Anterior discectomy and fusion with internal fixation for unstable hangman's fracture

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Abstract Between 1999 and 2004, 28 patients (average age: 41, range: 18–70 years) with unstable hangman's fracture underwent anterior discectomy and fusion with internal fixation at our unit. According to the Levine-Edwards classification, all cases were unstable with type II (10 cases), type IIA (17 cases) and type III (1 case). An average follow-up of 15 months was achieved (range: 3–48 months). The average operative time was 107 min (80–131 min). No patient received blood transfusion. No patient experienced worsening neurological function postoperatively. No other intra- or postoperative complication was observed. All patients were relieved from axial pain. Neurological status improved postoperatively in all four cases with neurological deficit. Each patient showed evidence of a solid anterior C2–3 interbody fusion after six months. No bone graft or plate screws complication was observed in any of the cases during the follow-up period. In our experience the anterior approach with primary internal stabilisation may be a feasible and safe method to treat unstable hangman's fracture.

Résumé Entre 1999 et 2004, 28 patients (âge moyen 41 ans de 18 à 70 ans), présentant une fracture instable de Hangman ont bénéficié d'une discectomie antérieure avec greffe et ostéosynthèse interne. L'évaluation a été faite selon la classification de Levine-Edwards. Tous les cas traités présentaient une instabilité de type II (10 cas), type IIA (17 cas) et type III (1 cas). Le suivi moyen a été de 15 mois (de 3 à 48 mois). Le temps opératoire moyen a été

de 107 minutes (80 à 131 minutes). Aucun patient n'a nécessité de transfusion. Aucun patient n'a présenté d'aggravation des signes neurologiques postopératoires. Aucune complication per ou post-opératoire n'a été observée. Tous les patients ont été améliorés de leur douleur. L'examen neurologique a été amélioré dans 4 cas et tous les patients ont montré, à l'évidence une fusion C2–3 importante après 6 mois. Nous n'avons observé aucune complication au niveau de la greffe, ni de la plaque d'ostéosynthèse. Pour nous, l'abord antérieur permettant une fixation primaire est une méthode tout à fait fiable dans le traitement les fractures instables de type Hangman.

Introduction

Hangman's fracture, or traumatic spondylolisthesis of the axis, is the second most common fracture of the second cervical vertebra [10]. It involves a bilateral arch fracture of the C2 pars interarticularis with variable displacement of C2 on C3. According to the classification of Levine and Edwards, type II, type IIA and type III injuries are thought to be unstable and need to be managed by rigid immobilisation [7]. In unstable hangman's fracture, extension forces have been implicated in disruption of the anterior longitudinal ligament, posterior longitudinal ligament and C2–3 disc [4, 10]. Conservative strategies that include traction and external immobilisation for unstable hangman's fracture often have some poor radiological results during the follow-up period [3, 9]. The optimal strategy for unstable hangman's fracture remains controversial. In cases of significant displacement and instability, surgical reduction and stabilisation are carried out, usually by posterior fusion of the upper cervical vertebrae or by anterior fusion of the second and third vertebrae.

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The goals in the surgical treatment of unstable hangman's fracture are reduction, stabilisation and maintenance of alignment. Surgical stabilisation has been described using both anterior and posterior approaches. Among the different posterior approaches, direct repair of the pars fracture with a screw across the fracture line has the advantage of preserving motion of the axis. Unfortunately, direct pars repair does not address instability at the disc and is not appropriate for all patients with hangman's fracture. The anterior approach, which has the advantage of technical ease and a relatively short fusion, involves a C2–3 discectomy with interbody fusion and plating. The anterior approach is especially suitable for hangman's fracture with intervertebral disc injury, which can compress the spinal cord or lead to spinal instability. Some authors reported surgical management for hangman's fracture, but there are few reports on unstable hangman's fracture treated by the anterior approach with large series and long-term follow-up. We have undertaken this retrospective study to assess the outcome and feasibility of anterior discectomy and fusion with screw-plate fixation of C2–3 for the treatment of unstable hangman's fracture.

Materials and methods

From January 1999 to May 2004, a total of 28 patients (18 men and ten women, aged 18–70 years, with an average age of 41 years) diagnosed with unstable hangman's fracture, treated and followed up in our unit were included in this study. Anterior discectomy and fusion with screw-plate fixation of C2–3 was performed in each case, and one

patient, classified as type III, was combined with a posterior approach. Fifteen were injured in vehicle accidents, ten were injured in falling and three in other actions. All patients felt cervical pain, and cervical spine motion was limited. Four patients had significant neurological deficits, and three of them gained complete neurological recovery within four weeks. Preoperative assessment of each case included plain radiography (anteroposterior, lateral), computed tomography and magnetic resonance imaging (MRI). All patients were found to have bilateral fractures through the pars interarticularis of the axis. Five patients had associated fractures of the body of C2, three patients had a fracture of the ring of C1 and eight patients had fractures of other spinal parts. According to the Levine-Edwards classification, all cases were unstable with type II (ten cases), type IIA (17 cases) and type III (one case). Evidence of intervertebral disc injury could be found in all cases through enhancement on the T2-weighted images from MRI. Six cases were combined with disc herniation on MRI. Spinal cord compression was found in three cases on MRI (Fig. 1).

After the hangman's fracture was diagnosed, all patients were placed in about 2 kg of traction at an appropriate angle according to injury mechanism.

Surgical techniques

Anterior C2–3 cervical discectomy and autologous bone fusion with a Zephir plate was performed in each patient. The patient was placed in the supine position with the neck slightly extended and 2 kg of axial traction. A standard horizontal incision was made, midway between the angle of

Fig. 1 A 41-year-old man with a type II hangman's fracture. **a** Preoperative lateral radiograph showing a type II hangman's fracture with severe angulation and translation. **b** Preoperative T2-weighted

sagittal MRI showing signal change in the disc and disc herniation. **c** Postoperative lateral radiograph showing C2–3 fusion with an iliac crest graft and Zephir plate fixation

the jaw and the thyroid cartilage. C2–3 anterior exposure was obtained, and a tear of the anterior and posterior longitudinal ligaments and disc disruption were observed in most cases. After the C2–3 discectomy was completed, iliac bone was taken to graft intervertebral space. An appropriate Zephir plate was selected to allow sufficient purchase on the C2 and C3 vertebral bodies, and final alignment was achieved by tightening the screws. The wounds were closed, and the drainage tube was removed after two days. Cervical support was used for four to six weeks. All of the patients were rechecked with an X-ray after three months, six months, one year, two years and four years and neurological examinations were performed during the follow-up period.

Results

The average operative time was 107 min (80–131 min). No patient received blood transfusion. An average follow-up of 15 months was obtained (3–48 months). No patient experienced worsening neurological function postoperatively. No other intra- or postoperative complication was observed. All patients were relieved from axial pain. Neurological status improved postoperatively in all four cases with neurological deficit. Each patient showed evidence of a solid anterior C2–3 interbody fusion after six months through plain radiography and dynamic films (Fig. 2). No bone graft or plate screws complication was observed in any of the cases during the follow-up period.

Fig. 2 Lateral radiograph 1 year after surgery showing solid fusion of C2–3 fracture; the alignment was satisfactory

Discussion

Several classification schemes for hangman's fracture have been proposed. The Levine-Edwards classification is most widely used and separates the fractures into four types based on consideration of trauma mechanisms. As such, type I are non-displaced fractures with no angulation between C2 and C3 and a fracture dislocation of less than 3 mm; type II are fractures with significant angulation ($>11^\circ$) and displacement (>3.5 mm); type IIA are fractures with minimum displacement and significant angulation ($>11^\circ$); and type III are fractures with severe angulation and displacement and concomitant unilateral or bilateral facet dislocation C2–3. Most cases of hangman's fractures responded to conservative treatment comprised of mild skeletal traction and external immobilisation in a halo device; surgery is only necessary under certain conditions [1, 7]. The treatment for unstable hangman's fracture is still controversial. In general, a marked angulation of C2 on C3, an anterior translation and a displacement of the fracture on initial lateral radiographs are considered signs of instability [2]. Surgery is recommended if radiological controls demonstrate an increasing anterior displacement at the C2–3 level in spite of rigid immobilisation. Further conditions necessitating surgical therapy [7] include the dislocated type IIA fractures (angulation $>8^\circ$ and anterior translation >3 mm); in exceptional cases dislocated type II fractures (anterior translation >3 mm), and type III hangman's fractures, lesions combined with a traumatic C2–3 disc herniation compromising the spinal cord and established nonunions may also require surgery. Levine and Edwards [7] reported a study of halo traction reduction followed by halo cast immobilisation in fractures with more than 3 mm of anterior translation. Although anterior translation and regional angulation decreased by 65% during traction, change to the halo cast was followed by a recurrence of anterior translation of 60% and of regional angulation of 40%. Indeed, accurate fracture reduction and realignment of C2–3 was seldom achieved in conservative treatment of unstable hangman's fracture. Most authors recommended that surgery be reserved for failures of conservative treatment, but nonunion and considerable kyphosis have been reported, suggesting the need for early operation in patients presenting with instability [7]. Occasionally, surgical treatment is employed in the hopes of improving neurological outcome [7] or for patients experiencing persistent pain in the cervical spine after treatment with an external orthosis [5].

Among the different posterior approaches, direct repair of the pars fracture with a screw across the fracture line has the advantage of preserving motion of the axis. Unfortunately, direct pars repair does not address instability at the disc and is not appropriate for all patients with hangman's

fracture. Although posterior C1–3 wiring techniques have also been described, these techniques have required postoperative halo-thoracic immobilisation. Another posterior stabilisation strategy uses a C2 pars screw connected to a C3 lateral mass screw. This technique addresses the detached posterior arch of C2 by pinning the fractured pars while simultaneously addressing instability at the disc by immobilising C2 relative to C3. The location of the fracture within the pars interarticularis and a patient's individual anatomy of C2 determine whether fractures are appropriate for treatment with pars screws. Also this strategy carries the risk of injury to the vertebral artery and spinal cord. It has been shown that the alignment of the vertebral artery through the body of C2 is variable in 4% of cases. Since this is a high-risk procedure, many surgeons prefer the anterior approach and achieve interbody fusion of C2–3 using a graft and plating. Also, this technique overcomes its limits in atypical hangman's fracture with fracture lines tracing the vertebral body of C2 far anteriorly. In such cases, grasping of anterior fragments can be difficult using bilateral transpedicular screw fixation of C2.

Unquestionably, posterior screw fixation is not indicated or sufficient in cases of a traumatic disc herniation compromising the spinal cord. In this instance, we advocate an anterior C2–3 discectomy and fusion with optional plating. The anterior approach has been confirmed to be an effective strategy for hangman's fracture by many authors [8, 9, 11]. A high anterior approach may impose a risk to vital structures, especially the facial and hypoglossal nerves, branches of the external carotid, the contents of the carotid sheath and the superior laryngeal nerve. But in skilled hands, the anterior approach offers our patients high primary stability, a high union rate in almost 100% of patients, anatomical reduction with reconstruction of cervical lordosis, favourable clinical outcome and avoidance of secondary salvage fusions after primary intended failed conservative treatment [6].

In hangman's fracture, stability should be discussed regarding discal and discoligamentous integrity. These pathomorphological findings have to be assessed prior to treatment of hangman's fracture using dynamic X-rays, MRI or at least with observation of the clinical and radiological course during some in-hospital days in a cervical collar. In our study, patients diagnosed as having disc injury had the evidence from MRI, and this was confirmed by intraoperative pathological findings. A displaced hangman's fracture is often combined with intervertebral disc injury. Disc injury may lead to instability

of the cervical spine, and disc herniation may lead to medullary compression. Nonoperative treatment of these injuries was associated with a significant rate of failure of stabilisation and delayed union. The posterior approach has difficulty in dealing with disc herniation and cervical instability simultaneously, but the anterior approach can manage this problem successfully. In skilled hands, anterior fusion of C2–3 for unstable hangman's fracture provides superior functional and radiological results with highest fusion rates.

In our study, the anterior approach was especially appropriate for hangman's fracture combined with intervertebral disc injury or disc herniation compressing the spinal cord. Using the anterior approach with primary internal fixation of these fractures, solid fusion was achieved in all cases combined with a low rate of complications. In our experience the anterior approach with primary internal stabilisation is the method of choice for unstable hangman's fracture.

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