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Posterior temporary fixation of C1–C2 screw-rod system for unstable C1 burst fracture

Yun-lin Chen, MD[a], Xu-dong Hu, MD[a], Yang Wang, MD[a], Wei-yu Jiang, MD[a,*], Wei-hu Ma, MD[a]

Abstract

Whether an unstable C1 burst fracture should be treated surgically or conservatively is controversial. The purpose of this study is to evaluate the effectiveness and motion-preserving function of temporary fixation of C1–C2 screw-rod system for the reduction and fixation of unstable C1 burst fracture.

We retrospectively reviewed 10 patients who were treated with posterior C1–C2 temporary fixation without fusion. We assessed age at surgery, gender, pre- and postoperative visual analog scale (VAS), Neck Disability Index (NDI), atlanto-dens interval (ADI), lateral mass distance (LMD), and rotation function of C1–C2 complex.

Six males and 4 females were included in our study. The average follow-up duration was 14.1 ± 1.37 months. The left-to-right ROMs of C1–C2 rotation was 9.6° ± 1.42°. The preoperative cervical VAS was 8.30 ± 0.48; the postoperative cervical VAS of C1–C2 fusion was 2.90 ± 0.57. The preoperative VAS for removal was 2.0 ± 0.00, and the postoperative VAS for removal was 2.3 ± 0.48. The preoperative cervical NDI was 81.40% ± 2.07%, the postoperative cervical NDI of C1–C2 fusion was 18.10% ± 1.52%. The preoperative NDI for removal was 15.9% ± 1.20%. The postoperative NDI for removal was 14.5% ± 1.08%. The preoperative ADI was 4.43 ± 0.34 mm, and postoperative ADI was 1.94 ± 0.72 mm. The preoperative LMD was 6.36 ± 0.58 mm, and postoperative LMD was 1.64 ± 0.31 mm.

Posterior temporary C1–C2 fixation can achieve a good fusion and satisfied reduction of C1 fracture, relieve the pain, improve the cervical function outcome, but may reduce the rotational range of motion of C1–C2. Posterior C1–C2 temporary fixation without fusion was not suitable for C1 burst fracture. We recommend permanent C1–C2 fixation and fusion for C1 burst fracture if surgery is necessary.

Abbreviations: ADI = atlanto-dens interval, CT = computed tomography, LMD = lateral mass distance, MRI = magnetic resonance imaging, NDI = Neck Disability Index, ORIF = open-reduction internal fixation, PTF = posterior temporary fixation, ROM = range of motion, VAS = visual analog scale.

Keywords: C1 burst fracture, posterior C1–C2 temporary fixation, rotational function

1. Introduction

The first cervical vertebra, also known as the atlas, is a crucial part of the craniocervical junction and the upper cervical spine. The atlas is a simple ring with 2 lateral masses bridged by anterior and posterior arches. It acts as a transitional structure between C0 and C2. Atlas fractures are the second most common injury of the upper cervical spine; they have accounted for 25% of the craniocervical injuries, 2% to 13% of all cervical spine injuries, and around 1% to 3% of all spine fractures.[1] The most common cause is axial loading on the osseous ring of the atlas such as the motor vehicle accidents and fall.

Isolated fractures of type 1, 2, and 5 were preferably managed conservatively according to the Gehweiler classification. Whether an unstable C1 burst fracture (type 3 and 4) should be treated surgically or conservatively is controversial. Previously, most of the patients with stable atlas fracture were treated with external immobilization. However, the outcome is not satisfactory. Lewkonia et al[2] performed a literature review about the outcome of conservative treatment of C1 burst fractures. They described a rate of 8% to 20% with complaints about stiffness in the neck, a rate of 14% to 80% with mild pain, and a rate of 34% of patients with limitations of their activities. Moreover, apparent nonunions after conservation have been reported in 17% to 20%.[3]

Hence, there are some studies describing the outcome of operative treatment of unstable atlas fractures. Surgical treatments of C1 fracture include direct open-reduction internal fixation (ORIF) of the C1, C1–C2 fusion. Ma et al[4] treated

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The patient and her family have provided consent to participate.

The authors declare that they have no competing interests.

[a]Department of Spine Surgery, Ningbo No. 6 Hospital, Ningbo, China.

*Correspondence: Wei-yu Jiang, Department of Spine Surgery, Ningbo No.6 Hospital, No.1059, Zhongshan East Road, Ningbo, China (e-mail: charleschen1991@163.com).

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20 patients with transpolar screws combined with plate; all patients had bony fusion without any instability and complications in 6 months follow-up. Sun et al[5] treated 8 patients with the same method; all patients had bony fusion without operative complications in 6 to 24 months of follow-up. He et al[6] treated 22 patients with posterior polyaxial screws and plate; a good bony fusion and normal physiological range of motion (ROM) were described in all 22 patients. ORIF of the C1 can preserve the motion function of C1–C2 rotation, but some studies also showed that it may accelerate cervical spondylosis in the remaining segments.[7,8] Also, the transoral approach has the risk of wound complications.[9] The ORIF of C1 needs more studies to ensure the clinical effects. Atlantoaxial (C1–C2) fusion represents the standard treatment for the C1 burst fracture. However, the fusion may result in the loss of 50% cervical rotation, which limits the C1–C2 arthrodesis as a primary treatment.

Posterior C1–C2 temporary fixation can preserve the motion of the C1–C2 complex. Some studies described this method used for type III odontoid fractures and showed good clinical outcomes.[10,11] This is the first study of C1 burst fracture stabilized by a motion-preserving method with a posterior C1–C2 temporary fixation. The purpose of this study is to evaluate the effectiveness and motion-preserving function of C1–C2 screw-rod system for the reduction and fixation of an isolated C1 burst fracture.

2. Materials and Methods

The ethical committee of Ningbo No.6 hospital approved this study. Informed consent was obtained from the patient to publish this case report details. We retrospectively reviewed the data for 10 patients who underwent posterior C1–C2 temporary fixation because of C1 burst fracture from January 2015 to June 2018. The inclusion criteria included patients with C1 burst fracture who could not tolerate long-term external fixation (type 3 and 4 according to the Gehweiler classification); patients whose fracture reduction could not be achieved with conservative treatment; patients refused to undergo the anterior approach. The exclusion criteria were patients without intact transverse ligament, the condition of patients could not tolerate the operation, and patients >65 years of age. All fractures were confirmed with plain cervical spine radiograph, computed tomography (CT), and magnetic resonance imaging. Skull traction was performed routinely after admission to stabilize the fracture with 2-kg weight.

Under general anesthesia, a 6 to 8 cm posterior midline incision is made to exposure the posterior structure of the upper cervical spine. C1 lateral mass screws combined with C2 pedicle screws without fusion (Shanghai Sanyou Company, China) were performed for each patient.

Anterior–posterior, lateral, mouth-open, and dynamic radiographs were taken preoperatively and 3 months, 6 months, and 1 year postoperatively. CT scans were obtained since 3 months postoperatively. Fracture healing was defined as evident bridging bone across the C1 fracture on CT construction. Time to fracture healing was recorded. After fracture healing, the implants were removed to preserve the C1–C2 complex motion. All patients wore a Philadelphia collar postoperatively for 4 weeks postoperatively.

The data collected for analysis included operation time, clinical and radiographic results, and complications. Patients were followed up in outpatient clinic after initial treatment. Visual analog scale (VAS) score for neck pain[12] and Neck Disability Index (NDI)[13] for 4 groups (preoperative and postoperative of C1–C2 fusion, preoperative and postoperative of removal of C1–C2 screw-rod system) were evaluated as functional outcomes. The preoperative and postoperative atlanto-dens interval (ADI) and lateral mass distance (LMD) were recorded to evaluate the reduction of fracture. The rotational capacity of the C1–C2 complex was measured by functional CT scans obtained in the supine position after 1 month of the removal. All patients underwent functional CT scans with the head first fully rotated to one side and then to the opposite side to evaluate the ROM of C1–C2 complex. C1–C2 ROM in rotation was the sum of the values from the C1 angles subtraction of the C2 angles at each side (Fig. 1).

The data were analyzed using SPSS Statistics for Mac, Version 22 (SPSS Inc., Chicago, IL). Statistics significance was defined as a P value of <.05.

3. Results

Four women and 6 men with an average age of 39.6 years (range, 32–47) were included in our study. There were 8 patients diagnosed with type 3 and 2 with type 4 according to the Gehweiler classification. All patients achieved fracture healing; the average fusion time was 5.10 ± 0.88 months (range: 4–6 months). After the fusion of fracture, we removed the internal fixation system. The average follow-up duration was 14.1 ± 1.37 months (range: 12–16 months). Three patients were injured by motor vehicle accident, while others got injured by falling. All patients had no neurological deficit (American Spinal Injury Association: grade E), and there were no complications for all patients (Table 1).

The preoperative cervical visual analog scale (VAS) was 8.30 ± 0.48; the postoperative cervical VAS of C1–C2 fusion was 2.90 ± 0.57, which was significantly less than preoperative group (P < .05). The preoperative VAS for removal was 2.0 ± 0.00, which was significantly less than postoperative fixation group. The postoperative VAS for removal was 2.3 ± 0.48; there was no significant difference compared to preoperative removal group (P = .08). The preoperative cervical NDI was 81.40% ± 2.07% and the postoperative cervical NDI of C1–C2 fusion was 18.10% ± 1.52%, which was significantly less than preoperative group (P < .05). The preoperative NDI for removal was 15.9% ± 1.20%, which was significantly less than postoperative fixation group (P < .05). The postoperative NDI for removal was 14.5% ± 1.08%, which was significantly less than preoperative removal group (P < .05).

The preoperative ADI was 4.43 ± 0.34 mm and postoperative ADI was 1.94 ± 0.72 mm, and there was significant difference between 2 groups (P < .05). The preoperative LMD was 6.36 ± 0.58 mm and postoperative LMD was 1.64 ± 0.31 mm, and there was significant difference between 2 groups (P < .05).

The left-to-right ROM of C1–C2 rotation was 9.6° ± 1.42°. The ROM was significantly decreased when compared to the Roche' study (right: 32.4 ± 8.2; left: 34.2 ± 9.4, P < .05).[14]

4. Discussion

Our study showed that posterior temporary fixation of C1 burst fracture can achieve a good fusion and satisfying reduction of C1 fracture, relieve the pain, improve the cervical function outcome, but may reduce the rotational ROM of C1–C2.

Whether an unstable C1 burst fracture should be treated surgically or conservatively is controversial. Isolated C1 fracture was often conservatively managed. Kesterson et al reported 17 patients diagnosed with Jefferson burst fracture. Thirteen cases of isolated C1 burst fractures were treated with external immobilization successfully.[15] However, Segal et al[3] reported 18 patients with atlas fractures who were treated with external immobilization, 3 patients had nonunion of the fracture, 4 patients had pain and limited ROM, and 1 patient had occipital neuralgia. So, some studies favor surgery for C1 burst fracture, particularly in the presence of transverse ligament disruption. If instability was identified after external immobilization, a C0–C2 fusion or C1–C2 fusion should be performed to prevent neurological deficit.[16–18]

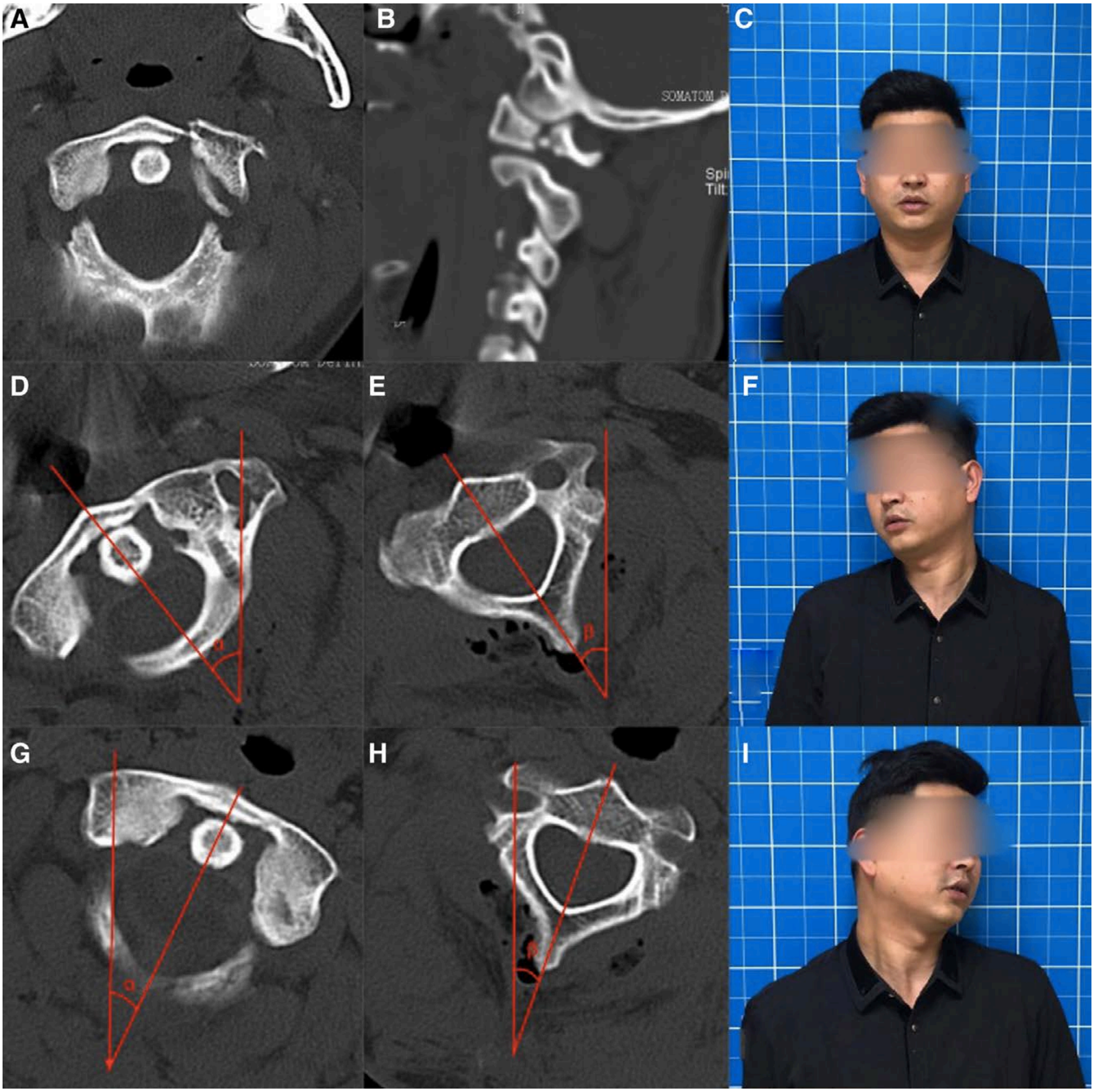

Figure 1. Pre- and postoperative CT scan of a 31-year-old male patient with C1 burst fracture. (A) Axial view and (B) sagittal view showing C1 burst fracture. (C) The neutral position of the patient. (D) Maximum angle of C1 shown on the right side; (E) Maximum angle of C2 shown on the right side. (G) Maximum angle of C1 shown on the left side; (H) Maximum angle of C2 shown on the left side; (F) and (I) showed right and left rotation function of the patient. α-β means the rotation angle of C1–C2 complex on each side.

Table 1

Details of included patients.

Age, yr	Gender	Reasons of injury	ASIA grade	Follow-up	Removal time (postoperative C1–C2 fusion)
32	M	Motor vehicle accident	E	15	4
47	F	Fall	E	16	5
40	M	Fall	E	14	6
38	M	Motor vehicle accident	E	12	6
42	M	Motor vehicle accident	E	13	5
45	F	Fall	E	14	6
36	F	Fall	E	13	4
38	M	Fall	E	13	4
40	M	Fall	E	15	6
38	F	Fall	E	16	5

ASIA = American Spinal Injury Association, F = female, M= male.

Several studies showed posterior C1–C2 temporary fixation (PTF) could preserve the rotation motion of the C1–C2 complex. Guo et al[10] showed the outcomes of PTF and external immobilization were comparable for treating type III odontoid fractures. Han et al[19] showed C1–C2 segment fixation without anterior screw might reduce the rotation function of C1–C2 complex (27.3%) when treated for type II dens fracture. In our study, posterior C1–C2 temporary fixation can achieve a good fusion of C1 fracture; however, it also reduces the rotation function of C1–C2 complex.

Fracture healing restores the tissue to its original physical and mechanical properties and is influenced by a variety of systematic and local factors.[20] Healing process can be classified into 3 stages: the early inflammatory stage, the repair stage, and the late remodeling. In the first inflammatory stage, a hematoma develops within the fracture site during the first few hours and days. Inflammatory cells and fibroblasts infiltrate the bone, resulting in the formation of granulation tissue. We found C1–C2 fusion occurred between posterior border of the anterior arch and apex of C2 (red arrow in Fig. 2). We assumed that the inflammatory cells caused by the C1 fracture induced the fusion of C1–C2 complex. Because the fracture location of C1 burst fracture and apex of C2 was at the same level, meanwhile, the C1–C2 fixation limited the motion of C1–C2 complex. While the fracture location of type III odontoid fracture was at different level when compared to C1 vertebral, temporary C1–C2 fixation had less fusion influence. Further study was needed to ensure our hypothesis.

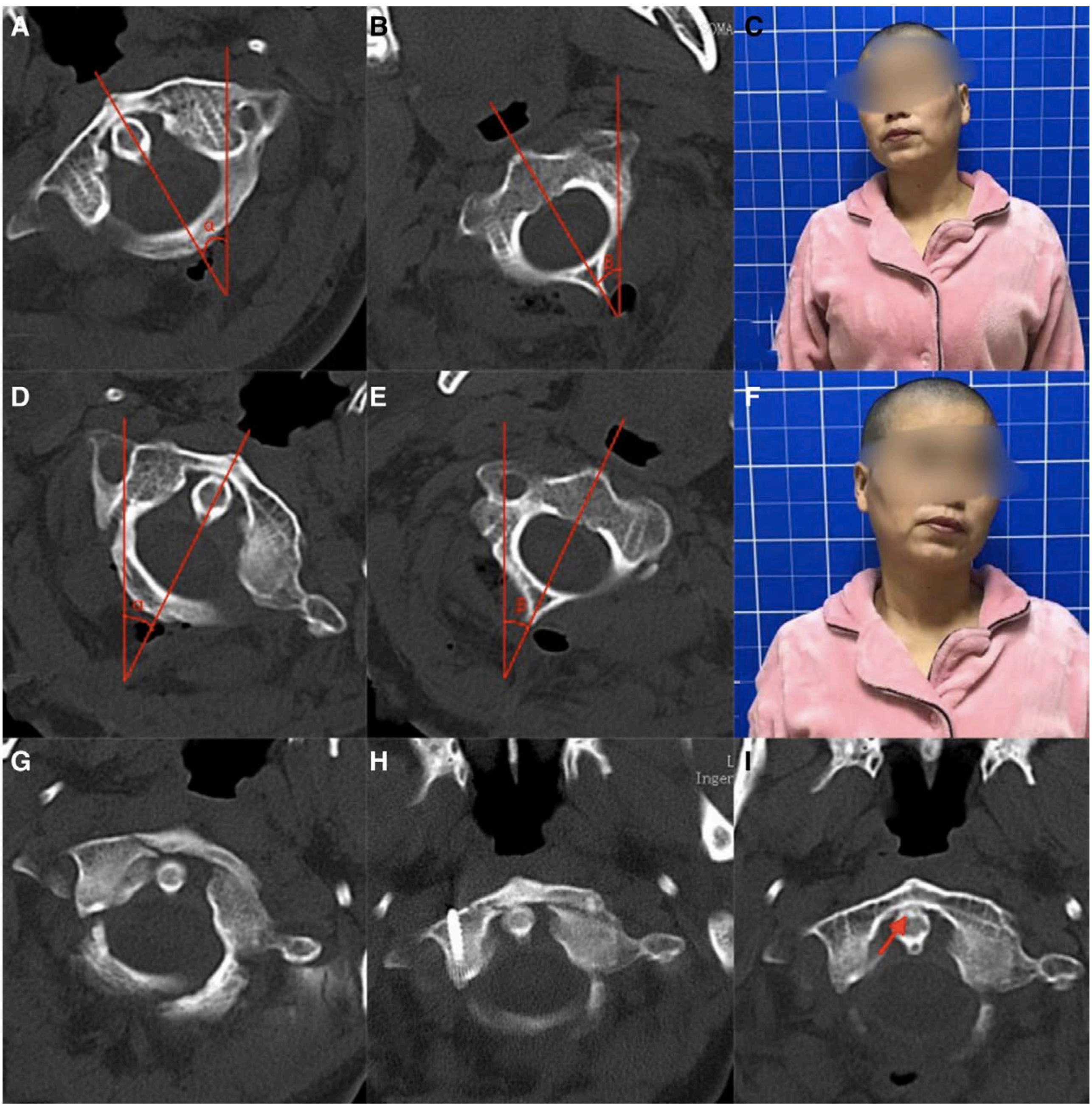

Figure 2. Pre- and postoperative CT scan of a 45-year-old female patient with C1 burst fracture. (A) Maximum angle of C1 shown on the right side. (B) Maximum angle of C2 shown on the right side. (D) Maximum angle of C1 shown on the left side. (E) Maximum angle of C2 shown on the left side. (G) C1 burst fracture shown before the operation. (H) showed postoperative of C1 after 3 mo. (I) The union of posterior border of C1 anterior arch and apex of C2 (red arrow). (C) and (F) showed right and left rotation function of the patient.

Temporary C1–C2 fixation is an alternative technique to manage the C1 burst fracture, but the need for implant removal needs to be questioned. Patients with CT scans before implant removal showing spontaneous fusion may potentially not profit from implant removal.

There are several limitations of our study. First, this is a retrospective study. Second, the small number of patients has potential bias. In addition, our study lacks the control group. Further prospective study with more patients is necessary.

5. Conclusion

In conclusion, posterior temporary C1–C2 fixation can achieve a good fusion and satisfied reduction of C1 fracture, relieve the pain, improve the cervical function outcome, but may reduce the rotational ROM of C1–C2. Temporary C1–C2 fixation is an alternative technique to manage the C1 burst fracture, but the need for implant removal needs to be questioned. For patients with CT scan before implant removal showing spontaneous fusion, they may potentially not profit from implant removal.

Author contributions

All authors participated in the management of the patient. CYL drafted the manuscript. CYL and WY collected the clinical data. JWY and HXD wrote discussion and introduction. JWY and MWH supervised the case and also supervised the writing of the manuscript. All authors read and approved the manuscript.

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