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# Traumatic Avulsion Fracture of the Occipital Condyles and Clivus with Associated Unilateral Atlantooccipital Distraction

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We describe an unusual traumatic fracture/distraction injury of the craniovertebral junction, which the patient survived. It is postulated that this represents an example of the spectrum of fracture dislocation injuries that may occur at, and adjacent to, the atlantooccipital joints. Avulsion fractures in this region, associated with atlantooccipital dislocation, may be more common than previously suspected, particularly in adults, in whom supporting ligaments are strong and not apt to rupture. Thin-section CT with coronal and sagittal reformation can best visualize these fractures, while MR imaging is useful in the assessment of the adjacent soft tissues.

## Case Report

A 43-year-old man was a competitor in a speedboat race, when, at an estimated speed of 130 kph (80 mph), the boat flipped and he was flung into the water. He was quickly retrieved and was found unconscious and without respiration. Cardiopulmonary resuscitation was immediately instituted. Some gagging was noted but no definite purposeful movement was witnessed. The patient was taken to the local district hospital where he was cautiously intubated before being transferred to the tertiary hospital in a cervical collar.

On arrival at the accident and emergency department a cross-table lateral cervical radiograph was obtained (Fig. 1), which revealed a longitudinal distraction injury at the craniovertebral junction, with significant separation between the atlas and base of the skull. Bone fragments were seen just superior to the lateral masses of the atlas, and an avulsion fracture of the occipital condyles was postulated. A small bone fragment was also evident, which represented an avulsed portion of the inferior clivus (anterior margin of the foramen magnum). The atlas and axis were intact and in normal relationship.

After stabilization of other injuries, the patient underwent a CT examination of the craniovertebral junction. Continuous sections, 1.5-mm thick, with reformations in the coronal and sagittal planes, were obtained. A fracture fragment, consisting of both occipital condyles and a small inferior portion of the clivus, was demonstrated and was displaced inferiorly. (The normal anatomic relationship of the occipital condyles, foramen magnum, and clivus is shown in Fig. 2.) While nearly normal articulation was maintained between the occipital condyle and the lateral mass of the atlas on the right, there was widening and some distraction of this joint on the left (Figs. 3–5). An MR scan

of the craniovertebral junction was then acquired, which demonstrated an intact spinal cord and brainstem with no evidence of transection. A hematoma was noted anterior to the upper cervical cord and medulla, resulting in posterior displacement of these structures (Fig. 6).

On arrival at the accident and emergency department, the patient was ventilating spontaneously, but no limb movements were noted and muscle tone was flaccid. There was no response to painful stimuli. Deep tendon reflexes were absent in the upper limbs, but present and symmetrical in both lower limbs. Over the next 4 weeks he was able to communicate with eye blinking, but remained quadriplegic. The patient underwent a surgical posterior fusion procedure for stabilization of the craniovertebral junction.

## Discussion

Craniovertebral fractures are a category of spinal fractures involving the occipital bone, atlas, and axis. Traumatic fractures and dislocations of the craniovertebral junction are commonly fatal in victims of high-speed motor vehicle accidents. Bucholz et al. [1] found that atlantooccipital dislocations represent the single most common injury to the cervical spine in victims of multiple trauma in high-speed accidents. Atlantooccipital dislocations probably occur more frequently than previously suspected in such instances, but the vast majority result in near instantaneous death [1]. Survival from such injuries is sufficiently rare to be considered reportable. A review of the literature indicates that there are only scattered reports of short- and long-term survival. The clinical picture and outcome is often varied, ranging from transient and minor neurologic disturbances with full recovery to profound deficits and poor outcome or death [2].

Werne [3] concluded that atlantooccipital joint stability is largely dependent on the integrity of the tectorial membrane and alar ligaments. The tectorial membrane, an intraspinal ligament, arises from the axis and attaches to the anterior foramen magnum, and can be considered a continuation of the posterior longitudinal ligament. This structure is responsible for checking hyperextension. The alar ligaments, one on

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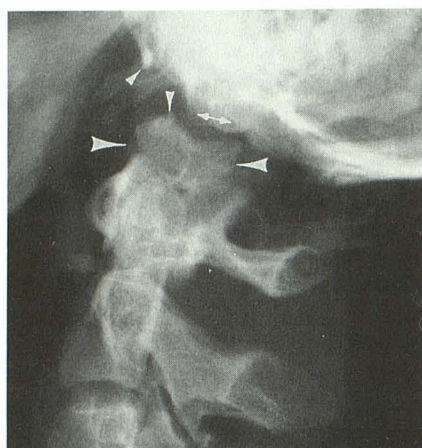


Fig. 1.—Lateral cervical spine radiograph, taken on admission, shows a longitudinal distraction injury at the craniocervical junction. The avulsed occipital condyles (*large arrowheads*) and the small, inferiorly displaced fragment of inferior clivus (*small arrowheads*) are demonstrated. The double-arrowed line represents the mastoid tips. Tubing external to patient is projected over atlas and dens.

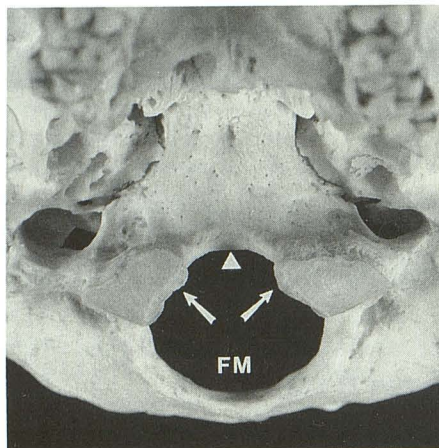


Fig. 2.—Photograph of base of skull, viewed from below and anterior, shows normal anatomic relationship of the occipital condyles (*arrows*) to the inferior portion of the clivus (*arrowhead*), which forms the anterior margin of the foramen magnum (FM).

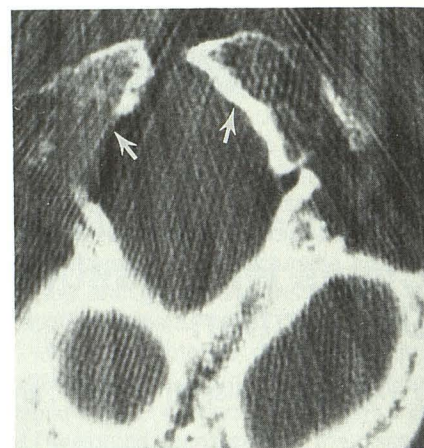


Fig. 3.—Axial 1.5-mm-thick CT section shows avulsed occipital condyles (*arrows*). Artifact is from metallic dental amalgam.

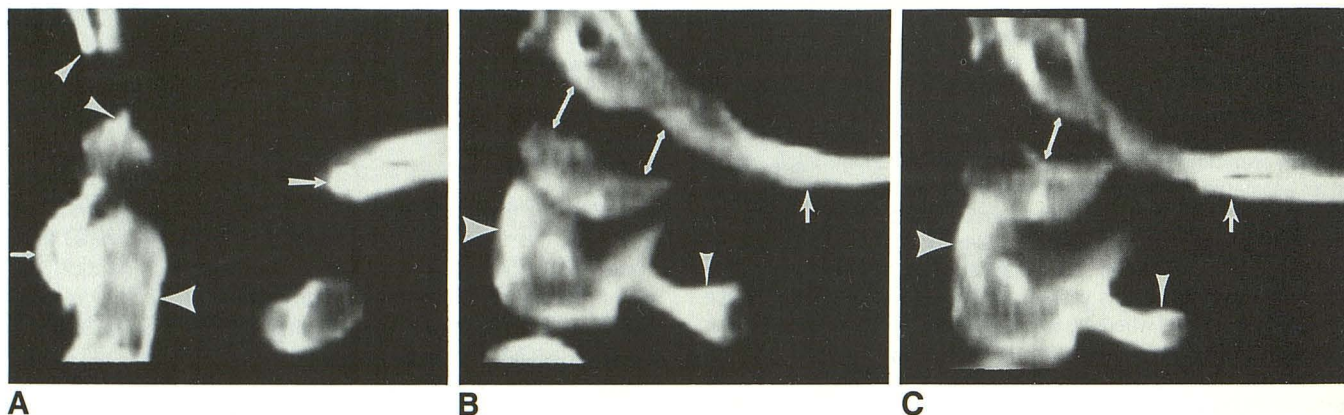


Fig. 4.—A, Sagittal CT reformation shows inferiorly displaced fragment of inferior clivus (*small arrowheads*) and the relationship to the anterior arch of atlas (*small arrow*), dens (*large arrowhead*), and posterior margin of foramen magnum (*large arrow*). B and C, Right (B) and left (C) parasagittal CT reformations show the avulsed occipital condyles (*double-arrowed lines*) and their relationship to the lateral masses of atlas (*large arrowhead*), posterior arch of atlas (*small arrowhead*), and occipital bone (*arrow*).

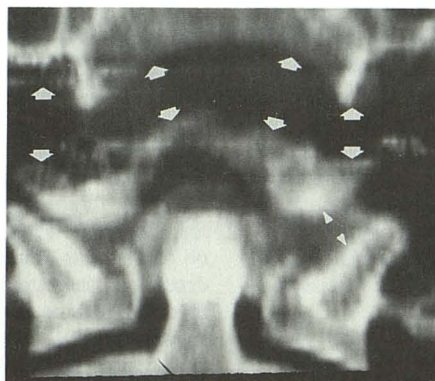
each side, arise from the odontoid process of the axis and attach to the occipital condyles, thereby preventing lateral flexion and rotation. These ligaments, in adults, are very strong and not apt to rupture. This fact may explain the occasional finding of an avulsion fracture of the occipital condyle in cases of atlantooccipital dislocation in adults [1, 4]. However, the majority of reported cases of atlantooccipital dislocation are not associated with such fractures. The incidence of pure dislocation of the atlantooccipital joint is higher in children than in adults, which may relate to the smaller size of the occipital condyles and the relative horizontal plane of articulation as compared with adults [1, 2].

The mechanism of injury in atlantooccipital dislocation is controversial, and both hyperflexion [4] and hyperextension [1] forces, in association with distraction and lateral flexion/rotatory forces, have been implicated.

The craniocervical fracture/distraction injury described here—namely, avulsion of both occipital condyles and clivus in association with some distraction of an atlantooccipital joint—is rare. However, it is considered to represent an example of the spectrum of fracture dislocation injuries that can occur at, and adjacent to, the atlantooccipital joints. It may be that avulsion fractures at this site are more commonly associated with atlantooccipital joint dislocation than pres-



Fig. 5.—Coronal CT reformation shows the fracture fragment consisting of both occipital condyles and inferior clivus, which is displaced inferiorly (arrows). There is some distraction of the left atlantooccipital joint (arrowheads).



5

Fig. 6.—Sagittal T1-weighted MR image (500/20/4) shows a hematoma (arrowheads) anterior to the cord, displacing this structure posteriorly. The cord and medulla are not transected.



6

ently suspected, and that these can be best visualized with thin-section CT and reformation in coronal and sagittal planes. It is postulated that a hyperextension and distraction force, with rotatory and lateral flexion components, is responsible for this injury. It seems plausible that such forces would result in strain in both tectorial and alar ligaments, which would then result in avulsion fractures at the sites of attachment, namely, the inferior clivus and both occipital condyles, respectively. This mechanism of injury can also account for the unilateral atlantooccipital distraction. This case therefore supports the theory that hyperextension (rather than hyperflexion) and distraction forces are largely responsible for atlantooccipital dislocation.

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