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Therapeutic Strategy for Traumatic Instability of Subaxial Cervical Spine

ABSTRACT

A simple, safe and effective therapeutic strategy for traumatic instability of the subaxial cervical spine, as well as its prognostic assessment, is still controversial. The therapeutic options for 83 patients of traumatic instability of the subaxial cervical spine, whose average age was 35 years, were determined, according to the Allen-Ferguson classification, general health and concomitant traumatic conditions, neurological function, position of compression materials, concomitant traumatic disc herniation/damage, concomitant locked-facet dislocation, the involved numbers and position, and the patients' economic conditions. An anterior, posterior or combination approach was used to decompress and reconstruct the cervical spine. No operations with an anterior-posterior-anterior approach were performed. The best surgical strategy should be determined by the type of subaxial cervical injury, patients' general health, local pathological anatomy and neurological function.

Keywords: *cervical instability, disease classification, surgical strategy*

1. Introduction

Traumatic instability of the subaxial cervical spine, a common type of injury, includes fracture or dislocation of the spine, as well as ligament damage. It often causes damage to the spinal cord or nerve root. Therapeutic options include decompression of the neural elements, reconstructing or recovering the normal anatomical alignment of the spine, which leads to immediate stability. Although surgery is the choice of most doctors, there is still no agreement on many correlative factors, such as deciding operation time, surgical approach, sequence/level, internal fixator, and dealing with concomitant local pathological situations (traumatic disc herniation/damage, locked-facet dislocation). In addition, the outcomes of its prognosis and evaluation show considerable differences. Another issue is whether an anterior or posterior approach to reconstruction is the better option for those patients who do not need a particular surgical approach or sequence, due to general or local pathological conditions. Our orthopaedics department has retrospectively visited 83 cases from January 1998 to December 2006.

2. Methods

2.1. Patients

There were 83 patients (59 male and 24 female), with an average age of 35 years (range 18–66 years), and the time between injury and seeking medication was 1.5–4 days. Main injury levels were: C3–4 (10 cases), C4–5 (28 cases), C5–6 (40 cases), C6–7 (10 cases), C7–T1 (3 cases), more than two main levels (C4–5+C5–6) (7 cases). Causes of injury were: traffic accident (49 cases), falling (24 cases), being hit by a heavy object (7 cases), and other causes (3 cases). Concomitant injuries were: traumatic brain injury (6 cases), rib fracture and hemopneumothorax (5 cases), and limb fracture (9 cases). According to the Allen-Ferguson classification, the injury types were as follows: 33 cases with distraction-flexion (including 23 with fracture-dislocation with locked facet), 29 with compression-flexion, 12 with vertical compression, six with compression-extension and three with compression-lateral. Among the 23 cases of fracture-dislocation with locked-facet, there were 17 with normal neurological functions or some neurological dysfunction, six with complete spinal cord injury (SCI) (including six with single locked-facet, 17 with double

locked facet, 13 with facet or neural arch fractures; and seven, nine, five and two with C4–5, C5–6, C6–7 and C7–T1 fracture-dislocations, respectively). All patients had full radiological examinations (static/dynamic X-ray and MRI/CT), neurological assessment (American Spinal Cord Injury Association (ASIA) neurological function assessment, ASIA motion function scale assessment), functional grade assessment (Japanese Orthopaedics Association (JOA) grade), and visual analog scale (VAS) assessment before and after surgery. Radiographic assessments included the following: degree of cervical kyphosis (based on Cobb angle), degree of vertebral body translation, disc height ratio, fusion process of the operated levels, as well as looseness and subsidence of the internal fixator. Among the 83 patients, after excluding those who needed a particular surgical approach or sequence due to general or local pathological conditions, 42 who were reconstructed with either a single anterior or posterior approach were included in this retrospective study.

2.2. Therapeutic Options

Patients were subjected to ASIA neurological function assessment and full radiological examinations (static/dynamic X-ray, and MRI/CT); some correlative complications were dealt with. Large doses of methylprednisolone were given to patients with SCI. All patients were treated with skull or Glisson tong traction.

Given that patients were generally in a stable condition, different therapeutic strategies and sequences were practised based on the injury type and local pathological conditions. We used early and continued closed skull traction-reduction to treat fracture-dislocation with locked facet in patients with distraction-flexion-type fractures, under the guidance of X-ray and neurological function grade assessment. When any neurological function deterioration or disability of reduction or intolerance of traction occurred, we performed different approaches to decompress and reconstruct the cervical spine. This depended on whether there was concomitant disc herniation and damage to the dislocated levels. Posterior reduction and fixation were performed in patients with no concomitant disc herniation; in those with concomitant disc herniation, we performed direct anterior reduction and fixation or a three-stage strategy (The first step was anterior decompression, followed by posterior reduction and fixation, and finally, anterior reconstruction). When closed reduction was successful, we continued with skull traction (some patients were given a further MRI scan), and chose an appropriate date to carry out reconstruction using an anterior, posterior or combination approach (Figures 1 and 2).

In patients with other types of injury, individual operations were adapted according to the location and level of injuries, general and concomitant diseases (for example, osteoporosis), location and number of spinal levels affected by the injury, and the economic conditions and needs of the patient. Patients who had injury to the posterior tension band of the cervical spine, those who were of relatively old age, and those with osteoporosis or multiple-level cervical injuries, needed posterior-approach surgery. Patients with anterior column compression needed anterior-approach decompression-reconstruction operations. Some patients needed a combined approach.

In the anterior approach operation, we used discectomy or corpectomy to perform decompression of the injured spine by the Smith-Robinson method, then the auto-iliac bone or titanium mesh was implanted with anterior locked-cervical plate fixation (CSLP, Synthesis, USA; Zephir/Orion plate, Medtronic, USA; Slim-lock/Codamn plate, Depuy, USA); Posterior-approach operations were mainly performed using reduction and fixation techniques. If infold fracture fragment of lamina or lateral mass, compression of the neural elements, or concomitant cervical spinal canal stenosis occurred, we performed total laminectomy or intervertebral foramen dissection decompression, using lateral mass fixators (Axis/Vertax, Medtronic; Cervifix, Synthesis, USA).

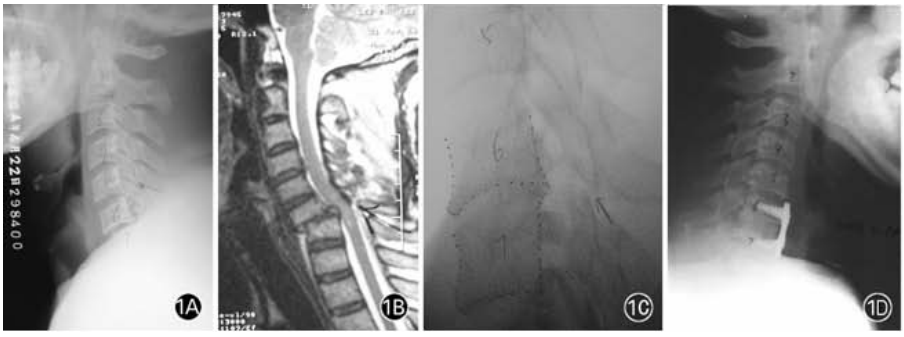

Figure 1. A: C6-7 fracture-dislocation with facet-locked occurred. B: C6-7 traumatic disc herniation occurred. C: Closed traction-reduction was successful. D: Anterior fusion and fixation was practised at an appropriate date.

Figure 2. A: C5-7 fracture-dislocation with instability occurred. B: Combined anterior and posterior-approach operation occurred.

Table 1. Patient characteristics and functional scores before and after operations (Mean value)

Variables	Preoperative	Postoperative	Student's *t* test	
			t value	*P* value
JOA score	11.2	15.3	8.67	<0.05
VAS score	7.8	2.6	14.31	<0.05
ASIA motor score	53.5	67.8	7.69	<0.05
Cobb angle (°)	+21.8	–2.9	18.13	<0.05
Anterior vertebral body translation (mm)	6.0	0.35	23.44	<0.05
Disc height ratio (%)	71	96	12.28	<0.05

Table 2. Pre- and post-operative functional scores and patient characteristics according to surgical approach (Mean value)

Parameters	Anterior group (24 cases)		Posterior group (18 cases)	
	Preoperative	Postoperative	Preoperative	Postoperative
JOA score	12.1	16.0	12.3	15.7
VAS score	6.9	2.2	7.2	2.6
ASIA motor score	58.4	68.2	59.7	65.5
ASIA grade numeric score	3.3	3.8	3.4	3.7
Cobb angle (°)*	+7.2	–3.1	–2.3	–2.1
Anterior vertebral body translation (mm)	1.7	0.2	1.5	0.2
Disc height ratio (%)*	76	108	75	97
Operation time	2 hours and 2 minutes		2 hours and 33 minutes	
Blood loss (ml)	125		287	

*The difference between the anterior and posterior groups was significant (P <0.05)

2.3. Postoperative Follow-up

Patients were given antibiotics and vitamin B-12 for nerve recovery, and instructed to wear a cervical collar for 2–3 months. We visited the patients regularly and recorded their ASIA neurological function grades, ASIA mobility function index scores, JOA scores, and VAS scores. Radiological assessment included the following:

Cobb angle, vertebral body translation, disc height ratio, fusion process of the operated levels, as well as looseness and subsidence of the internal fixator.

2.4. Statistical Analysis

Statistical analysis was performed by Student's *t* test and $P < 0.05$ was considered significant.

3. Results

All cases were followed up for an average of 3 years and 9 months (range, 3 months to 6 years and 4 months). There were 16 cases with complete SCI, 39 with incomplete SCI, and 28 cases with normal neurological function. Twenty-eight patients had anterior cord syndrome, five had Brown-Sequard syndrome, and 22 had central cord syndrome. There were 46, 28 and 9 cases treated with anterior, posterior and combination operations, respectively. There were no operations using an anterior-posterior-anterior approach. Before surgery, the average JOA and VAS scores were 11.2 (0–17) and 7.8 (1–10), respectively. At the final assessment, the JOA and VAS scores improved to 15.3 (1–17) and 2.6 (0–6) respectively. The average ASIA motor score was 53.5 (0–100) before operation and 67.8 (11–100) at the final follow-up. For incomplete SCI, the average ASIA neurological function score was improved by 1–2 levels. Patients with complete SCI had no neurological recovery, but nerve root function recovered to a different extent. The average Cobb angle, vertebral body translation, and disc height ratio were +21.8° (+46 to –2.1°), 6.0 mm (posterior translation 0.6 mm, anterior translation 8.3 mm), and 71% (38%–89%) respectively, before surgery, and –2.9° (+2.4 to –4.1°), 0.35 mm (0–2.2 mm), and 96% (82%–145%), respectively, at final follow-up (Table 1). Forty-two patients were treated with either single anterior or posterior approach reconstruction (Table 2). Fusion was achieved in all patients. The complications were as follows: one patient with internal fixator looseness and esophagus fistula; four with titanium mesh subsidence; five with temporary recurrent laryngeal nerve injury; and two with superficial infection.

4. Discussion

Traumatic instability of the subaxial cervical spine is a common injury that often causes severe neurological disability. Although the general therapeutic principles of spinal surgery are followed, namely, to decompress the neural elements, reconstruct or recover normal anatomical alignment of the spine, and acquire immediate stability, specific therapeutic methods and strategies need to be individually tailored according to general and local pathological situations.

Some authors[1,2] believe that cervical dynamic X-ray at an early stage can help overcome the false-positive results of MRI. Although cervical dynamic X-ray is economic and convenient, patients' protective spasm and potential neurological risks limit its early use. Therefore, we only used cervical dynamic X-ray under close surveillance when MRI could not be practised, or when subaxial cervical spinal instability could not be determined.

Although there are different opinions,[3-6] giving patients with cervical cord injury high-dose methylprednisolone at an early stage can reduce secondary injury to the spinal cord. In addition, we followed the NASCIS[5] therapeutic option so as to retain as much function as possible in the spinal cord and nerve roots. Theoretically, quickly decompressing the cervical spinal cord and reconstructing or recovering the normal anatomical alignment of the cervical spine is beneficial for promoting nerve function recovery, and this has been supported by the results of animal experiments.[7,8] However, due to a lack of randomized double-blind and prospective clinical trials, there is still controversy concerning the operation time in patients who have cervical cord injuries.[7-9] Because of the common concomitant limb and visceral injuries, as well as the preoperative diagnosis and preparation periods, we think it is difficult to finish an emergency operation within 6–8 hours. Moreover, emergency operations increase blood loss and perioperative complications. Therefore, it is reasonable and feasible to perform an early, but non-emergency operation on patients with cervical cord injuries, and to adopt the strategy of proper operation time in patients who have subaxial cervical spinal injury without neurological disability.

Treatment of subaxial cervical spine fracture-dislocation with concomitant locked facet is still controversial, especially in cases in which there is disc herniation in front of the dislocated cervical cord, but there is normal neurological function or only partial dysfunction.[10,11] The greatest risk in closed or posterior unlocking reduction lies in catastrophic deterioration of neurological function if there is major traumatic disc herniation before the operation.[12] Therefore, decompression, reduction and reconstruction of the subaxial cervical spine using an anterior approach has been suggested by many authors.[13-17] It is believed that this option can reduce neurological

function deterioration and cervical axial pain induced by the trauma of surgical exposure, and it has the advantage of acquiring fixation levels that are as low as possible.

We are opposed to closed or reduction under general anesthesia, and disagree with the three-stage therapeutic strategy of Vital et al.[18] We believe that MRI before treatment has great significance in establishing the spinal cord compression status (level, direction, materials and nature of the compression) and injury to the surrounding soft tissue, in order to determine if the cervical spine is stable, although it is possible to delay the course of reduction to some extent and increase the potential risks during examination.[19] We think that if the patient is in a conscious and cooperative status, a close and dynamic examination of the neurological function grade and cervical anatomic realignment can, to the greatest extent, reduce neurological deterioration, and that continued traction can, to the greatest extent, eliminate patients' protective muscle spasm, which is good for reduction. If neurological function deteriorates during traction- reduction, excess traction of injured levels occurs, severe and refractory neck or upper limb pain appear discontinuing traction, or resistance against the traction weight cannot be maintained during skull traction, we use surgical reduction and fixation instead of closed traction-reduction.[16,20] If closed traction-reduction is successful, we continue skull traction and determine an appropriate time to carry out internal fixation and fusion, so as to finish the operation under the best conditions for both the surgeon and the patient. The operation approach is determined by the results of MRI before and after reduction. The location of the materials causing compression, the stability status of the injured spinal units, assessment of bone mass and bone structure, and the patient's general condition and economic status should all be taken into consideration. An anterior approach operation is the first choice, and when necessary, operations using the posterior approach, combined approach, or anterior-posterior-anterior approach can be used.

Although there are different methods of classifying traumatic subaxial cervical fracture-dislocation,[21-23] we think that the Allen-Ferguson classification system[21] is useful for deciding the correct therapeutic strategy. We determined specific operation types according to the following criteria: location and extent of the injury, general condition and concomitant injury status (for example, osteoporosis), injury level and number of lesions, and the patient's economic status. Patients who had injuries to the posterior tension-band of the cervical spinal cord were of relatively old age, and those who had osteoporosis or multiple-level cervical injuries needed posterior-approach operations; patients with anterior column compression needed anterior-approach decompression-reconstruction operations; and some patients needed combination approach surgery. Brodke et al[24] compared two groups of prospective randomized cases who underwent anterior or posterior operations, excluding some patients with decompression or reduction-fixation through special approach. Among our 83 cases, 46 were treated with an anterior approach, 28 with a posterior approach, and 9 with a combined approach. If we excluded those who needed a particular operation approach or surgical sequence, due to general or local pathological conditions, 42 cases who underwent either a single anterior or posterior approach reconstruction were included. With the improvement in cervical spine fixation equipment, if we exclude those operations performed using a special approach for decompression and reduction-reconstruction, there is not much difference between anterior- and posterior-approach operations. However, anterior-approach operations have the advantages of fewer posture changes, simple surgical exposure, less traumatic bleeding and fixed levels in the operation, as well as lower occurrence of postoperative cervical axial pain. In addition, with the improvement in surgical skills, we can realize decompression and recovery of normal spinal height and physiological curvature at the same time. However, posterior-approach operations retain their value when certain conditions exist, such as invaginated fracture of lamina or zygapophysial joint, development of cervical canal stenosis, refractory locked-facet dislocation or old subaxial cervical injury, multiple-level cervical injuries, serious osteoporosis, or poor general health. In addition, although posterior cervical pedicle screws can provide the strongest three-dimensional support, posterior cervical lateral mass screws are still regarded as the best choice if technical requirements and subsequent surgical risks are taken into consideration. Combined-approach operations are usually performed in cases of serious subaxial cervical spinal instability, those requiring long segment reconstruction, severe osteoporosis, serious injury to the cervical-thoracic junction, and some irreversible locked-facet dislocation caused by spinal cord compression, which results from serious anterior column fracture or disc herniation.[10,11]

We carried out a functional assessment during follow-up, by adopting the JOA and ASIA neurological assessments and functional grades. Before operation, the average JOA scores and ASIA functional grades were 11.2 (0–17) and 53.5 (0–100), respectively. At the final assessment, they improved to 15.3 (1–17) and 67.8 (11–100), respectively. For incomplete SCI, the average ASIA neurological function scale was improved by 1–2 levels. Patients with complete SCI had no neurological recovery, but their nerve root function recovered to different extents.

The spine trauma study group[25] has stated that the undermentioned radiological parameters can be used as a follow-up index before and after the following operations: cervical kyphosis (Cobb angle), vertebral body translation, disc height ratio, maximal spinal canal compromise and spinal cord compression, facet fracture fragment size, and percentage facet subluxation. The average Cobb angle, vertebral body translation, and disc height ratio were +21.8° (+46 to –2.1°), 6.0 mm (posterior translation 0.6 mm, anterior translation 8.3 mm), and 71% (38%–89%), respectively, before operation, and –2.9° (+2.4 to –4.1°), 0.35 mm (0–2.2 mm), 96% (82%–145%), respectively, at final follow-up, which indicated that both normal cervical physiological lordosis was recovered and disc height or vertebral body alignment was reconstructed. Fusion was achieved in all patients and neurological functions were improved at different levels, although few cases had internal fixator looseness and esophageal fistula, titanium mesh subsidence, and superficial infection. The average VAS grades decreased from 7.8 (1–10) before operation to 2.6 (0–6) after operation.

In conclusion, based on a full application of modern spinal fixation (cervical anterior self-locked plate/anterior column supporting structure, posterior lateral mass screws/pedicle screws), as well as imaging techniques and cervical injury classification, the best surgical strategy is determined by the subaxial cervical injury type, patients' general health, local pathological anatomy and neurological function. Individual tailoring of surgical treatment is the key to success.

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