Anterior C3 corpectomy and fusion for complex Hangman's fractures

Cong Wang · Hui Ma · Wen Yuan · Xinwei Wang ·
Huajiang Chen · Xiaodong Wu

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Abstract

Purpose The aim of this study was to assess the effectiveness and feasibility of anterior C3 corpectomy and fusion with screw-plate fixation of C2–4 for the treatment of Hangman's fracture in which spinal cord compression comes from the posterosuperior part of C3 vertebral body and the intervertebral disc injury at the C2–3 level.

Methods From August 2000 to December 2005, 11 patients (eight males and three females) with traumatic spondylolisthesis of the axis underwent the above surgery. Neurological status was evaluated by the Japanese Orthopaedic Association Score (JOA score). The fusion of the graft, healing of the fracture, and range of motion of the whole cervical spine were examined according to X-ray imaging.

Results No patient received blood transfusion. There was no deterioration of the neurological function in any case postoperatively. The mean JOA score was significantly improved from 9.1 ± 2.3 preoperatively to 14.8 ± 1.2 at the 12-month postoperative visit. All patients were relieved of axial pain. Imaging evaluation confirmed a high fusion rate and healing rate in all patients. No patient complained of limited mobility of the cervical spine in flexion, extension and rotation. No graft or plate-related complication was observed in any patients during the whole follow-up period. The only postoperative complication was trouble in swallowing liquids in two

cases which resolved three months after surgery without any treatment.

Conclusions Anterior C3 corpectomy and fusion may prove to be safe and applicable for the treatment of complex Hangman's fractures.

Introduction

Hangman's fracture was first discovered by Haughton in 1866 in hanged criminals, and officially named by Schneider in 1965 to describe traumatic spondylolisthesis of the axis (TSA) [1]. It is defined as fracture of the laminae, articular facets, body, pedicles or pars interarticularis of the axis vertebra. As a mechanically weak and stress concentration point, the pars interarticularis of the axis is at a high risk of injury in the upper cervical spine [2]. Although concomitant injury to the head, cervical spine and thorax is high in TSA, the incidence of neurological impairment and non-union is relatively low. For this reason, surgical indications and clinical treatment of TSA, compared to other injuries are controversial. Some researchers recommend the use of traction and halo-vest external immobilisation [3]; while others consider it to be a grossly unstable fracture and advocate surgical stabilisation [4]. The Levine-Edwards classification has been introduced to help clinicians decide on treatment strategies depending on different types of fracture [5]. According to the Levine-Edwards classification, type II injury is complex with extension forces and axial loading followed by flexion and compression forces. Type IIA injury is mostly caused by buckling associated with distraction. Type III injury is caused by sudden and tremendous buckling. These unstable Hangman's fractures are usually characterised by significant angulation and translation associated with injuries to the anterior longitudinal ligament, posterior longitudinal ligament and C2–3 disc [6], for which surgical reduction and rigid immobilisation are necessary.

Cong Wang and Hui Ma contributed equally to this work.

C. Wang · W. Yuan (✉) · X. Wang · H. Chen · X. Wu
Department of Orthopedics, Changzheng Hospital,
Second Military Medical University,
415 Fengyang Road,
Shanghai 200003, China
e-mail: wenyuan123321@hotmail.com

H. Ma
Department of Orthopaedic Surgery,
Shanghai First Rehabilitation Hospital,
Shanghai 200090, People's Republic of China

Surgical management of unstable Hangman's fracture usually includes anterior cervical discectomy and fusion (ACDF) at C2–C3; posterior fusion of the upper cervical vertebrae; or both anterior and posterior approaches [3, 7–10]. Knowing that Hangman's fracture mostly involves the posterior arch of the axis, some orthopaedic surgeons prefer the posterior approach [11]. However, the pathogenesis of this special fracture often causes C2–C3 disc hernia and spinal cord compression. Some other surgeons choose the anterior approach [12]. But this motion-preserving procedure excluding the C2–3 segment is not appropriate for fractures in which spinal cord compression comes from the posterosuperior part of C3 vertebral body and the intervertebral disc injury at the C2–3 level. The loss of motion at the operated segment has to be compensated by increased rotation at the subaxial cervical spine to minimise the effect of fusion on mobility. C3 corpectomy should be especially suitable for this condition as well as C3 fracture and failing traction. At present, there are few reports on unstable Hangman's fracture treated by anterior C3 corpectomy and fusion. This study aims to retrospectively review our experience with the management of 11 Hangman's fracture patients by using anterior C3 corpectomy and fusion with screw-plate fixation of C2–4. This study was also undertaken to assess the effectiveness and feasibility of this surgical modality for the treatment of Hangman's fracture.

Patients and methods

Patients

Thirty-seven patients with TSA were admitted to our unit from August 2000 to December 2005. Skull traction with a weight of 1.5–2 kg at an appropriate angle in the supine position was initiated for seven to nine days according to the injury mechanism and the situation in each patient. However, 11 of them still had residual spinal cord compression after traction and subsequently underwent anterior C3 corpectomy and fusion with screw-plate fixation of C2–4. These 11 patients included eight males and three females with a mean age of 34 years (range, 20–62). The causes of injuries were road accidents (54.5 %), falls (27.3 %), and unknown reasons (18.2 %). Axial pain and restricted motion of the cervical spine were the common complaints in all patients. Neurological evaluation on admission showed that ten patients had significant neurological deficits, presenting as decreased peripheral muscle power and limb numbness (Table 1). Imaging evaluation included standard anteroposterior (AP), lateral and open-mouth plain radiography of the cervical spine, computed tomography (CT) scan and magnetic resonance imaging (MRI). They showed that spinal cord compression in all patients was from the posterosuperior part of the C3 vertebral

body accompanied by damage to the integrity of the C2–3 intervertebral disc (Fig. 1). According to Levine–Edwards classification [5], type II fractures were found in seven patients and type IIA in four patients.

Surgical technique

All patients underwent anterior C2–3, C3–4 discectomy, C3 corpectomy and autologous iliac bone fusion with a Zephir plate. The patient was positioned in the supine position with the neck slightly extended without axial traction. A standard anterior horizontal incision was made midway between the angle of the jaw and the thyroid cartilage. The anterior cervical approach was exposed routinely. C2–3 anterior longitudinal ligament tear stasis and disc disruption were noticed when the front of the cervical spinal vertebra was being exposed. Exploration was made at the C3–4 level, only to ensure that the C3–4 anterior longitudinal ligament and disc were intact. C2–3, C3–4 discectomy and C3 corpectomy were performed routinely, followed by the removal of the posterior longitudinal ligament to achieve a thorough decompression. Since the main compression came from the prolapsed disc, especially the posterosuperior part of C3 vertebral body as shown on MRI, the decompression procedure was carefully started from the bottom to the top of the C3 vertebral body after disc discectomy. Arthrodesis with supplementary autogenous iliac bone graft and anterior titanium plate purchasing on the C2 and C4 vertebral bodies was performed to obtain lordotic alignment. The incision was closed with a drainage tube retained for 48 hours. A complementary neck brace was used during the first six weeks and then gradually weaned off over the second six weeks.

Follow-up

The patients enrolled in our study were followed up for a mean of 17 months (range, six to 48 months). Re-evaluations were performed at a three month interval in the first six months and yearly thereafter. Clinical neurological symptoms were re-examined and neurological status was evaluated by the Japanese Orthopaedic Association Score (JOA score) [13]. X-ray was taken to assess the fusion of the graft and healing of the fracture. Range of motion (ROM) of the whole cervical spine was examined by comparing the dynamic X-ray films with the neutral position X-ray films in all cases.

Results

The mean operative duration was 158 minutes (range, 110–186 min). All patients were relieved from axial pain. The

Table 1 Imaging features and neurological deficit in 11 cases

Case	Age/sex	Typing	Injury mechanisms	Imaging features	Neurological deficit
1	31/M	IIA	Fall	Spinal cord compression(a)(b)* and high T2 signal	Decreased peripheral muscle power and limb numbness
2	29/M	II	Road accident	Spinal cord compression*(b) and high T2 signal	Weakness and numbness in hands
3	20/M	II	Fall	Spinal cord compression*(b) and high T2 signal	Trouble in walking and weakness in grasping and numbness in extremities
4	31/F	II	Road accident	Spinal cord compression*(b)	Numbness in both upper extremities
5	37/F	IIA	Road accident	Spinal cord compression(a)(b)* and high T2 signal and C3 fracture	Hypoesthesia in the trunk below the clavicle; numbness in extremities
6	40/M	II	–	Spinal cord compression*(b)	Numbness in both upper extremities
7	62/M	II	–	Spinal cord compression*(b)	Hypoesthesia below fovea jugularis; numbness in both shoulders; weakness in two arms
8	27/M	II	Fall	Spinal cord compression*(b)	Weakness and numbness in hands
9	33/F	II	Road accident	Spinal cord compression*(b)	Weakness and numbness in hands
10	35/M	II	Road accident	Spinal cord compression*(b) and high T2 signal	
11	29/M	II	Road accident	Spinal cord compression*(b)	Weakness and numbness in hands

M male, *F* female

Typing: Levine–Edwards Classification; *spinal cord compression: (a) the posterosuperior part of C3 vertebral body; (b) C2/3 intervertebral disc which enter the rear of the C3 vertebral body

neurological status of all patients had improved, although residual numbness and weakness remained in six cases at the final follow-up. The mean JOA score was significantly improved from 9.1 ± 2.3 preoperatively to 14.8 ± 1.2 at the 12-month postoperative visit (Table 2). Static plain radiography and dynamic films showed evident signs of fusion at C2–3 and C3–4 in all patients six months after surgery. The gaps between the pars of the axis were no longer detectable, and increased radiological density on the axis pars demonstrated that the fractures knitted well without posterior surgical treatment (Fig. 2). No patient received blood transfusion. No intra-operative complication was observed. No graft or plate-related complication was present in any patients during the whole follow-up period. No significant

limitation of ROM was seen in any case. None of the patients complained of limited mobility of the cervical spine in flexion, extension or bending. The only postoperative complication was trouble in swallowing liquids in two cases which resolved three months after surgery without any treatment.

Discussion

Levine-Edwards classification is most generally accepted among all classification schemes of Hangman's fracture, based on which modern surgical treatment protocols have evolved according to the mechanisms of traumatic loading

Fig. 1 A 54-year-old patient with a type II Hangman's fracture. **a** Preoperative lateral X-ray. **b** Preoperative T2-weighted sagittal MRI shows compression and signal change in the cervical cord. **c** Preoperative 2D sagittal CT shows that compression comes from the posterosuperior part of the C3 vertebral body

Table 2 Clinical outcomes of patients preoperatively and during follow-up

Parameter	Pre-operative	Postoperative	Postoperative 12 months
JOA score	9.1±2.3	11.4±1.7	14.8±1.2

described in 1985 [14]. However, the optimal treatment for fractures of the isthmus of axis remains controversial due to continuous improvement in imaging and surgical techniques.

Conservative treatment played a dominant role in the treatment of Hangman's fracture in the 1980s [1, 7, 15], and several researchers have reported a series of satisfactory cases using this technique. But some studies also have found disadvantages of conservative treatment, such as pseudarthrosis, anterior dislocation, angulation of C2 over C3, and recurrent axial pain [5, 16]. In addition, long-term external immobilisation also produces much discomfort and inconvenience since the halo vest needs to be worn for a mean of three to six months [15, 17]. Therefore, orthopaedic surgeons have sought surgical methods to resolve these problems.

At present, surgical intervention mainly includes the posterior and anterior approach. Some researchers feel that the posterior approach is relatively simple for exposure without involving the major visceral and vascular structures, superior laryngeal nerve, hypoglossal nerve, trachea and oesophagus. Several clinical studies also have confirmed relatively good outcomes from this approach [18]. Even though the posterior pars fracture of the axis is fixed and repaired, visible injuries to the anterior ligament and disc are neglected with a potential risk of instability. More seriously, cervical spinal cord compression from the front can not be addressed directly due to intervertebral disc protrusion. It is reported that transpedicle screw poses a risk to intraoperative neurological and vascular injury [19, 20]. In recent

years, CT guidance [9, 21] has been gradually applied to improve the accuracy of screw placement. However, intraoperative complications of posterior screws can not be completely avoided, given the difference in the learning curve of individual surgeons.

According to the systematic review of the management of Hangman's fracture by Li et al., the posterior approach and the anterior approach for type III TSA have a similar healing rate (39.32 % vs. 42.86 %) [22]. Thus, it is worth considering whether the anterior approach may become an alternative to the posterior approach. Anterior fusion with iliac graft and plates at C2–3 has been confirmed as an effective management for Hangman's fracture [12, 23]. Importantly, complications related with the anterior approach including injury to the hypoglossal nerve and superior laryngeal nerve are no longer the hindrances for proficient and experienced surgeons. Nevertheless, when compression comes from the postero-superior part of the C3 vertebral body, a motion preserving procedure only excluding the C2–3 segment may not be optional. For the purposes of decompression and in consideration of a neurological deficit (such as peripheral muscle power loss and limb numbness; Table 1), patients with these high-energy injuries require anterior corpectomy to decompress the cord and roots to foster neurological recovery [24, 25]. Subsequently, implants can be used in order to achieve a very rigid fixation [25]. Thus, we proposed C3 corpectomy and autologous iliac bone fusion with a Zephir plate in this study. C3–4 disc was sacrificed prior to C3 corpectomy because a safe pathway of decompression could be obtained from the bottom to the top of C3. In the meantime, the ruptured intervertebral disc of C2–3 could be addressed completely and easily. The loss of motion at the fusion site was compensated by adjacent segments. The effect of fusion on mobility could be limited flexion, extension, and lateral bending, with negligible effect on the rotation. As expected, our clinical results suggested that this procedure provides excellent neurological recovery of function (JOA score was significantly improved from 9.1±2.3 preoperatively to 14.8±1.2 at the 12-month postoperative visit) and a high fusion rate (100 %), but with a low rate of complications.

Fig. 2 Postoperative lateral X-ray. **a** Radiographic imaging immediately after surgery. **b** Radiographic imaging 1 year after surgery shows solid fusion and healing

Conclusion

In our experience, the surgical method of anterior C3 corpectomy, iliac grafting and internal fixation is especially appropriate for treatment of Hangman's fractures accompanied by medullary compression from the vertebral body and disc. It provides good neurological recovery of function and solid fusion with a low rate of complications. A randomised trial of longer duration with a greater number

of patients would be more appropriate to obtain definitive conclusions. Further investigation also should aim to confirm the treatment difference between our procedure and ACDF.

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