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Case Report

Management of traumatic atlanto-occipital dislocation in a 10-year-old with noninvasive halo immobilization: A case report

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ABSTRACT

Background: Traumatic atlanto-occipital dislocation is an unstable injury of the craniocervical junction. For pediatric patients, surgical arthrodesis of the occipitocervical junction is the recommended management. While having a high success rate for stabilization, the fusion comes with obvious morbidity of limitation in cervical spine flexion, extension, and rotation. An alternative is external immobilization with a conventional halo.

Case Description: We describe the case of a 10-year-old boy who was treated successfully for traumatic AOD with a noninvasive pinless halo. Following initial brain trauma management, we immobilized the craniocervical junction with a pinless halo after reducing the atlanto-occipital dislocation. The pinless halo was kept on at all times for the next 3 months. The craniocervical junction alignment was monitored with weekly cervical spine X-rays and CT craniocervical junction on day 15th, day 30th, and day 70th. A follow-up MRI C-spine 3 months from presentation confirmed resolution of the soft-tissue injury and the pinless halo was removed. Dynamic cervical spine X-rays revealed satisfactory alignment in both flexion and extension views. The patient has been followed up for 2 years postinjury and no issues were identified.

Conclusion: Noninvasive pinless halo is a potential treatment option for traumatic pediatric atlanto-occipital dislocation. This should be considered bearing in mind multiple factors including age and weight of the patient, severity of the atlanto-occipital dislocation (Grade I vs. Grade II and incomplete vs. complete), concomitant skull and scalp injury, and patient's ability to tolerate the halo. It is vital to emphasize that this necessitates close clinicoradiological monitoring.

Keywords: Atlanto-occipital dislocation, Children, Halo, Trauma

BACKGROUND

Traumatic atlanto-occipital dislocation is an unstable injury of the craniocervical junction. Up to a third of patients with mortality related to cervical spine trauma have atlanto-occipital dislocation. Perhaps, due to the improved survival of trauma victims with modern trauma management, this injury is occasionally seen in survivors with craniocervical spine trauma.

Atlanto-occipital dislocation is commoner in children[9] and this is presumed to be due to higher head-to-body proportion and weaker neck musculature.

For pediatric patients, surgical arthrodesis of the occipitocervical junction is the recommended management.[4,6] This usually involves instrumented fusion of the occiput to C2. Due to the challenging anatomy or immaturity, the fusion may be extended to C3 or C4. There are also a few reports of occiput to C1 fusion. While having a high success rate for stabilization, the fusion comes with obvious morbidity of limitation in cervical spine flexion, extension, and rotation.

An alternative is external immobilization with a conventional halo. This has been described for patients with a "mild AOD"[9] or "incomplete AOD."[16] Recently, neurosurgeons at Toronto's Hospital for Sick Children published their experience with managing eight children with traumatic AOD with conventional halo immobilization.[1] We had also successfully managed a pediatric patient with traumatic atlanto-occipital dislocation with a conventional halo in 2014.[14] We report the first case of successful management of traumatic AOD in a 10-year-old boy with external immobilization using a noninvasive pinless halo.

CASE DESCRIPTION

A 10-year-old boy was admitted to our hospital following a collision of his head to the underside of a metal barrier whilst riding at 30 mph on a motorized scooter. He sustained a hyperextension injury of the cervical spine. The patient also had considerable intracranial injuries. He was

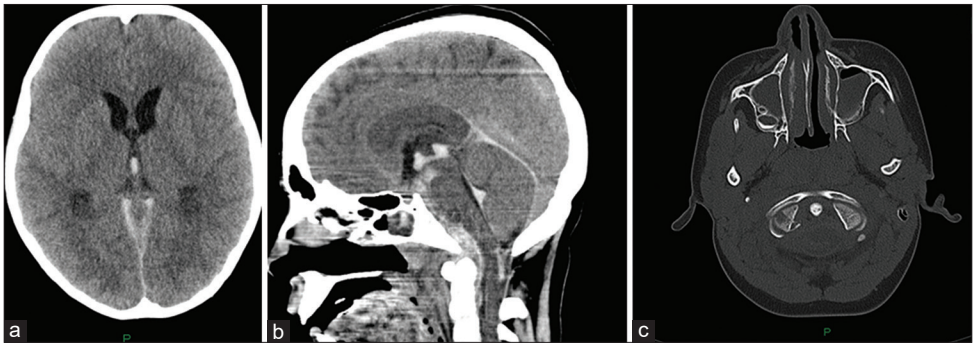

Figure 1: (a) CT brain shows intraventricular hemorrhage and hydrocephalus, (b) sagittal MPR shows the intraventricular hemorrhage and extensive extra-axial hematoma anterior to the brainstem and extending to cervical spine, and (c) CT brain (bone window) shows fracture of the right occipital condyle with medial displacement of fractured fragment.

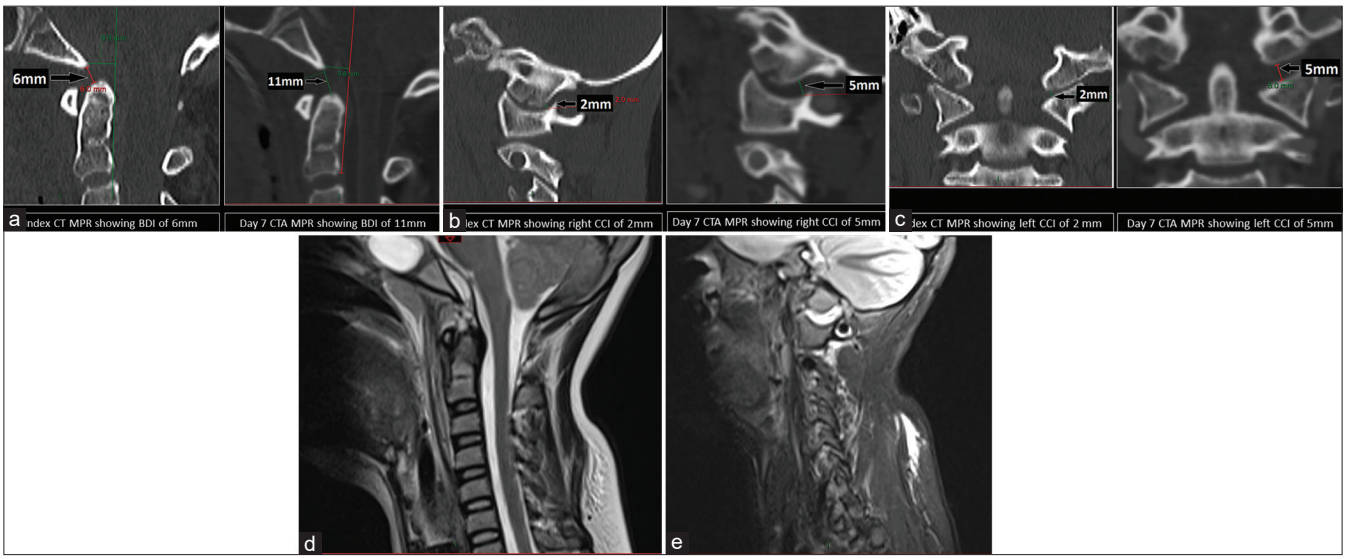

Figure 2: CT MPR showing increase in the basion-dens interval from 6 mm to 11 mm between the index CT and the D7 CTA, (b) CT MPR showing increase in the right C0C1 interval from 2 mm to 5 mm between the index CT and the D7 CTA, (c) CT MPR showing increase in the left C0C1 interval from 2 mm to 5 mm between the index CT and the D7 CTA, (d) MR cervical spine (midsagittal T2) shows apical ligament injury and intact tectorial membrane elevated by retroclival hematoma, and (e) MR cervical spine (parasagittal T2) shows C0C1 joint injury with hemorrhage.

reported to be orientated and obeying commands at the scene of the accident but by his admission to the emergency department, he was GCS 9 (E2V4M3). He was intubated and ventilated. His injuries were assessed as per the ATLS protocol and his cervical spine was immobilized. IV mannitol was administered for suspected raised intracranial pressure. The initial trauma CT [Figure 1] revealed acute hydrocephalus with subdural, subarachnoid, and fourth ventricular hemorrhage. In addition, there was a minimally displaced right occipital condyle fracture and a hematoma at the craniocervical junction displacing the medulla posteriorly. There was no evidence of AOD seen in the index trauma CT. The cervical spine was kept immobilized with hard collar.

The patient underwent insertion of a left frontal intracranial pressure monitoring probe and a right frontal ventricular access device. Following his transfer to pediatric ICU, he had external CSF diversion through the ventricular access device and his intracranial pressure remained well controlled. On the 5th day, the sedation was weaned and the patient was extubated.

He had CT and MR cerebral angiograms 7 days after presentation to investigate suspected vascular injury and this revealed ligamentous injury at the craniocervical junction [Figure 2]. The apical ligament was suspected to be disrupted in the presence of a new increase in the basion-dens interval or BDI (was 11 mm, increased from 6 mm in the index trauma CT). Effusions were noted between the occipital condyles and lateral masses of C1 and the atlanto-occipital joint interval was increased bilaterally (C0-C1 interval or CCI was 5 mm). There was also prevertebral edema, edema related to the ligamentum nuchae, and elevation of the tectorial membrane by hematoma. AOD was diagnosed and we discussed the clinical case specifics at our departmental multidisciplinary meeting. Then, the management options were discussed with patient's parents. On day 10 postinjury, we proceeded to immobilize the craniocervical junction with a noninvasive pinless halo after reducing the atlanto-occipital dislocation [Figure 3]. He had no sensory-motor deficits or sphincter control disturbance at this stage.

Under general anesthesia, the dislocation was reduced with gravity (30° head end elevation) and gentle compression with the pinless halo, under fluoroscopic guidance. We used the "Lerman" noninvasive halo for this patient.

The pinless halo was kept on at all times for the next 3 months. The craniocervical junction alignment was monitored with weekly cervical spine X-rays and the noninvasive halo brace was reviewed weekly by orthotics. We also performed CT craniocervical junction to monitor the alignment and healing on day 15th day 30th, and day 70th [Figure 4]. These radiological investigations were performed using our pediatric protocol to minimize radiation dose.

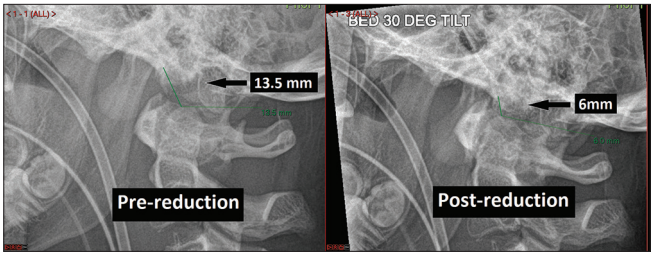

Figure 3: Intraoperative cervical spine lateral X-rays showing reduction in the basion-dens interval from 13 mm to 6 mm following reduction of the atlanto-occipital dislocation.

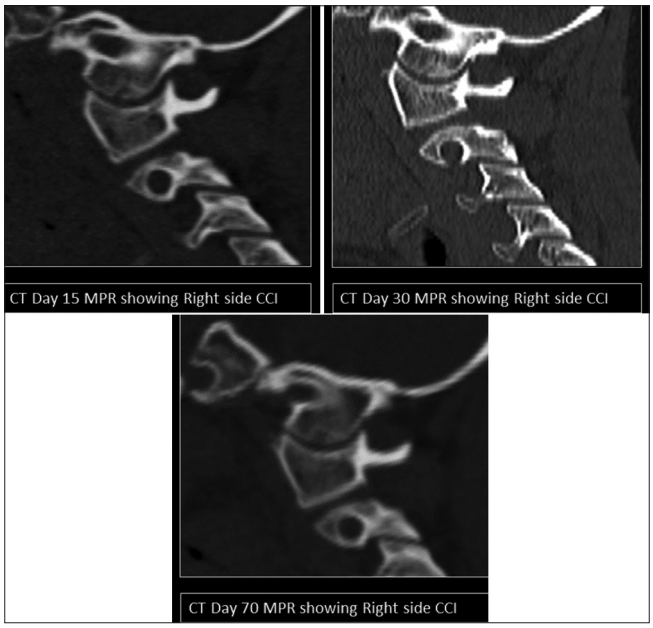

Figure 4: Parasagittal MPR views of follow-up CT scans showing well-apposed right C0C1 joint.

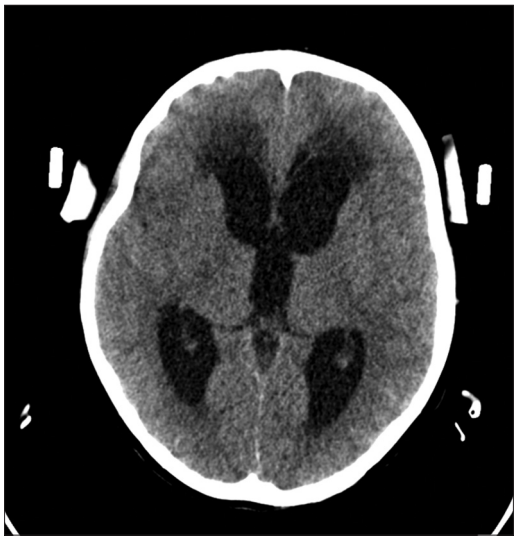

Figure 5: CT brain shows worsening in hydrocephalus post-CSF drainage withdrawal.

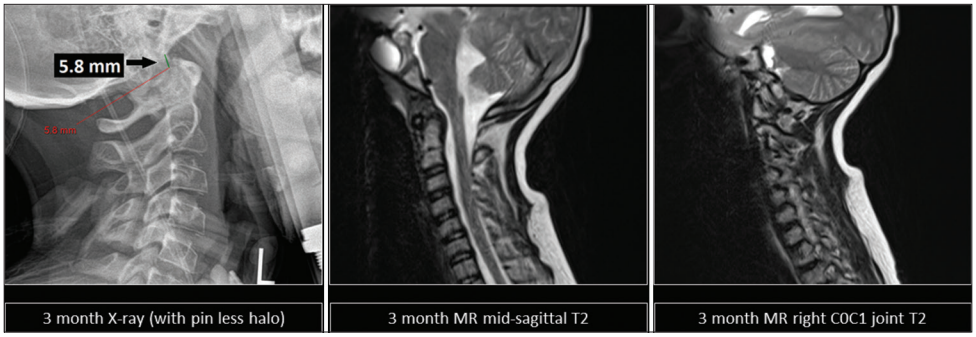

Figure 6: Three-month MR showing healing of craniocervical junction injury and 3-month X-ray showing normal craniocervical junction alignment.

During this 3-month period, the patient received regular physiotherapy, orthotics, and pain medicine input. He had an occipital laceration from the original trauma and this progressed to a pressure sore. This pressure sore was debrided and treated with IV antibiotics at 3 weeks postadmission. He developed worsening hydrocephalus on withdrawal of CSF drainage [Figure 5], and consequently, he underwent insertion of a ventriculoperitoneal shunt 2 months after his injury.

A follow-up MRI C-spine at 3 months from presentation confirmed resolution of the soft-tissue injury [Figure 6]. The noninvasive halo was replaced with a hard collar for 2 further weeks. His dynamic cervical spine X-rays revealed satisfactory alignment in both flexion and extension views. He needed extensive inpatient rehabilitation (physiotherapy, occupational therapy, speech therapy, and psychology support) before discharge. The patient was discharged home 4 months after his initial admission with no focal neurological deficits. After his discharge, we continued with clinical monitoring and the radiological monitoring was stopped. While making considerable progress with his neurorehabilitation, he had ongoing difficulty with confusion, aggression, impulsivity, and pressured speech. He had ongoing input from the psychology service to support him and his family with his rehabilitation.

At the 2-year follow-up, he was noted to have made excellent recovery without any symptoms and signs of any spinal instability.

CONCLUSION

This report describes the successful management of traumatic AOD with a noninvasive halo. The case serves to illustrate that it is possible to gain sufficient stability with noninvasive halos in selected cases. The previous literature on pediatric traumatic craniocervical junction injury strongly advocates occipitocervical instrumented stabilization.[4,6] This procedure is associated with significant risks including wound infection, CSF leak, pseudoarthrosis, vascular injury, and spinal cord injury.[10] There is also long-term morbidity of decrease in mobility of cervical spine (especially rotation, flexion, and extension).

The question of how to select patients for whom conservative strategy is appropriate is both difficult and as-of-yet unanswered.[1]

Horn *et al*. classified[9] AOD into two categories: Grade I with normal findings on CT with only high signal in posterior ligaments or atlanto-occipital joints and Grade II with abnormal findings on CT (BDI, BAI, etc.) or MR findings of injury of the tectorial membrane, alar ligaments, cruciate ligament, and disruption of atlanto-occipital joints. They recommend using external immobilization with halo for Grade I AOD. They used halo for two pediatric patients in their case series.

Steinmetz *et al*.[16] classified pediatric AOD into two types: "complete" (with total disruption of tectorial membrane) and "incomplete" (with incomplete rupture of the tectorial membrane and alar ligaments or disruption of other ligaments). In their review in 2003, they identified 41 cases of pediatric AOD in published literature, who had survived more than 48 h. They recommend that, regardless of neurological injury, incomplete AOD should be treated with orthotic immobilization. They used halo vests for 10 weeks followed by Minerva orthosis for 4 weeks and cervical collar for the final 4 weeks.

Abel *et al*.[1] recently published their experience with external immobilization with halo for pediatric patients with AOD (with CT showing CCI > 5.0 mm or BDI > 8.0 mm). They report the outcomes for eight patients and none of them needed delayed surgery. Their follow-up varies from 4 months to 120 months (mean 28 months).

For the patient described in our report, the decision to try a noninvasive halo was based on the consensus opinion of the pediatric neurosurgical team and their discussions with the parents. The tectorial membrane was intact on MR, suggesting an "incomplete" type AOD.[16] Integrity of the tectorial membrane has also been reported as a favorable prognostic factor by other reports.[11]

There exist no cases to our knowledge which have made use of a noninvasive pinless halo in the context of traumatic AOD. AOD is a highly unstable craniocervical junction injury which can present with severe neck pain, lower cranial nerve palsies, spinal cord injury, and vascular injury (vertebral artery and carotid artery). Atlanto-occipital dislocation is commonly associated with traumatic brain injury,[9] as is the case in this report, and this can affect initial identification of the spinal injury. Posttraumatic hydrocephalus is a common sequelae and many survivors need CSF diversion surgery.[3]

Several methods have been proposed for the radiological diagnosis of atlanto-occipital dislocation such as the Harris method using plain X-rays or the Condyle-C1 interval (CCI) on CT imaging. The Congress of Neurological Surgeons published a guideline in March 2013 which recommends using CT to determine the CCI method in pediatric patients with suspected AOD. This is also supported by other studies.[4]

However, in our patient, the index CT did not reveal any evidence of AOD. AOD was diagnosed on delayed CT and MR angiograms performed to investigate intracranial hemorrhage [Figure 2]. Delayed diagnosis of AOD, with normal CCI on index CT, has also been reported by other case reports.[2,15] AOD might be missed in children, when only CT is used for diagnosis. If there is a high index of suspicion of AOD in pediatric patients, then a MR should be performed.[8,12] This is also endorsed by the National Institute of Clinical Excellence.[13]

During the first 3 months, we monitored our patient's craniocervical junction alignment with X-rays (on a weekly basis) and CT (at less frequent intervals). A further cervical spine X-ray with flexion-extension views was performed in the 4th month. Frequent clinicoradiological follow-up is very important factor in conservative management of AOD, as a patient may lose the reduction of the AOD despite halo immobilization.[7]

The conventional halo can be associated with significant adverse events: infection, pin loosening, dysphagia, dural/skull penetration, and pressure ulcers.[5] A pinless halo avoids many of these problems at the perceived expense of the stability which the pins ensure. Indeed, noninvasive halos are applied widely in pediatric neurosurgery for immobilization in situations such as congenital muscular torticollis, conservative management of nontraumatic atlantoaxial rotary subluxation, post cervical fusion surgery, and stable occipital condyle fractures.[5] Pinless halo use can lead to occipital pressure ulcers and skin infection. Our patient had an occipital laceration from the original trauma and this developed into a pressure ulcer, which needed debridement and a course of antibiotics.

A multidisciplinary team input from a team of pediatric neurosurgeons, physiotherapists and occupational therapists, neuropsychologist, play therapist, speech therapist, and rehabilitation team leads to excellent clinical recovery in our case. Patient continues to remain asymptomatic on a 2-year follow-up. He mobilizes independently and attends mainstream school.

Pediatric patients with AOD and traumatic brain injury may require intense rehabilitation with input from physiotherapy, occupational therapy, and other therapists to address the child's physical and psychological needs. We recommend that these patients are managed in a tertiary care center adapting a multidisciplinary approach lead by the pediatric neurosurgical team.

Noninvasive pinless halo is a potential treatment option for traumatic pediatric atlanto-occipital dislocation. This should be considered bearing in mind multiple factors including age and weight of the patient, severity of the atlanto-occipital dislocation (Grade I vs. Grade II and incomplete vs. complete), concomitant skull and scalp injury, and patient's ability to tolerate the halo. It is vital to emphasize that this necessitates close clinicoradiological monitoring.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

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