Circumferential fracture of the skull base causing craniocervical dislocation

Case report

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Fractures of the craniocervical junction are common in victims of high-speed motor vehicle accidents; indeed, injury to this area is often fatal. The authors present the unusual case of a young woman who sustained a circumferential fracture of the craniocervical junction. Despite significant trauma to this area, she suffered remarkably minor neurological impairment and made an excellent recovery. Her injuries, treatment, and outcome, as well as a review of the literature with regard to injuries at the craniocervical junction, are discussed.

KEY WORDS • cervical spine trauma • craniocervical junction • occipitocervical stabilization

TRAUMATIC fractures of the craniocervical junction are associated with a high mortality rate. Post-mortem evaluations of victims of high-speed MVAs have suggested an incidence of AO or atlantoaxial injury as high as 21%. Death is typically instantaneous and results from transection of the medulla or spino-medullary junction. Although mortality rates from this injury remain high, more patients are surviving due to on-scene cervical spine stabilization with advanced vehicular extraction techniques. More trauma centers are now using advanced imaging techniques to evaluate the craniocervical junction to identify these injuries, which allows for prompt treatment.

Fractures of the clivus are associated with a mortality rate between 50 and 67% depending on the fracture type. These fractures have been categorized into three types, which are dependent on the mechanism of injury. Associated vascular and cranial nerve injuries are not uncommon. Prior to the advent of CT scanning many of these injuries were not identified; however, the routine use of CT scanning in trauma cases has made these injuries more reliably diagnosable.

Given the severity of these injuries and the potential consequences of undiagnosed or untreated injuries, thorough evaluation of the skull base and craniocervical junction by using modern imaging techniques is justified. Although more patients are surviving these types of injuries, unusual injuries with the patient surviving is still rare enough to be reportable. We present the case of a young woman who sustained significant injury to the craniocervical junction, yet had very minor neurological impairment. We discuss the diagnostic modalities and treatment techniques used in this patient.

Case Report

History. This 16-year-old woman was involved in a high-speed MVA in which she was a restrained passenger. The driver failed to stop at a “T” junction, but instead continued across the roadway. The vehicle left the highway and briefly became airborne before impacting on an earth mound in a field. Three other individuals riding in the same vehicle were killed in the accident. Prolonged efforts were required to extricate our patient from the vehicle. She was initially semicomatose with a Glasgow Coma Scale score of 11 and underwent intubation. She was transported to a local hospital where she was noted to be awake and following some commands.

Examination. On arrival at the University of Utah Medical Center the patient was noted to have unequal pupils: the right was 4 mm and the left 2 mm. There was also blood in her ear canals bilaterally, diffuse neck swelling, and a right mandible fracture. She displayed distal upper-extremity weakness bilaterally, with relatively normal deltoid, triceps, and biceps muscle function bilaterally. She had normal strength and reflexes in her left lower extremity but we were unable to assess her right lower extremity because of the right fibula and ankle fractures. Her sensory examination was normal to light touch and vibratory sensation throughout.
Neuroimaging Evaluation. Neuroimaging examination including CT scanning of the head revealed subarachnoid hemorrhage in the prepontine and basilar cisterns, cerebral edema, and confirmed the right mandible fracture. Computerized tomography scanning of the base of skull and cervical spine demonstrated a displaced fracture of the clivus with 7 to 8 mm of distraction extending into the left and right occipital condyles, a left temporal bone fracture, a nondisplaced fracture involving the right jugular foramen and possibly hypoglossal canal, and a comminuted fracture of the base of skull with a small fracture off of the posterior margin of the foramen magnum (Figs. 1–3). In addition, on parasagittal slices (Fig. 2) there was 4 mm of posterior subluxation of C-1 on C-2 on the left side. Magnetic resonance imaging was performed to evaluate her injuries further. The MR study demonstrated an abnormal signal and swelling in the upper medulla and lower pons, which was considered a “stretch” injury (Fig. 4). There was also injury of the posterior AO and atlantoaxial membranes. Finally, there was prevertebral soft-tissue swelling from the clivus to the midcervical spine. Magnetic resonance angiography revealed no vascular injury to the intracranial vessels.

Operation and Postoperative Course. The patient was clearly severely injured. The 8-mm gap in her inferior clivus, circumferential fracture of the low skull base extending through the occipital condyles and posterior lip of the foramen magnum, coupled with the increased MR imaging signal in the brainstem suggested instability between the skull base and upper cervical spine. We therefore avoided the use of traction and instead used an external orthosis and kept the patient flat and immobilized to maintain occipitocervical alignment. The patient subsequently underwent surgical stabilization. We placed bilateral transarticular screws at C1–2 by using stereotactic and fluoroscopic guidance after realigning C-1 and C-2 intraoperatively. After the screws had been placed, a U-loop coupled to the C1–2 transarticular screws was used to fix rigidly the occiput–C2. Four-millimeter cortically threaded bone screws (12–14 mm in length) were placed bicortically under fluoroscopic guidance: one in the midline occipital keel and two others in paramedian locations. We opted for this placement to take advantage of the thickest and strongest portion of the occipital bone. Full-thickness iliac crest bone was harvested for the bone fusion of the occiput–C2. A titanium cable was placed around the arch of C-1 bilaterally and over the graft. It was used to compress the graft against the occiput, C-1 arch, and the lamina of C-2 and to secure it in position (Fig. 5). The patient was observed in the neurological critical care unit for 3 days and then transferred to the floor as her medical condition stabilized. Her mandible fracture required operative reduction and internal fixation. Massive edema throughout her pharyngeal region made a tracheostomy necessary. In addition, she was found to have bilateral vocal cord paralysis, which was treated with collagen injection to reduce the risk of aspiration. Twelve days after admission she was transferred to the rehabilitation service where her neurological function improved slowly. After a 6-week stay at the inpatient rehabilitation unit she was discharged to home with no obvious neurological deficits and having had her tracheostomy removed. She returned to school and subsequently rejoined her high school class.
Discussion

The injuries described in our patient include: a clival fracture extending into both occipital condyles across the floor of the posterior fossa into the posterior aspect of the calvaria just above the foramen magnum; atlantoaxial subluxation; and brainstem injury likely resulting from axial distraction.

Corradino, et al., previously classified clivus fractures as occurring in three varieties: longitudinal, transverse, and oblique. These occurred with almost equal incidence in their series of 17 patients. Longitudinal fractures were thought to arise from a direct occipital blow, which can cause a fracture line to develop through the foramen magnum and into the clivus. Another possible mechanism is an axial force that traps the clivus between the petrous bones and the vertebral column. The mortality rate associated with longitudinal clivus fractures in this series was 67%. The fractures were often associated with severe injury to the central nervous system including brainstem infarctions. As a result, most were identified postmortem. These injuries also are implicated in damage to the posterior circulation including traumatic aneurysms.

Transverse and oblique fractures may both result from an anterolateral impact. These fractures are associated with injury to the anterior circulation, including carotid arterial spasm and carotid–cavernous fistulas. These are more often identified before death but mortality remains high (50 and 60%, respectively). Transverse and oblique fractures are also associated with a high incidence of cranial nerve palsies (up to 67% in transverse fractures and 100% with oblique fractures). Concomitant petrous bone fractures occurred frequently. Posterior pituitary dysfunction is also associated with transverse clival fractures. Our patient’s injury is consistent with a transverse fracture. She had fractures horizontally in the inferior clivus and into the skull base.

Atlantooccipital dislocation is a common injury in patients involved in a high-speed MVA. Patients who survive this injury are less rare, no doubt because of improved injury scene extrication and stabilization techniques; this type of injury has become more recognized with the routine use of CT scanning, which allows for appropriate stabilization techniques to be performed. Since 1908 when the first case report of AO dislocation was published (a patient who survived 38 hours), there have been some 36 reported survivors. Recognition and diagnosis of AO dislocation are dependent on imaging studies of the craniovertebral junction. The importance of plain radiographic and CT evaluation are well documented. Magnetic resonance imaging is also useful because it can be used to assess injury to the spinal cord and ligamentous structures. The mechanism of injury is generally agreed to be a combination of hyperflexion and hyperextension, with associated distraction and lateral flexion rotation. Our patient almost certainly experienced similar forces as well as a direct blow to the skull, as evidenced by her clival fracture and occipital condyle fracture.

In this case, our patient suffered an injury functionally similar to an AO dislocation with the line of dislocation extending through the low skull base rather than across the AO joint.

Common clinical features of AO dislocation include: 1) loss of consciousness originating from damage to the
brainstem; 2) hemiparesis or tetraparesis; 3) cranial nerve palsy (particularly seven, and nine–12), which may result from avulsion from the brainstem; and 4) submental laceration or fracture of the mandible, which often accompanies the injury and is consistent with a hyperextension mechanism. Although our patient’s injury was a circumferential skull fracture, there were elements of all of the aforementioned findings. The vocal cord paralysis may have been attributable to cranial nerve injury and she also exhibited elements consistent with cruciate paralysis. This is a rare pattern seen after injury to the superior spinal cord and thought to occur as a result of selective injury to descending corticospinal tracts as they decussate at the cervicomedullary junction. These patients will experience weakness of the upper extremities with little compromise of their lower-extremity function.

Our patient also had bilateral OCFs, which were extensions of her basilar skull fractures into the condyles. This qualifies these condylar fractures as Type II OCFs. A Type I OCF is a comminution of the condyle caused by axial loading. Type II OCF is an extension of a basilar skull fracture extending into the condyle after a direct blow to the skull. Type III is an avulsion fracture of the condyle at the insertion site of the alar ligament. Type III is generally accepted to be unstable whereas the other two are not. The patient presented in this case is remarkable because despite her injuries and cranial nerve deficits, she regained consciousness quickly and has recovered fully. She suffered a craniocervical injury that includes a low circumferential skull base fracture creating an effective AO dislocation and in addition an atlantoaxial injury with dislocation. Recognizing the severe instability these injuries produced, we avoided traction, kept her immobilized, and proceded quickly to surgical stabilization. This was accomplished using C1–2 transarticular screw fixation coupled to a U-loop to create a rigid occiput–C2 construct, and ultimately, fusion. There have been other authors who have described both external immobilization and surgical stabilization. Belzberg and Tranmer discussed the different techniques used and commented on the frequent failure of external immobilization.

References


Manuscript received June 11, 2001.
Accepted in final form February 19, 2002.

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