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Posterior C1-C2 screw-rod fixation and autograft fusion for the treatment of os odontoideum with C1-C2 instability

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Objective: To report our experience treating os odontoideum with C1-C2 instability via C1-C2 screw-rod fixation and autograft fusion and to explore the clinical efficacy of such a treatment strategy.
Patients and methods: We retrospectively reviewed the medical records of patients who were diagnosed with os odontoideum with C1-C2 instability and treated by posterior C1-C2 screw-rod fixation and fusion. Neurological deficits were measured with the Japanese Orthopedic Association (JOA) scoring system and neck pain was assessed using the Visual Analogue Scale (VAS) score. Fusion was determined based on the presence of bridging bone in computed tomography (CT) imaging, whereas stability was determined based on the lack of movement in dynamic radiographs.
Results: Thirty-two patients (18 males) were included in the study. The surgery was successfully accomplished in all patients. Thirty (93.8%) patients had confirmed C1-C2 bony fusion in CT images and all patients (100%) were stable in dynamic radiographs. The mean preoperative JOA score was 14.3 ± 1.4 (range 11–16); at the final visit, it increased to 16.2 ± 0.8 (range 14–17) ($p < 0.001$). The mean preoperative VAS score was 3.8 ± 0.7 (range 3–5) and decreased at the final visit to 1.0 ± 0.6 (range 0–2) ($p < 0.001$).
Conclusion: Our treatment strategy (C1-C2 screw-rod fixation and autograft fusion) can achieve excellent clinical results with minor complications for patients with os odontoideum with C1-C2 instability.

1. Introduction

Os odontoideum is an ossicle with smooth, circumferential cortical margins (representing the odontoid process) that has no osseous continuity with the body of C2 [1]. The exact incidence of os odontoideum is unknown, but it is thought to be rare [2,3]. The pathogenesis of os odontoideum is controversial; there is evidence for both congenital and acquired causes. However, its pathogenesis is not relevant to the diagnosis and treatment [4]. According to the guidelines proposed by the Congress of Neurological Surgeons (CNS), patients with os odontoideum with C1-C2 instability should be treated with posterior C1-C2 fixation and fusion [4]. A few reported studies have included a small number of cases of os odontoideum with C1-C2 instability as part of their surgical case series [5–8]. Also, there have been a few studies reporting the use of C1-2 screw-rod fixation for treating os odontoideum with C1-2 instability. However, most of these studies presented only very small case series [2,7–10], and some reported only pediatric patients [7,8]. To the best of our knowledge, there is no study that has specifically focused on the treatment of adult os odontoideum with C1-C2 instability by C1-C2 screw-rod fixation and fusion based on a relatively large number of patients. In the past several years, we have treated a relative large number of such cases by posterior C1-C2 screw-rod fixation and autograft fusion. The purpose of this study is to report our experience in the treatment of os odontoideum with C1-C2 instability via C1-C2 screw-rod fixation and autograft fusion and to explore the clinical efficacy of such a treatment strategy.

2. Patients and methods

2.1. Ethics statement

This retrospective study was approved by the Ethics Committee of the authors' institution. Due to the retrospective nature of this study, patient consent was not required.

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2.2. Patients

We retrospectively reviewed the medical records of patients who were diagnosed as having os odontoideum with C1-C2 instability and were treated by posterior C1-C2 screw-rod fixation and fusion between January 2012 and December 2014 in our department. C1-C2 instability was defined as atlantoaxial dislocation in dynamic lateral radiographs; this dislocation could also be reduced when the position of the head and neck was adjusted [11]. The inclusion criteria included: (1) the patient was ≥ 18 years old, (2) the material for fusion was a morselized iliac crest autograft, (3) the patient was followed up regularly and for at least 24 months, and (4) the medical records were complete. The exclusion criteria were: (1) suffering severe spinal trauma at the same time, (2) the presence of other upper cervical spine deformities.

2.3. Surgical procedures

After general anesthesia was administered, all of the patients were placed in the prone position on the operating table. Before surgery, the position of the head and neck was adjusted under fluoroscopic guidance to guarantee that the head was in the neutral position and that the relative positions of C1 and C2 were as normal as possible. Afterward, the posterior elements of C1-C2 were exposed by a standard posterior approach. The screw placement techniques we used were the C1 pedicle screw technique and C2 pedicle screw technique, as reported previously [12]. The exact screw entry point and screw trajectory were designed according to the preoperative computed tomography (CT) images of each patient. C1 pedicle screw placement is technically demanding. The ideal screw path is a line through the midpoint of the C1 vertebral artery groove (defined as C1 pedicle) which is the thinnest part of the screw trajectory. The path should be straight or slightly medial in an anteroposterior direction in the axial plane and parallel to the direction of C1 pedicle in the sagittal plane. The entry point is determined by the projection point of the screw path on the dorsal surface of the C1 posterior arch. Usually, it is about 2 mm superior to the inferior border of posterior arch in the midsagittal plane of the junction of posterior arch and lateral mass (Fig. 1). There were 3 patients whose C1 pedicle height was less than 4.0 mm on at least one side. Our previous study demonstrated that if there is a medullary canal in the C1 pedicle, a 3.5-mm-diameter pedicle screw can be safely inserted into the atlas and C1 pedicle screw fixation can be performed without any impact on fixation stability and clinical efficacy, even if the C1 pedicle height is less than 4.0 mm [13]. Fortunately, there was a medullary canal in the C1 pedicles of all these patients. Therefore, C1 pedicle screw fixation was safely performed in all of these patients. After the pedicle screws were inserted into C1 and C2, the ipsilateral C1 and C2 screws were connected by a rod. Notably, while inserting the C1 and C2 pedicle screws, we used a self-made elasticity awl to make the pilot hole. The elasticity awl bends when its head touches the solid cortical bone of the pedicle, which indicates that the doctor should readjust the placement direction to avoid piercing the pedicle. Our previous study demonstrated that the use of the elasticity awl could improve the safety of C1, C2 pedicle screw placement [13]. After C1-C2 fixation by the screw–rod system, the bone graft bed was decorticated by a high-speed burr. C1–2 joint decortication was not performed. Morselized iliac crest autografts were used as the fusion material. All surgical procedures were performed under cortical somatosensory evoked potential (CSEP) monitoring, which could also decrease the risk of spinal cord injury and nerve root injury.

2.4. Clinical and radiographic evaluation

The patients' medical records were thoroughly reviewed. The operation time and blood loss were recorded. Any possible perioperative complications recorded in the medical records (including vertebral artery injury, spinal cord injury, incision infection, wound dehiscence, donor site pain, cardiovascular stroke, pulmonary embolism, deep venous thrombosis, etc.) were screened. Postoperative plain radiographs and CT scans were obtained prior to discharge to assess internal implant placement. Patients were followed up regularly in the clinic or by telephone (at 3 months, 6 months, and 12 months after operation and every 12 months thereafter). All patients underwent a CT scan at the 12-month follow-up. If atlantoaxial fusion was not confirmed, the patient would be asked to undergo a CT scan and dynamic radiographs every 12 months thereafter until fusion was confirmed or the study was completed. Neurological deficits were measured via the Japanese Orthopedic Association (JOA) scoring system. Neck pain was assessed using the Visual Analogue Scale (VAS) score. The JOA and VAS scores were accessed at each follow-up. Fusion was determined based on the presence of bridging bone between C1 and C2 laminas in CT imaging and stability was determined based on the lack of movement in dynamic radiographs; the judgments were made by a trained radiologist.

2.5. Statistical analyses

The C1-C2 fusion rate and the stability rate were calculated. The Wilcoxon signed-rank test was used to compare JOA scores before surgery and at the final follow-up as well as the preoperative VAS score and that at the final follow-up. SPSS version 18.0statistical software (SPSS Inc., Chicago, IL) was used for data entry and analysis. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

Thirty-two patients (18 males) were included in the study. The general information is shown in Table 1. The average age of the patients

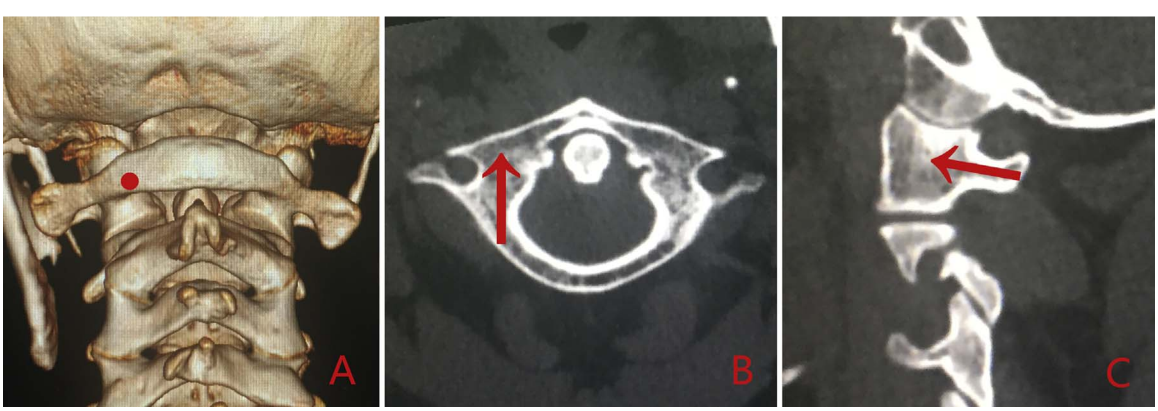

Fig. 1. A. Entry point (red point) of C1 pedicle screw. B. Direction of C1 pedicle screw in the axial plane (arrow). C. Direction of C1 pedicle screw in the sagittal plane (arrow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)