The Spine Journal 15 (2015) e69–e74

Case Report

Recurrent dislocations of the atlantooccipital and atlantoaxial joints in a halo vest fixator are resolved by backrest elevation in an elevation angle–dependent manner

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Received 19 November 2014; revised 6 May 2015; accepted 1 June 2015

Abstract

BACKGROUND CONTEXT: Halo fixation is now universally performed in the initial reduction and fixation of unstable upper cervical spine injuries; however, persistent high instability and recurrent dislocations of the atlantooccipital and atlantoaxial joints after fixation are not well recognized.

PURPOSE: The aim was to describe persistent instability of traumatic dislocations of the atlantooccipital and atlantoaxial joints after halo fixation and a useful method for preventing instability.

STUDY DESIGN: This was a case report of a patient who survived traumatic dislocations of the atlantooccipital and atlantoaxial joints.

PATIENT SAMPLE: A 73-year-old woman diagnosed with dislocations of the atlantooccipital and atlantoaxial joints along with multiple other injuries sustained in a traffic accident was included.

METHODS: After initial closed reduction and halo fixation, congruity of the atlantooccipital and atlantoaxial joints was evaluated using, condylar gap, atlantodental interval, and flexion angulation of C1–C2 after the initial examination and before surgery.

RESULTS: Changes in parameters 12 hours after halo fixation revealed re-dislocations and instability of the joints. Backrest elevation with halo fixation tended to reduce re-dislocations. Therefore, we carefully increased the backrest angle and measured the parameters at several angles of elevation within a range that did not affect vital signs to observe the effectiveness of elevation against re-dislocations. Elevation changed the parameters in an elevation angle–dependent manner, and these changes suggested that elevation was effective for reducing re-dislocation of both the atlantooccipital and atlantoaxial joints during halo fixation. With no major complications, this method enabled us to maintain good congruity of the joints for approximately 2 weeks until posterior spinal fusion with internal fixation.

CONCLUSIONS: Backrest elevation with halo fixation appears safe to be performed without any other devices and is beneficial for blocking re-dislocation of both the atlantooccipital and

FDA device/drug status: Not applicable.

Author disclosures: ***GK:*** Nothing to disclose. ***KKa:*** Nothing to disclose. ***NT:*** Nothing to disclose. ***KKo:*** Nothing to disclose. ***KM:*** Nothing to disclose. ***TO:*** Nothing to disclose. ***HO:*** Nothing to disclose. ***SH:*** Nothing to disclose. ***TM:*** Nothing to disclose.

No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

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http://dx.doi.org/10.1016/j.spinee.2015.06.009

atlantoaxial joints as well as possible secondary damage to the upper cervical spinal cord during the external fixation period.

Keywords: Trauma; Preoperative management; Atlantoaxial; Atlantooccipital; Dislocation; Re-dislocation; Halo vest; External fixation

Introduction

Traumatic atlantooccipital dislocation (AOD) is a rare injury that includes approximately 1% (0.7%–1.3%) of all cervical spine injuries [1–3]. The injury is usually severe and fatal [3] and often accompanied by atlantoaxial dislocation (AAD) [4–6]. Atlantooccipital dislocation and AAD can cause translational movement of the upper cervical spine in both sagittal and vertical planes. Distraction of the upper cervical spinal cord and/or medulla due to vertical translational movement can cause violent stretching force to the upper cervical spinal cord and/or medulla potentially resulting in severe neurologic deficits, including acute respiratory dysfunction and quadriplegia. Sagittal translational movement can cause vertebral artery injuries, which can cause basilar territory infarction and death [7] as well as impingement of the upper cervical spinal cord and/or medulla that can cause lethal neurologic deficits. However in recent years, survival rates have increased with the advent of emergency management techniques, includingon-site resuscitation and immobilization-efficient transportation and management, which increase the rate of survival for patients being transferred to a hospital [4–6,8,9]. Prompt diagnosis and fusion surgery are required for definitive treatment in adults [5,6,10–12]. However, this trauma is commonly the result of a traffic accident or a fall from a great height [13]; therefore, the surgery is often hampered by the need to wait for sufficient recovery from other life-threatening injuries, and temporary preoperative external fixation is frequently necessary. Halo fixation is generally used for preoperative external fixation, although some reports have reported failed immobilization of AOD and AAD [5,12,14,15]. Here, we report a case of concurrent adult traumatic AOD and AAD in which re-dislocations of the atlantooccipital joint (AOJ) and atlantoaxial joint (AAJ) were observed after halo fixation and demonstrate an effective management strategy for instability.

Case report

A 73-year-old woman was involved in a head-on collision with a dump truck while driving and was trapped inside the car. After rescue, the patient immediately underwent intubation for respiratory distress at the accident site. She was diagnosed with craniocervical dislocation and quadriplegia along with other injuries, including traumatic subarachnoid hemorrhage, hemopneumothorax, aortic dissection, and multiple bone fractures. She was subsequently transported to our hospital by a medical helicopter service. Although her vital signs were relatively stable on arrival, her Glasgow Coma Scale score was 3, and she underwent chest tube insertion for hemopneumothorax. Evaluation of the condylar gap [16] (Fig. 1 , Left) and atlantodental interval (Fig. 1, Middle) on computed tomography reaffirmed AOD and AAD. Magnetic resonance imaging of the area revealed ruptures of the craniovertebral ligaments. The dural sac was mildly compressed due to a pincer effect of the posterior arch of C1 and odontoid process; however, almost no compression of the upper cervical spinal cord was observed (Fig. 1, Right). Because of her poor general condition, she was first placed in a halo fixator after reduction

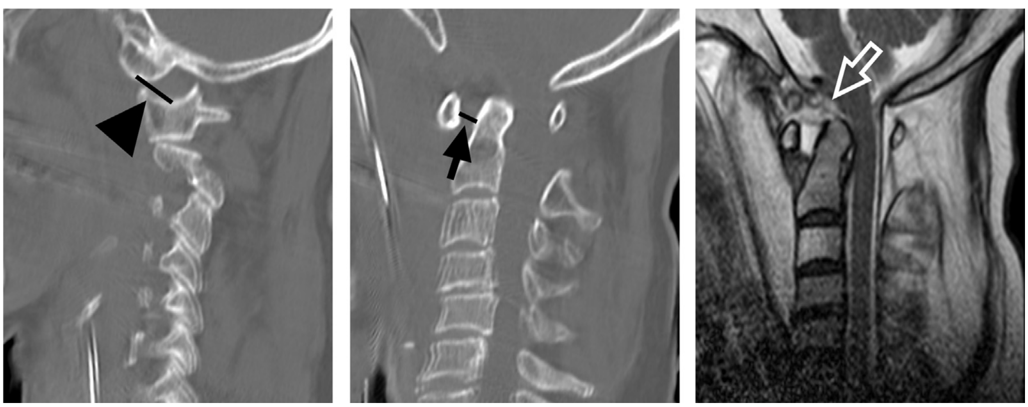

Fig. 1. Initial left parasagittal computed tomography CT (Left), sagittal cervical spine CT (Middle), and T2-weighted magnetic resonance imaging (Right). (Left) Condylar gap (CG, closed arrowhead), the distance between the condyle and superior facet of the atlas, was 13 mm (normally <2 mm). (Middle) Atlantodental interval (ADI, filled arrow, normally <3 mm) was 6 mm. (Right) Dural sac was mildly pinched between the posterior arch of C1 and the odontoid process. Ligamentous ruptures were suggested by regions of high intensity (open arrow).

of AOD and AAD under image intensification. Although mild AOD and AAD were still observed, the incongruity of AOJ and AAJ was considered adequately resolved (Fig. 2). However, a follow-up computed tomography 12 hours after halo fixation revealed recurrence of AOD and AAD (Fig. 3). Improving the fit of the halo vest to her chest and shortening of the bars connecting the halo ring to the vest to reduce distraction force on the craniovertebral junction did not improve the incongruity. Recurrent AOD was attributed to distraction force on AOJ within the halo fixator; therefore, we performed backrest elevation for caudal migration of her head against her chest to increase compression force. Thus, AOD and, surprisingly, AAD, were resolved in an elevation angle–dependent manner (Fig. 4). An elevation angle greater than 50° was not applied because her blood pressure was decreased. Backrest elevation at an angle of 40° was, therefore, maintained during the preoperative period until improvements in vital signs were observed. After improving her general condition 10 days after the injuries, surgical reduction and posterior spinal fusion of the occiput to the axis with autogenous bone from the iliac crest were performed (Fig. 5). A decompressive laminectomy or laminotomy was not performed because cord compression was not observed, and decompression

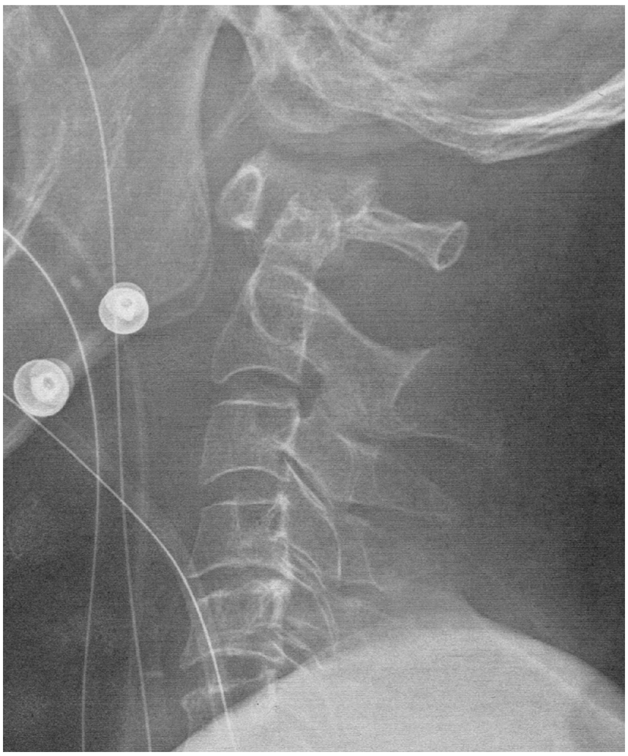

Fig. 2. Lateral cervical spine radiography immediately obtained after halo fixation. Condylar gap and atlantodental interval were reduced to 6 mm and 4 mm, respectively. At this point, further reduction was not obtained, potentially because of multiple ligamentous ruptures in the craniovertebral junctions, hematoma, and soft-tissue fragments in atlantooccipital joints that could be identified as high-intensity areas on T2-WI in atlantooccipital joints.

appeared to be ineffective for the stretch injury to the cord. Instability of AOJ and AAJ was postoperatively resolved although motor and sensory functions did not significantly improve. The patient was discharged from our hospital with ventilator support and transferred to a rehabilitation hospital 2 months after surgery. However, the patient could not be weaned from ventilator support and eventually died from pneumonia 5 months after surgery at the rehabilitation hospital. Evaluation of sensory function was not obtained because she could not make any voluntary movement or utterance during the follow-up period. No significant change in motor function was observed, and complete quadriplegia remained unchanged during the follow-up period. The Glasgow Coma Scale score slightly improved to 5 (E3V1M1) at final follow-up from 3 (E1V1M1) at the first examination.

Discussion

The current report described a case of traumatic simultaneous AOD and AAD. The occipital condyles were rostroventrally displaced to the atlas, representing a Type I injury with Type II elements according to the classification of Traynelis et al. [8] and Stage 3 according to the classification system proposed by Bellabarba et al. [5]. From an anatomical point of view, AOD occurs if the alar ligament, superior longitudinal bands of the cruciform ligament of the atlas, tectorial membrane, or a combination of these structures is disrupted [4]. Atlantoaxial dislocation occurs if the transverse ligament of the cruciform ligament of the atlas is ruptured. Therefore, multiple ruptures of ligamentous structures in the craniovertebral junction are involved in AOD and AAD, resulting in substantial instability of these dislocations. Several previous reports have also demonstrated high instability of AOD and AAD even with halo fixation [5,12,14,15]. Once unstable AOD is diagnosed, immediate reduction and immobilization are required because marked instability of AOJ and AAJ resulting from tears to multiple ligaments at the craniovertebral junction [4,9] may cause neurologic risk and/or vertebral artery injury. Spinal distraction has been demonstrated to cause decreased spinal cord blood flow and neurologic deficits [17,18]. These phenomena are in contrast to the results seen when the spinal cord is shortened within the range of not causing spinal cord deformation [19]. Therefore, preventing eccentric vertical re-dislocation of AOJ is important in protecting the upper cervical spinal cord/or medulla in patients with AOD with or without AAD. Moreover, AAD can cause basilar territory infarction [7] and impingement of the upper cervical spinal cord and/or medulla. Therefore, vigilance of recurrence of AOD and AAD and forcing these dislocations back toward a compressed and neutral position are very important for better neurologic outcomes, such as upper and lower extremities, respiratory system, and the brain stem functions.

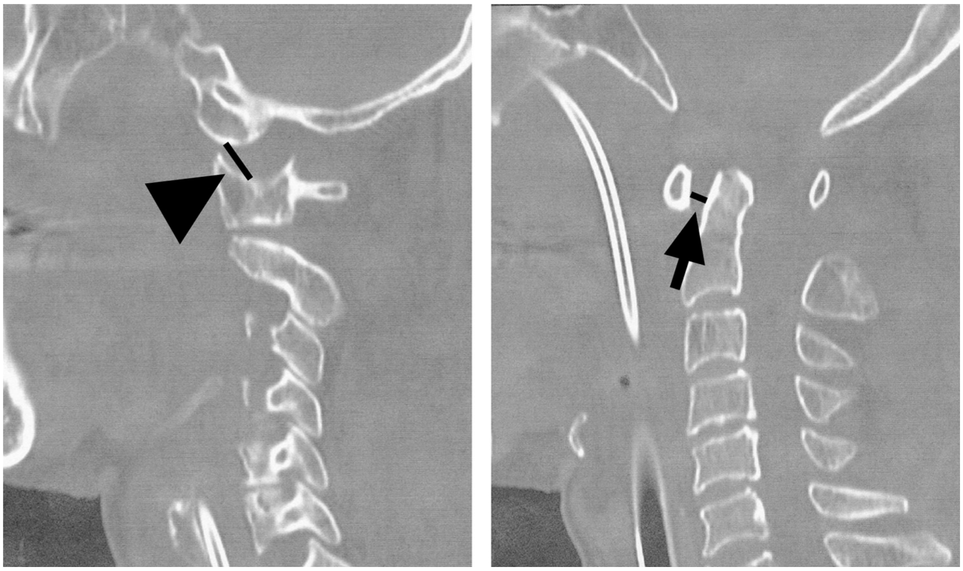

Fig. 3. Left parasagittal (Left) and sagittal cervical spine computed tomography (Right) 12 hours after halo fixation. Condylar gap (closed arrowhead in [Left], 10 mm) and atlantodental interval (filled arrow in [Right], 5 mm) were widened again.

As a standard treatment, halo fixation has been widely used for initial treatment [4,6,9], followed by early rigid internal fixation as a definitive treatment in adults [5]. Because AOD and AAD develop high instability as previously described, reductions of these injuries should be carefully performed either with fluoroscopy or in X-ray suite and should be monitored as long as possible to check whether there is no drift after obtaining optimized reduction. We followed the reduced positioning for approximately half an hour to insure that the re-dislocations did not occur with fluoroscopy. However, in our case, reduced AOD and AAD recurred with halo fixation in the supine position. This does

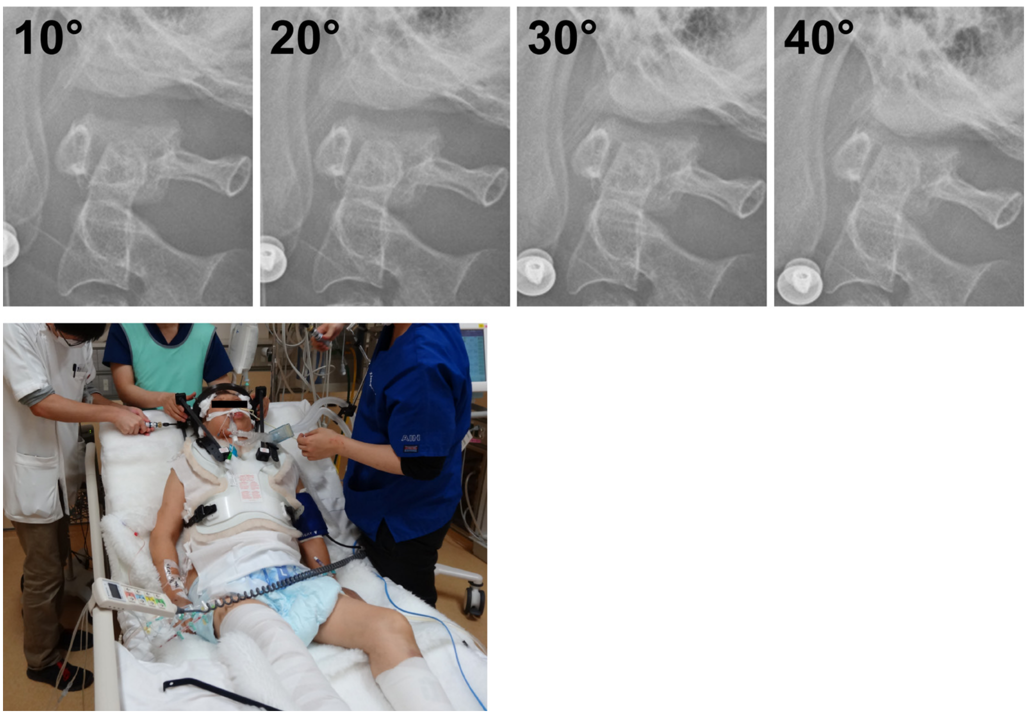

Fig. 4. (Top) Lateral cervical spine radiography obtained during backrest elevation of 10°–40°. Condylar gap and atlantodental interval (ADI) 12 hours after halo fixation were recovered by backrest elevation in an elevation angle–dependent manner. The trend in ADI appeared inversely proportional to that of C1–C2 angulation, defined as the angle between the line parallel to the C2 end plate and the line connecting the C1 anterior and posterior arches. (Bottom) Photograph of backrest elevation with halo fixation. Note that hip and lower legs are mildly immobilized on the bed, and only the halo fixator and head are allowed to migrate caudally in this situation, which differs from the reverse Trendelenburg position described previously (Bellabarba et al.).

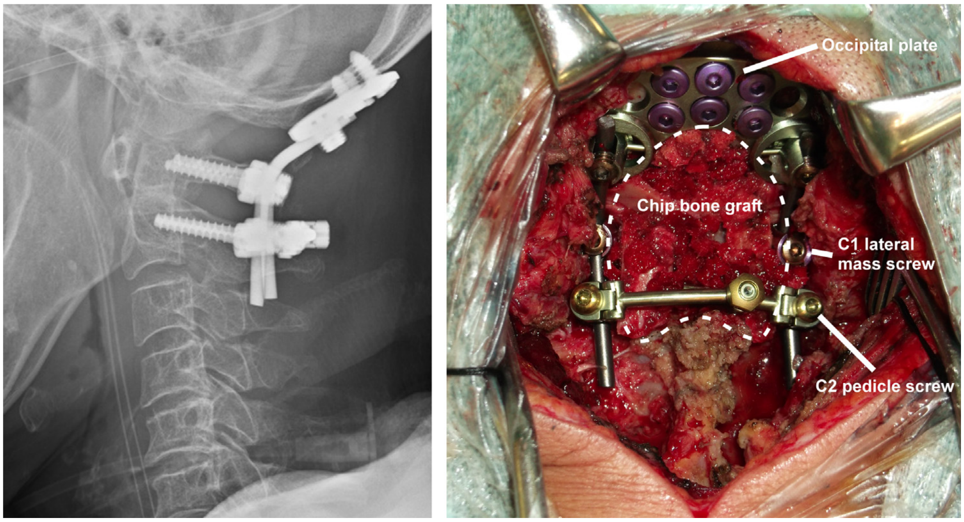

Fig. 5. (Left) Postoperative lateral cervical radiogram. (Right) Intraoperative photograph, revealing occipitocervical fusion using an occipital plate, polyaxial C1 lateral mass, and C2 pedicle screws with rod fixation. Chip bone graft was performed on the posterior surface of the occiput, C1, and C2. At this point, condylar gap and atlantodental interval were both 2 mm.

not appear to be a rare situation with several previous reports describing accentuation of distractive deformity at the upper cervical spine with halo vest fixation [5,14,15]. Additionally, a few studies have quantitatively demonstrated instability under halo fixation in patients with cervical spine injuries [20,21]. Koch and Nickel demonstrated, using a strain gauge attached to halo support bars, that distraction forces on the neck were apparent in the supine position, whereas these forces were reduced in the sitting position with half of the patients with cervical spine fractures demonstrating compression forces on the neck.

This position-dependent change in compression-distraction force should be considered when determining the response to cervical spine injury. In the case of vertical AOD, it is reasonable to maintain the patient in a more upright position to increase compression force on AOJ. Moreover, Koch and Nickel [20] claimed that the chest settled to the back of the halo vest in response to gravity, although the head was rigidly immobilized to the halo ring, resulting in flexion and extension motions in the cervical spine in supine and upright positions, respectively. Likewise, in our observations, an increase in C1–C2 extension angle was observed in an elevation angle–dependent manner; therefore, the change in atlantodental interval observed in the current case was potentially explained by the aforementioned mechanism. As an alternative method of external fixation, dual-strap augmentation of the halo vest used for infants and young children [14] may also be applicable, although it remains unclear whether this method is suitable for adults and whether AAD would be reduced. Another method is Minerva casting; however, this allows more movement than halo fixation [22,23], and the casting is time consuming and labor intensive for temporary external fixation in the preoperative period. Compared with the previous methods, we conclude that backrest elevation with halo fixation is easily performed without any extra devices and beneficial for preventing both re-dislocations of AOJ and AAJ as well as possible secondary damage to the upper cervical spinal cord during the external fixation period. Using this method, the angle of elevation should be carefully chosen under fluoroscopy to provide sufficient compression force on the upper cervical spine to achieve good congruity of AOJ and AAJ within a range that does not adversely affect vital signs. A possible method for applying compression force to the craniovertebral junction other than the backrest elevation method would be to use the Trendelenburg position by fixing the head of the patient to the bed. The cause of traumatic atlantooccipital dislocation is usually a high-energy trauma, for example, a motor vehicle accident, and patients may often sustain head injuries as observed in our patient. Previous studies demonstrated that a head-up tilt of 30° significantly reduced intracranial pressure in most of head-injured patients without reducing the cerebral blood flow [24], whereas a head-down tilt increased both the cerebral blood flow [25] and the intracranial pressure of healthy subjects depending on the angle of the elevation tilt [26]. Elevation of the head-up tilt to 30° is generally accepted in the conservative treatment of head-injured patients for lowering the intracranial pressure. Therefore, in patients with craniocervical dislocations with head injuries, the backrest elevation method is desirable from the viewpoint of protecting the brain.

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