis and the elapsed time between injury and surgery.

Discussion

Although several studies have assessed fractures occurring with ankylosing spinal disorders, most have not distinguished between ankylosing spondylitis and DISH. Until now, the largest single series to study cervical fractures with DISH was conducted by Branford et al., with 33 cases that were all treated surgically [12]. The present study included 38 patients with DISH cervical fractures, all of whom underwent posterior instrumentation surgery. This is a first study showing that surgical treatment within 8 hours after injury significantly improved the neurological status in the patients with cervical DISH fractures. The injury was due to low-energy trauma in more than half of the patients (52.6%). This proportion was lower than that reported in other series [13, 14]. Our hospital is specialized for spinal-cord injury, and this probably accounts for the proportion of cervical DISH fractures caused by high-energy trauma being relatively high compared to that in other studies.

In our study, 4 patients (10.5%) died within 6 months after injury. Other studies have reported mortality rates of 11% to 79% [15]. All of the deaths in the present series were due to severe pulmonary disorders related to complete cervical spinal cord injury. All of the patients with severe pulmonary complications, including those who died, were ASIA-A on admission. This finding underscores the necessity for careful pulmonary monitoring in this frail population, as noted by Bransford et al. [12].

Of the 33 cases of cervical DISH fracture reported by Bransford et al., 16 patients were treated with an anterior-only procedure, 12 patients with posterior-only instrumentation surgery, and 5 with a one-stage anterior-and-posterior procedure; patients treated with a posterior-only procedure had an average of 6.5±1.4 (range, 4-8) instrumented vertebrae [12]. The patients in our series had an average of 4.5±2.5 instrumented vertebrae (range, 2-7). This improvement in the number of instrumented levels in our study is likely to reflect advances in cervical posterior instrumentation that have occurred since previous studies. All of the patients in our series were treated with posterior-only instrumentation and decompression. Halo vests were required in 6 cases because of screw loosening after the surgery. Bone union was achieved in all cases at final follow-up. We chose the posterior-only procedure with instrumentation because of recent improvements in posterior cervical devices and the possibility of tracheotomy in cases with a neurological injury above the C5 level.

Although the bone mineral density (BMD) of both the lumbar spine and femur neck is increased in patients with cervical or thoracic DISH, the bone quality of elderly patients with DISH remains to be elucidated. Since the ossified anterior longitudinal ligament influences the results of BMD measurement, routine dual-energy X-ray absorption scanning may overestimate the true vertebral body BMD in DISH patients [16, 17]. We hope that new validation tools, perhaps using methods such as quantitative CT, will become available in the near future for evaluating bone microstructures and other factors related to bone quality. Fractures in the ankylosed spine resemble those in long bones, and the consequent stress concentration at the fracture site makes these fractures unstable [18]. Unlike ankylosing spondylitis, DISH presents with a diverse morphology and range of ankylosed vertebrae [19]. For example, the number of mobile segments in the cervical spine was different in each case in our series, with some patients having segments with a fused, long-bone-like appearance, and others having a wide range of motion at the levels involving DISH. Furthermore, in some cases of

Table 4. Neurological outcomes for patients with surgical time over 8 hours (n, %)

Neurological status	Surgical time over 8 hours		Surgical time in 8 hours	
	Before surgery	After surgery	Before surgery	After surgery
A	11 (28.95)	9 (23.68)	3 (7.89)	2 (5.26)
B	0 (0)	2 (5.26)	4 (10.53)	1 (2.63)
C	6 (15.79)	2 (5.26)	2 (5.26)	2 (5.26)
D	6 (15.79)	9 (23.68)	1 (2.63)	5 (13.16)
E	5 (13.16)	6 (15.79)	0 (0)	0 (0)

cervical DISH fracture, the fractured vertebrae at the ankylosed site appeared osteosclerotic in preoperative CT images, and difficulties faced by the surgeons in determining the lateral mass adequately by feel or in fixing the pedicle screws resulted in more levels being included in the fusion. This divergence between CT findings and what the surgeon can determine by feel during the surgery might arise from cancellous bone regression caused by ankylosis extending into the vertebra. To determine the appropriate therapeutic strategies for cervical DISH fracture, it is mandatory to assess factors such as stress concentration, instability of the ankylosed spine, and bone fragility [20].

In our series, the elapsed time from injury to surgery was correlated with the neurological prognosis in patients that presented as ASIA-A/B upon admission, suggesting that there is an 8-hour golden window for avoiding complete motor paralysis after spinal injury. Although our study is the largest case series of cervical fractures in DISH to date, it is still limited by a relatively small sample size. Among patients that presented with partial motor paralysis (ASIA-C/D), the elapsed time from injury to surgery had no correlation with prognosis. However, Einsiedel et al. reported that because of unstable fracture configurations in the ankylosing spine, initially intact patients may sustain secondary neurologic deterioration after unprotected transfers or manipulation [21]. Even in patients that initially present as ASIA-C/D, motor function can deteriorate if the cervical spine is not positioned appropriately in a neck collar during emergency transport; thus, meticulous management is essential in all cases of partial motor paralysis. ASIA-A cases present a serious clinical challenge because of the high frequency of severe pulmonary complications and mortality. Our data show that surgical intervention within 8 hours of the injury can improve postoperative outcomes, emphasizing the importance of early diagnosis and surgery for spinal-cord injuries with complete motor paralysis.

Disclosure of conflict of interest

None.

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