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Technical note

A novel technique using a pedicle screw and bucking bar for the treatment of hangman's fracture

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ABSTRACT

The treatment of hangman's fracture is controversial. If treated with a traditional surgical procedure, there will likely be many complications, such as kyphosis, pseudarthrosis and nonunion. Our present study aims to describe a bucking bar method with pedicle screw fixation to treat hangman's fracture. Thirty-two patients with an unstable hangman's fracture who underwent posterior C2-3 pedicle lag screw fixation surgery assisted by a bucking bar between May 2004 and Jan 2017 were evaluated. All the participating patients were successfully treated using this novel technique, and follow-up revealed anatomical fusion in 27 patients, incomplete fusion in 4 patients, and C2-3 angular deformity healing in 1 patient. No patient developed throat wall edema or pseudomembrane formation. Satisfactory reduction, fixation and fusion of C2 pedicle fractures can be achieved using a pedicle screw assisted with the transoral bucking bar technique.

Level of evidence: IV, retrospective case-series study.

1. Introduction

In 1982, Levine-Edward [1] classified hangman's fractures into four types according to the injury mechanism, fracture morphology and stability. Type I hangman's fracture is stable and usually treated conservatively [2,3]. Type II, IIa and III hangman's fractures are unstable; however, the application of conservative, surgical treatments and fixation methods [4,5] remain controversial. Long-term conservative treatment and unstable fixation at the fracture ends cause 20–60% of patients to present C2/3 kyphosis or pseudarthrosis; consequently, an increasing number of scholars have recommended surgical treatment [3,6–8].

However, due to the floating lamina of C2 and fracture line asymmetry, hangman's fracture usually cannot achieve complete anatomical reduction using only the half-thread lag screw technique and proximal reaming/threaded screw technology. Therefore, we designed a transoral bucking bar and combined it with a posterior C2 semithreaded lag screw and a C3 pedicle screw to treat hangman's fracture. The advantage of this novel technique is that it allows better control of the vertebral body in front of the fracture through the transoral bucking bar to achieve successful implantation of the pedicle screw and improved fracture reduction.

Therefore, the current study aimed to evaluate the clinical efficacy of this novel technique for the treatment of hangman's fracture.

2. Technique description

A retrospective study was conducted of 32 patients with unstable hangman's fracture who were treated using the bucking bar technique combined with posterior C2-3 pedicle screw fixation between May 2004 and Jan 2017. The demographics and clinical characteristics of patients are presented in Table 1.

A video of the surgical procedures is presented in the supplementary materials. Briefly, after successful anesthesia and nasal intubation, the top of the self-designed bucking bar connected to the pressure test device was placed in the posterior pharyngeal wall and was temporarily fixed. The patients were then placed in the prone position in continuous skull traction at 3-4 kg. C2∼3 reduction of the intervertebral joint was observed using fluoroscopy. A conventional median incision was performed to expose the C2-3 lamina and facet joint. The upper part of the center of the lateral mass on C2 was confirmed as the pedicle screw insertion point. The C2 pedicle was maintained in the reset state, and a hole was drilled into the pedicle screw insertion point at an inclined angle determined by preoperative CT measurement. A Caspar pin was

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Table 1
Demographic and clinical characteristics of patients.

Characteristic	Value
Number of patients	32
Male-to-female ratio	23:9
Age, years, mean ± SD (range)	43 ± 6.7
Duration trauma to surgery, days, mean ± SD (range)	3.8 ± 1.5
Levine-Edward fractures classification	
Type II	10
Type IIA	4
Type III	18
Injury mechanism	
Traffic accidents	7
Fall injuries	23
Heavy load injuries	2
ASIA Grade	
Grade C	1
Grade D	5
Grade E	26
Surgical duration, minutes, mean ± SD (range)	75 ± 32
Force of the bucking bar, *n*, mean ± SD (range)	5.2 ± 1.6
Blood loss, mL, mean ± SD (range)	123 ± 68
Time of follow-up, month mean ± SD (range)	15.7 ± 4.2

driven into the drilled hole. A positioning pin was driven into the drilled hole, and G-arm fluoroscopy was implemented. The assistant adjusted the position of the bucking bar so that it was in front of the axis body and forced it to the rear so that fracture reduction could be performed under fluoroscopy. When the anatomical reduction criteria were achieved, the assistant maintained the position of the bucking bar, and the operator selected the appropriate pull screws and inserted them according to the preoperative design. C3 pedicle lag screws were implanted using the Abumi method [9]. The posttraumatic ASIA score, VAS score, angulation and displacement of the axis and intervertebral fusion were evaluated before the operation and 6 months postoperation.

3. Results

The operations were completed successfully in 32 patients. No patients developed intraoperative spinal cord, vertebral artery or nerve root injuries. One patient developed transient ischemic cerebellar body balance disorders. Two patients developed superficial wound infections that were cured after incision dressing changes. There was 1 case of postoperative chronic neck pain. No throat wall edema or pseudomembrane formation was found in any patients. The ASIA scores were E for all the patients at the last follow-up. Postoperative X-rays showed good reduction of the C2-3 fractures in all patients. The neck pain and cervical movement disturbance were relieved, and the function of the cervical spine had recovered well 6 months after the surgery.

The posttraumatic clinical score of the cervical spine and VAS score differed significantly between the preoperative measurement (53.1 ± 7.2; 5.8 ± 2.3) and the last follow-up (91.1 ± 5.0, $t = 15.6$, $p < 0.05$; 2.5 ± 1.2, $t = 8.3$, $p < 0.05$). Bone fusion was found on X-ray, CT scan and three-dimensional reconstruction in 32 patients at 3 months after operation: anatomical fusion was observed in 27 cases, incomplete fusion was observed in 4 cases, and C2-3 angular deformity healing was observed in 1 case. Preoperative axis displacement and axis angulation (4.0 ± 1.5 mm; 9.2 ± 4.7°) differed significantly from those at the last follow-up (1.3 ± 1.2 mm, $t = 5.270$, $p < 0.05$; 2.1° ± 1.9°, $t = 5.270$, $p < 0.05$). A typical case is presented in Fig. 1.

4. Discussion

Hangman's fracture is often caused by violent contact between the superior and inferior atlantoaxial articular processes, which is accompanied by injuries to the surrounding ligaments and intervertebral discs and followed by vertebral axis instability or dislocation. The stability of a hangman's fracture is a decisive factor in the choice of treatment. At present, there is still no consensus on the choice of the fixation segment, fusion or nonfusion, surgical approach or screw type for unstable fracture treatment [10–12]. Although some authors have recommended the use of C1-3 posterior pedicle fixation to treat unstable hangman's fracture, we used only C2-3 pedicle lag screw fixation in this study to preserve atlantoaxial rotation and reduce the risk of injury to the vertebral artery and spinal cord.

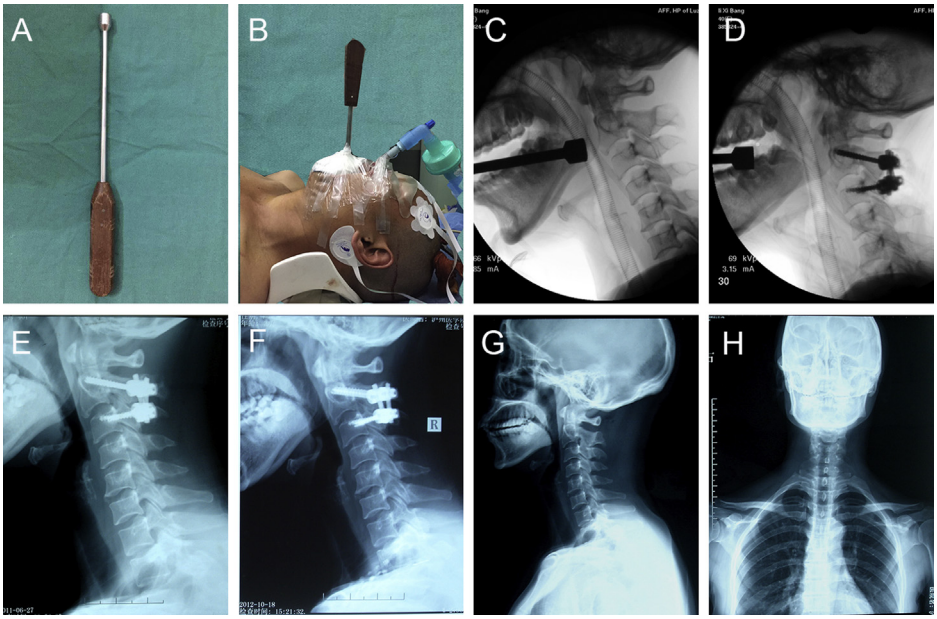

Fig. 1. A 40-year-old female with a type II hangman's fracture. A. A bucking bar. B. The bucking bar was placed in the posterior pharyngeal wall and temporarily fixed. C. The head of the bucking bar was placed in front of the axis vertebral body via the mouth after anesthesia. D. C2 pedicle screw-threaded lag screw fixation was performed with the assistance of the bucking bar. E. The C2 pedicle was healed at 3 months postoperatively. F. A large amount of callus formation was observed in the C2 pedicle 2 years after the operation. G (lateral radiograph) and H (posteroanterior radiograph): The C2 pedicle achieved anatomic bony fusion after the removal of the internal fixation.

Clinical observation indicated that the C2 pedicle fractures have different shapes and sizes, but most of the vertebral body was free of fractures, or the fracture line only affected the vertebral posterior wall. Conventional pedicle screw techniques are likely the cause of failed functional recovery after fractures and lead to even worse fracture, false joints, C2/C3 dislocation and angling. Therefore, we implanted a half-thread lag screw, it offered several advantages: parallel implantation of lag screws into the proximal fracture line, a partially nonthreaded screw, and easy reduction and placement operations [13,14].

An appropriate fulcrum for assisting the reduction is the existing hot spot, and we developed the bucking bar technique based on the concept of lag screw implantation for the treatment of limb fractures. In this method, the patients were anesthetized through nasal intubation, and the self-designed bucking bar was inserted into the mouth, with the top placed and fixed in front of the posterior pharyngeal wall; during the reduction process, an assistant physician wearing a lead apron can adjust the position of the bucking bar under C-arm X-ray view to as far in front of the anterior vertebral body as far as possible. The reduction was observed under fluoroscopy with appropriate force placed on the posterior part; once the anatomical standard was achieved, the assistant physician maintained the position of the bucking bar and appropriate pressure, and lag screws were implanted for anatomic reduction. This procedure can avoid deterioration resulting from separation and displacement, false joints, and C2/C3 dislocation; during the operation, this procedure reduces the risk of spinal cord and vertebral artery damage caused by serious injuries of the C2-3 ligaments and intervertebral disc and the floating cranio-cervical junction during spinous process stabilization, and longitudinal dislocation of the lag screws induced by the floating C2 lamina and fracture displacement is prevented. Postoperative laryngoscope results indicated that no patient presented throat wall inflammation or necrosis or pseudomembrane formation. Twenty-seven patients achieved anatomic reduction during follow-up, and the remaining 5 patients' function was restored. There was no loss of correction at the last follow-up.

In summary, the bucking bar technique combined with posterior C2-3 pedicle screw fixation achieves good clinical efficacy in the treatment of unstable hangman's fracture.

Disclosure of interest

The authors declare that they have no competing interest.

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None.

Authors' contribution

Dr. D.M.J. and Dr. Q.W. were responsible for the study design. Dr. G.J.W. was responsible for performing the experiments, analyzing the data, and drafting the manuscript. Dr. G.J.W. and C.H.Y. were responsible for analyzing the data, and revised the manuscript. Dr. S.X. and J.Y. were responsible for statistics and drafting. All authors have read and approved the manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.03.005.

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