

WITHDRAWN: Posterior Temporary Fixation of C1-2 Screw-rod System for Unstable C1 Burst Fracture

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Abstract

Background 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 C1-2 screw-rod system for the reduction and fixation of unstable C1 burst fracture (type 3 and 4 according to the Gehweiler classification).

Patients and Methods We retrospectively reviewed 10 patients who were treated with posterior temporary C1-C2 fixation. We assessed age at surgery, gender, pre- and post-operative VAS, NDI, atlanto-dens interval, lateral mass distance and rotation function of C1-C2 complex.

Results 6 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 $9.6 \pm 1.42^\circ$. The pre-operative cervical VAS was 8.30 ± 0.48 ; the post-operative cervical VAS of C1-C2 fusion was 2.90 ± 0.57 . The pre-operative VAS for removal was 2.0 ± 0.00 , the post-operative VAS for removal was 2.3 ± 0.48 ; The pre-operative cervical NDI was $81.40\% \pm 2.07\%$, the post-operative cervical NDI of C1-C2 fusion was $18.10\% \pm 1.52\%$. The preoperative NDI for removal was $15.9\% \pm 1.20\%$, The post-operative NDI for removal was $14.5\% \pm 1.08\%$. The pre-operative ADI was 4.43 ± 0.34 mm, post-operative ADI was 1.94 ± 0.72 mm. The pre-operative LMD was 6.36 ± 0.58 mm, post-operative LMD was 1.64 ± 0.31 mm.

Conclusion Posterior temporary C1-2 fixation can achieve a good fusion, satisfied reduction of C1 burst fracture, relieve the pain, improve the cervical function outcome, but may reduce the rotational ROM of C1-2. 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.

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 is the second most common injury of the upper cervical spine, they have accounted for 25% of the craniocervical injuries, 2%-13% of all cervical spine injuries and around 1%-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^[1].

Isolated fracture of type 1, 2 and 5 were preferably managed conservatively according to the Gehweiler classification^[2]. Whether an unstable C1 burst fracture (type 3 and 4) should be treated surgically or conservatively is controversial^[3]. Previously, most of the patients with stable atlas fracture were treated with external immobilization. However, the outcome is not satisfied. Lewkonja et al^[4] performed a literature review about the outcome of conservative treatment of C1 burst fractures. They described a rate of 8–20% with complaints about stiffness in the neck, a rate of 14%– 80% with mild pain and a rate of

34% of patients with limitations of their activities. Moreover, apparent malunions and nonunions after conservation have been reported [5].

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 [6] treated 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 [7] treated 8 patients with the same method; all patients had bony fusion without operative complications in 6–24 months follow-up. He et al [8] treated 22 patients with posterior polyaxial screws and plate, a good bony fusion and normal physiological range of motion were described in all 22 patients. ORIF of the C1 can preserve the motion function of C1-C2 rotation [6], but some studies also showed it may accelerate cervical spondylosis in remaining segments [9–10]. Also, the transoral approach has the risk of wound complications [11]. 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 or C1-C2 subluxation [3, 12, 13]. However the fusion may result to the loss of 50% cervical rotation, which limited the C1-C2 arthrodesis as a primary treatment.

Posterior temporary C1-C2 fixation can preserve the motion of the C1-2 complex. Some studies described this method using for type III odontoid fractures, showed good clinical outcomes [14, 15]. This is the first study of C1 burst fracture stabilized by a motion-preserving method with a posterior temporary C1-C2 fixation. The purpose of this study is to evaluate the effectiveness and motion-preserving function of temporary C1-C2 screw-rod system for the reduction and fixation of unstable C1 burst fracture.

Materials And Methods

The ethical committee of our hospital approved this study. Informed consent is given or provided by all patients. All patients were performed in accordance with relevant guidelines and regulations. Informed consent for publication for identifying images was obtained from all patients. We retrospectively reviewed the data for 10 patients who underwent posterior C1-2 temporary fixation because of C1 burst fracture from January 2015 to June 2018. The inclusion criteria included (1) patients with C1 burst fracture who could not tolerate long-term external fixation (type 3 and 4 according to the Gehweiler classification); (2) patients whose fracture reduction could not achieved with conservative treatment; (3) patients refused to undergo the anterior approach. The exclusion criteria were (1) patients without intact transverse ligament; (2) the condition of patients could not tolerate the operation; (3) patients > 65 years of age. All fractures were confirmed with plain cervical spine radiograph, computed tomography (CT), and magnetic resonance imaging (MRI). Skull traction was performed routinely after admission to stabilize the fracture with 2-kg weight.

Under general anesthesia, a 6–8 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, 6 months and 1 year postoperatively. CT scans was 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 C1-2 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 in outpatient clinic after initial treatment. Visual analog scale score for neck pain ^[16], Neck Disability Index (NDI) ^[17] for four groups (pre-operative and post-operative of C1-C2 fusion, pre-operative and post-operative of removal of C1-2 screw-rod system) were evaluated as functional outcomes. The preoperative and postoperative atlanto-dens interval (ADI) and lateral mass distance (LMD) were recorded to evaluation the reduction of fracture. The rotational capacity of the C1-2 complex was measure 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 range of motion of C1-2 complex. C1-C2 ROM in rotation was the sum of the values from the C1 angles subtraction the C2 angles at the each side (Fig. 1).

The data were analyzed using SPSS Statistics for Mac, Version 22 (SPSS Inc., Chicago, IL, USA). Statistics significance was defined as $p < 0.05$.

Results

Four women and six men with an average age of 39.6 years (range, 32–47) were included in our study. There are eight patients diagnosed with Type 3 and two 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). 3 patients were injured by motor vehicle accident, while others were by falling. All patients had no neurological deficit (ASIA: grade E.), there were no complications for all patients (Table 1).

Table 1
Details of included patients.

Age (years)	Gender	Reasons of injury	ASIA grade	Follow-up (months)	Removal time (months) (post-op C1-2 fusion)	Fracture Classification (Gehweiler type)
32	M	Motor vehicle accident	E	15	4	4
47	F	Fall	E	16	5	4
40	M	Fall	E	14	6	4
38	M	Motor vehicle accident	E	12	6	4
42	M	Motor vehicle accident	E	13	5	3
45	F	Fall	E	14	6	3
36	F	Fall	E	13	4	4
38	M	Fall	E	13	4	4
40	M	Fall	E	15	6	4
38	F	Fall	E	16	5	4

The pre-operative cervical VAS was 8.30 ± 0.48 ; the post-operative cervical VAS of C1-C2 fusion was 2.90 ± 0.57 , which was significant less than pre-operative group ($p < 0.05$). The pre-operative VAS for removal was 2.0 ± 0.00 , which was significant less than post-operative fixation group. The post-operative VAS for removal was 2.3 ± 0.48 ; there was no significant difference with pre-operative removal group ($p = 0.08$). The pre-operative cervical NDI was $81.40\% \pm 2.07\%$, the post-operative cervical NDI of C1-C2 fusion was $18.10\% \pm 1.52\%$, which was significant less than pre-operative group ($p < 0.05$). The preoperative NDI for removal was $15.9\% \pm 1.20\%$, which was significant less than post-operative fixation group ($p < 0.05$). The post-operative NDI for removal was $14.5\% \pm 1.08\%$, which was significant less than pre-operative removal group ($p < 0.05$).

The pre-operative ADI was 4.43 ± 0.34 mm, post-operative ADI was 1.94 ± 0.72 mm, there was significant difference between two groups ($p < 0.05$). The pre-operative LMD was 6.36 ± 0.58 mm, post-operative LMD was 1.64 ± 0.31 mm, there was significant difference between two groups ($p < 0.05$).

The left-to-right ROM of C1-C2 rotation was $9.6 \pm 1.42^\circ$. The range of ROM was significant decreased when compared to the Roche' study (right: 32.4 ± 8.2 ; left: 34.2 ± 9.4) ($p < 0.05$)^[18].

Discussion

Our study showed posterior temporary fixation of C1 burst fracture 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 C1-2.

Whether an unstable C1 burst fracture (type 3 and 4 according to the Gehweiler's classification) should be treated surgically or conservatively is controversial. Isolated C1 fracture was often conservatively managed. Kesterson reported 17 patients diagnosed with Jefferson fracture. In 13 cases of isolated C1 burst fractures were treated with external immobilization successfully ^[19]. However, Kandziora reported malunion and nonunion with atlas fractures who were treated with external immobilization ^[5]. 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 ^[20, 21].

Several studies showed posterior C1-2 temporary fixation (PTF) could preserve the rotation motion of the C1-2 complex. Guo et al. showed the outcomes of PTF and external immobilization were comparable for treating type III odontoid fractures ^[14]. Han et al. showed C1-2 segment fixation without anterior screw might reduce the rotation function of C1-2 complex (27.3%) when treated for type II dens fracture ^[22]. In our study, posterior C1-2 temporary fixation can achieve a good fusion of C1 fracture, however it also reduces the rotation function of C1-2 complex.

Fracture healing restores the tissue to its original physical and mechanical properties and is influenced by a variety of systematic and local factors ^[23]. Healing process can be classified into three 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 the hematoma and inflammatory cells during the first inflammatory stage caused by the C1 fracture might result to the fusion of C1-2 complex. Because the fracture location of C1 burst fracture and apex of C2 was at the same level, the C1-C2 fixation limited the motion of C1-C2 complex, while; the location of type III odontoid fracture was at different levels when compared to C1.

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.

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

Conclusion

In conclusion, posterior temporary C1-2 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 C1-2. 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.

Declarations

Conflict of interest

The authors declare that they have no competing interests.

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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.

Ethics approval and consent to participate

The patient and her family have provided consent to participate.

Consent for publication

The patient and her family have provided consent for the data in this case report to be published.

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Not Applicable.

Available of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

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Figures

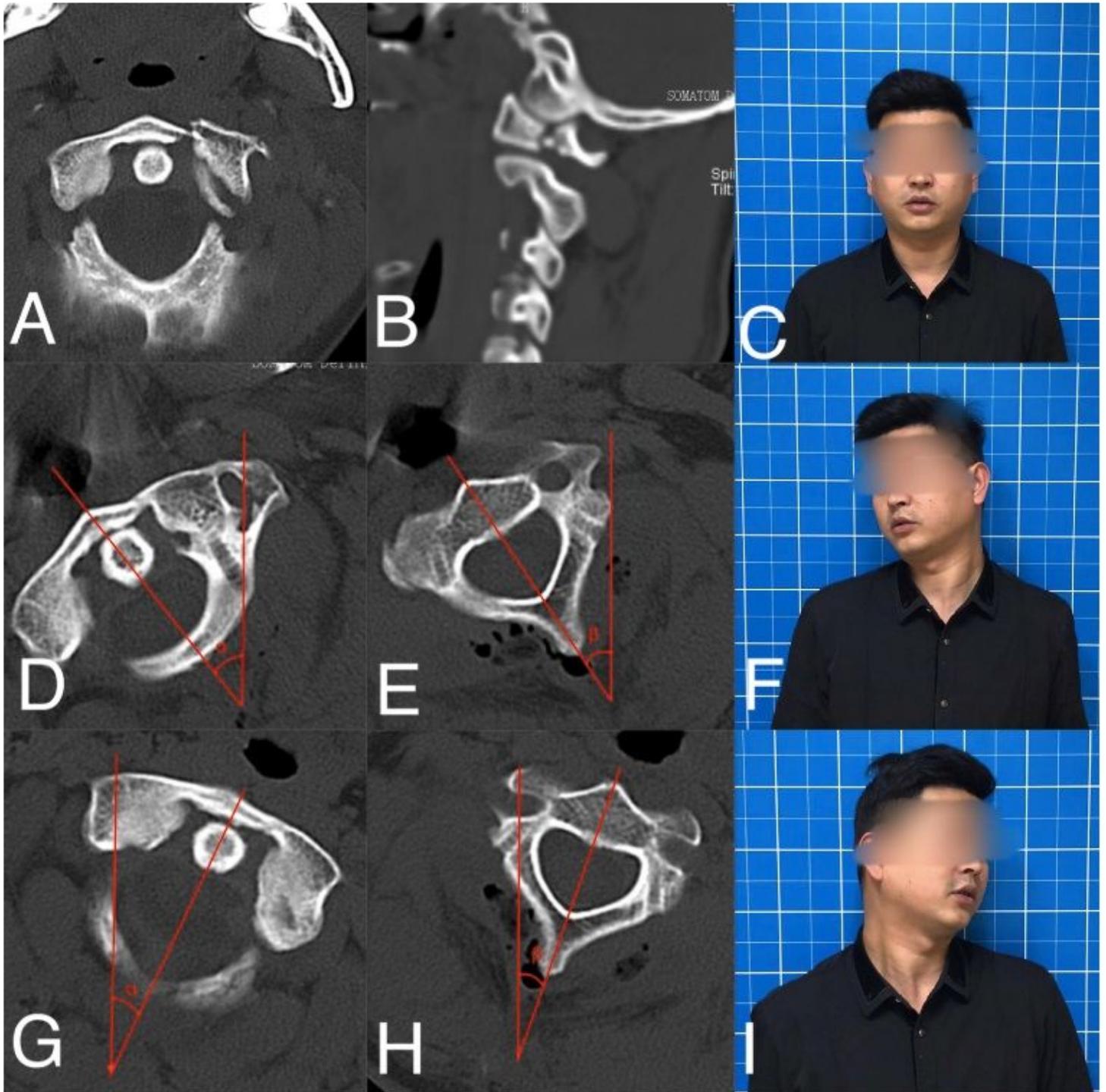


Figure 1

A (axial view) and B (sagittal view) showed C1 burst fracture. C showed the neutral position of the patient. D showed maximum angle of C1 on the right side; E showed maximum angle of C2 on the right side; G showed maximum angle of C1 on the left side; H showed maximum angle of C2 on the left side; α - β means the rotation angle of C1-2 complex on each side.

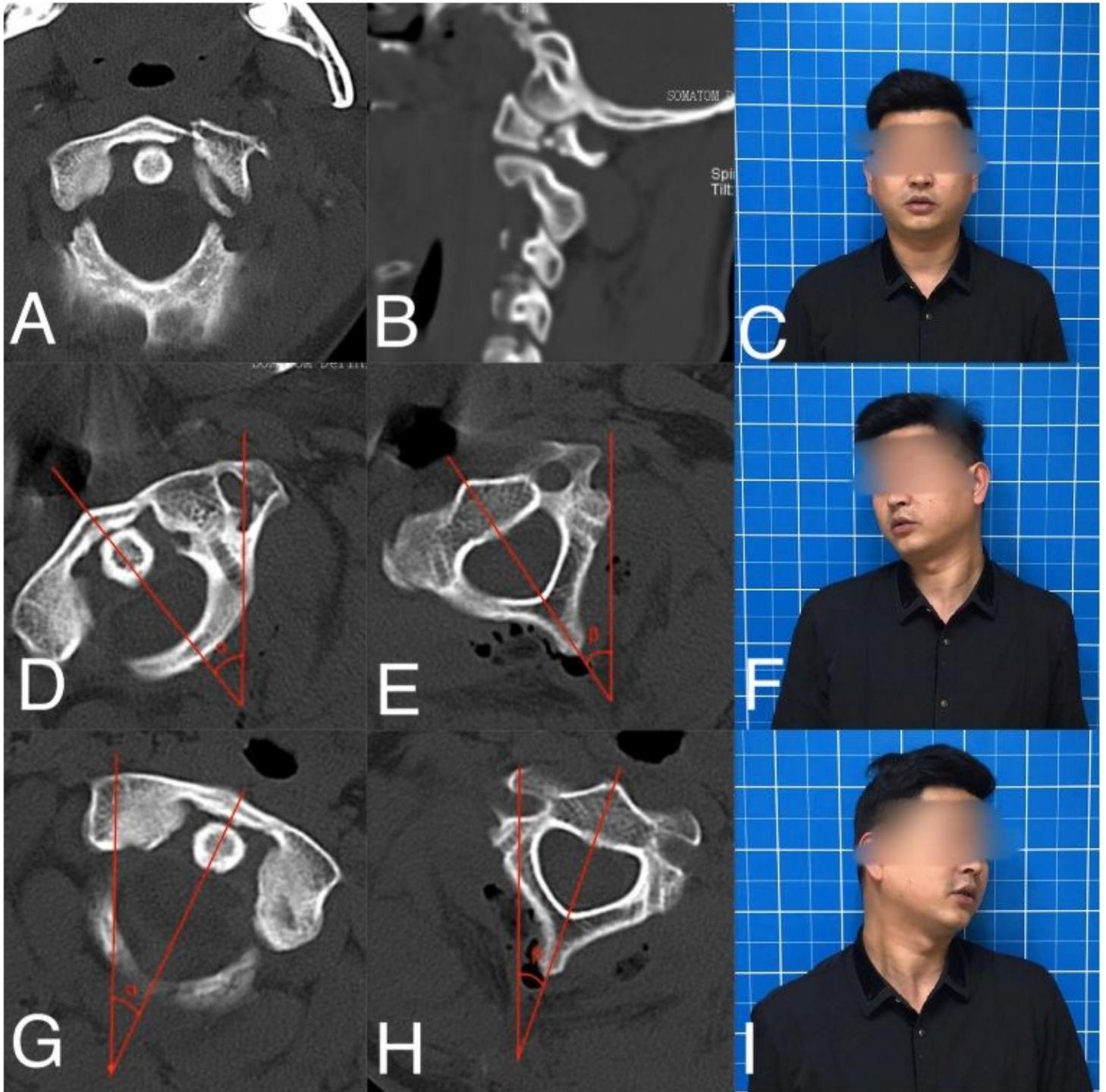


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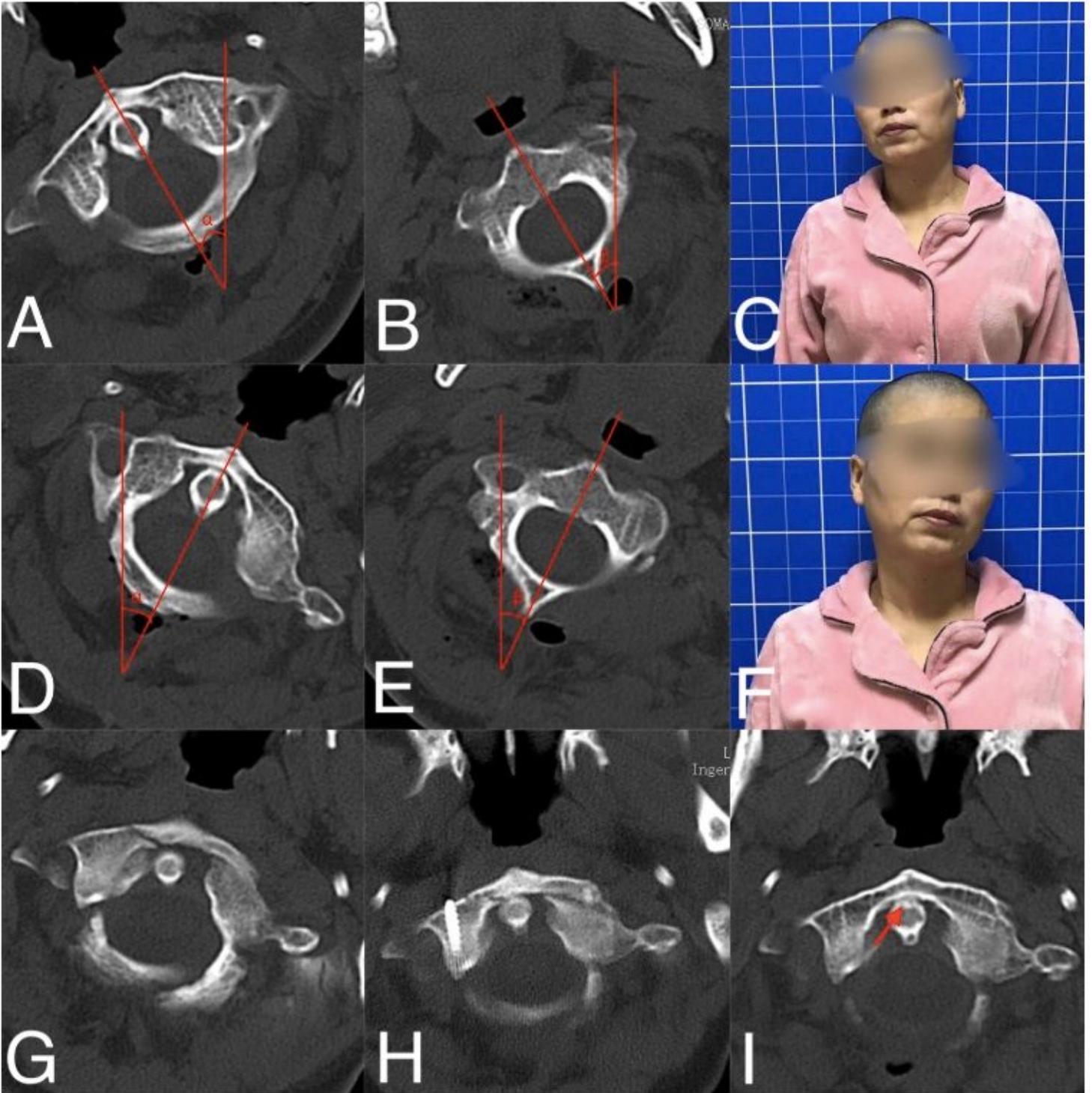


Figure 2

A showed maximum angle of C1 on the right side; B showed maximum angle of C2 on the right side. D showed maximum angle of C1 on the left side; E showed maximum angle of C2 on the left side. G showed C1 burst fracture before the operation. H showed post-operative of C1 after 3 months. I showed the union of posterior border of C1 anterior arch and apex of C2 (Red arrow).

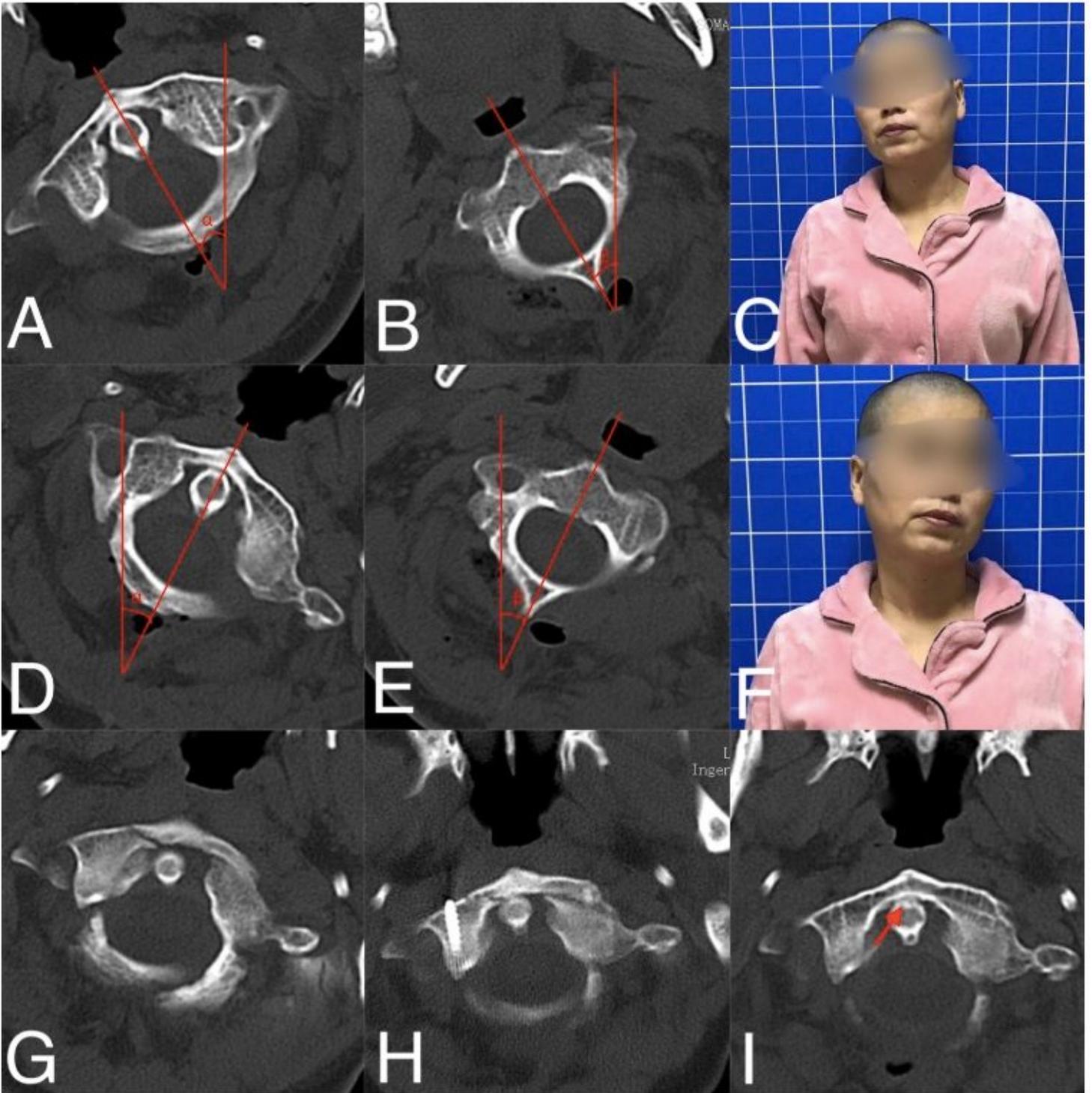


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