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The Forgotten Condyle: The Appearance, Morphology, and Classification of Occipital Condyle Fractures

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PURPOSE: To evaluate the appearance, morphology, and treatment of occipital condyle fractures (OCF). **METHODS:** Cases were collected by a retrospective and prospective analysis of teaching files and case logs. Patients' charts, when available, were reviewed for age, sex, mode of injury, physical examination, Glascow Coma Scale score, and associated injuries. Plain films and CT images were reviewed to determine OCF type and to assess for the presence of associated cervical spine and/or intracranial trauma. **RESULTS:** Fifteen patients with OCF, 13 occurring in a 43-month period, were identified. Ten patients were involved in motor vehicle accidents. Severity of closed head injury and associated clinical findings were variable. Three patients had associated cervical spine fracture. According to the Anderson and Montesano classification, two patients (13%) had type I OCF, eight patients (54%) had type II OCF, and five (33%) had type III OCF. Fourteen of the fractures were identified on screening trauma head CT scans. Treatment varied according to the presence of associated injuries and stability of the cervical spine. **CONCLUSIONS:** Although OCFs are rare, they will be encountered by most radiologists who see a significant amount of trauma. Type II OCFs were the most common fracture type in our series. Type III fractures were the second most common and potentially unstable. CT should be initiated at the level of the C-1 ring to screen for the presence of OCF in all patients who have suffered trauma.

Index terms: Occipital bone; Skull, computed tomography; Skull, fractures

An occipital condyle fracture (OCF) was described by Sir Charles Bell in 1817 (1). Another fracture was reported in 1900, by Kissinger (2). Since that time approximately 55 OCFs have been reported in the English-language literature (3–28).

Sir Charles Bell's patient sustained his fracture by falling backward off a wall. When the patient was leaving the hospital, he turned to thank the physicians and nurses and suddenly dropped dead. This, rather vividly, demonstrates the potential instability of these fractures.

In 1988, Anderson and Montesano described three types of OCFs, distinguished on the basis of their radiographic appearance and presumptive mechanism of injury (3). The type I OCF, produced by an axial load injury with a component of ipsilateral flexion, is considered an impaction fracture of the occipital condyle. The type II OCF refers to a basilar skull fracture that extends to involve the occipital condyle and is usually the result of a direct blow to the skull. The fracture line can reach the condyle after crossing either the more posterior squamous portion of the occipital bone or the more anterior basiocciput. The type III OCF is essentially an avulsion fracture of the inferomedial portion of the condyle, most probably the result of severe contralateral flexion and rotation (Fig 1).

We describe 15 additional cases of OCF; review the pertinent anatomy, mode of injury, presentation, mechanism of diagnosis, and fracture type; and discuss the current therapeu-
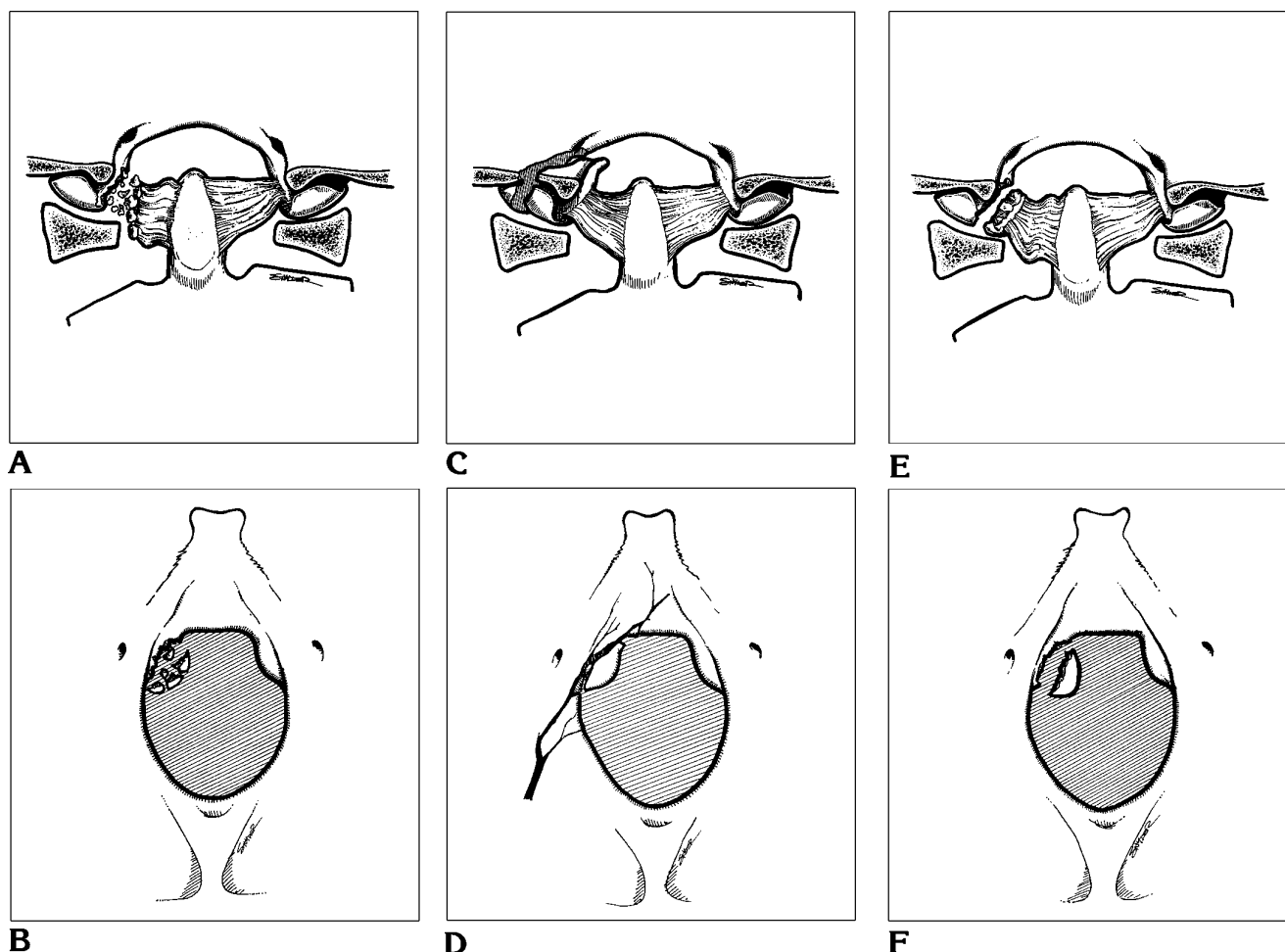
Fig 1. Line drawings illustrate type I (*A* and *B*), type II (*C* and *D*), and type III (*E* and *F*) occipital condyle fractures.

tic options available for treatment of these uncommon fractures.

Methods

The first five patients of our study were identified from teaching files of our Department of Radiology's neuroradiology section. The remaining cases were procured by prospectively evaluating incoming trauma head computed tomography (CT) scans. All patients with fractures involving the occipital condyles were admitted into the study.

One of the patients (patient 13) was admitted to the hospital before CT was in use, and his diagnosis was made by plain film tomography. The remaining patients had plain radiography of the cervical spine and CT of the head. Plain cervical spine radiographs included anteroposterior, lateral, oblique, and odontoid views. Routine head CT scans included 5-mm-thick axial images from the ring of C-1 through the posterior fossa and 10-mm-thick axial images through the remainder of the calvaria. Two sets of images were reviewed for each examination, one with the window and level optimized for evaluation of osseous structures and a second optimized for evaluation of brain parenchyma. Three patients had additional thin-section, bone algorithm imaging of the craniovertebral junction for further evaluation of their injuries.

Medical records for 13 of the 15 patients were reviewed. The remaining patients' charts were not available for review. Each chart was evaluated for age, sex, mechanism of injury, Glascow Coma Scale score, physical examination findings (particularly cranial nerve evaluation), and associated injuries, especially cervical spine and/or intracranial injury.

Results

A total of 15 patients with OCF were discovered (See Table). Thirteen of the 15 patients presented over a 43-month period. At our institution, approximately 3400 head CT scans are performed in the emergency department per year. Of these, it is conservatively estimated that 50% are performed in trauma patients. The exact numbers could not be retrieved. Even with this conservative estimate, it is clear that OCFs

Fifteen patients with occipital condyle fractures

Patient	Age, y/Sex	Mechanism of Injury	GCS/CHI Grade	Cervical Spine Fracture	Cranial Nerve Palsy	Associated Injury	Fracture Type	Treatment
1	33/M	MVA	14/I	None	Delayed right XII	Clavicle fracture	I	None
2	26/M	MVA	15/I	None	None	Pneumothorax, hemothorax, femur fracture	I	None
3	16/M	Fell from car	13/II	None	None	Bifrontal contusion	II	None
4	32/M	MVA	15/I	Hyperextension teardrop C-2	Right VII and XII	Forearm and rib fractures, temporal contusion, Lefort II fracture	II	None
5	53/F	MVA	8/III	None	None	Ankle fracture, SDH, SAH, contusion	II	None
6	47/F	Hit by car	15/I	None	None	Contusion, SAH, SDH, intraperitoneal hemorrhage	II	None
7	37/M	MVA	8/III	None	None	SDH, SAH, contusions	II	None
8	11/M	Hit by car	13/II	None	None	Epidural hematoma, R lower extremity fracture	II	None
9	33/M	Assault	15/I	None	None	None	II	None
10	23/M	MVA	. . .	. . .	. . .	. . .	II	. . .
11	39/M	MVA	15/I	Type II dens	Left VII	Humeral, clavicle, and rib fractures	III	Halo
12	88/M	Fall	15/I	Anterior arch C-1, type II dens	None	None	III	Halo
13	29/M	MVA	. . .	. . .	. . .	. . .	III	. . .
14	14/F	MVA	11/II	None	None	None	III	Soft collar
15	17/F	MVA	7/III	None	None	Mandible and lower extremity fractures, SDH	III	None

Note.—CHI = closed head injury; GCS = Glascow Coma Scale; MVA = motor vehicle accident; SAH = subarachnoid hemorrhage; SDH = subdural hematoma.

are rare, occurring in fewer than 1% of trauma patients. The majority of patients (11/15) were male, and ranged in age from 11 to 88 years. Most patients were either drivers or passengers involved in motor vehicle accidents (10/15). Fourteen OCFs were identified on trauma head CT scans, although none was detected prospectively on plain cervical spine radiographs. The one additional OCF (in patient 13) was detected by plain film tomography, because CT was not yet in use.

There was great variation in the severity of associated closed head injuries, with the majority of the patients having either moderate or low-grade injuries. Three (20%) of our 15 patients had cranial nerve palsies, 2 with involvement of cranial nerve XII. Seven of the 14 pa-tients examined by CT had other CT evidence of intracranial injury, including subdural hema-toma, epidural hematoma, subarachnoid hem-orrhage, and/or intraaxial contusion. Three (20%) of the 15 suffered cervical spine fracture, all involving C-2, in addition to their OCF. Two of the 3 patients had type II (high) dens frac-tures according to the classification of Anderson and D'Alonzo (29).

Type II OCFs were the most common (54%) (patients 3–10). Five (33%) of the 15 patients had type III OCF (patients 11–15), and 2 (13%) had type I OCF (patients 1 and 2). Two of the patients with type III OCF were treated with rigid cervical orthosis (halo device). These patients also had type II odontoid fractures, which would have required rigid orthosis for treatment, re-
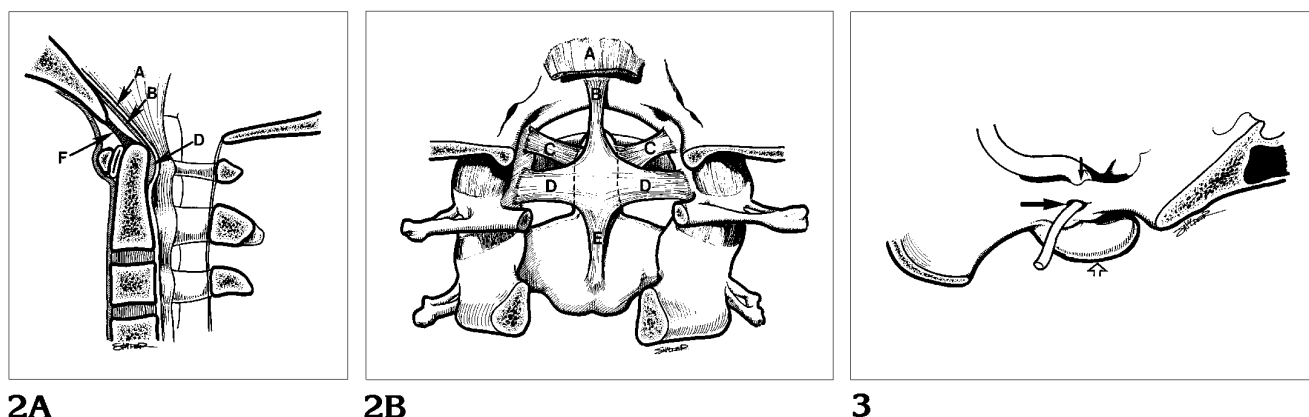
2A   **2B**   **3**

Fig 2. Sagittal (*A*) and coronal (*B*) line drawings of the craniovertebral junction (viewed from behind) show the normal ligaments of the cervicocranium. *A* = tectorial membrane; *B* = upper band (rostral crus) of the transverse atlantal ligament; *C* = alar ligaments; *D* = transverse atlantal ligament; *E* = lower band (caudal crus) of transverse atlantal ligament; *F* = apical ligament of the dens.

Fig 3. Sagittal line drawing of the skull base shows the relationship among the hypoglossal canal (*large arrow*), jugular foramen (*small arrow*), and occipital condyle (*open arrow*).

gardless of the OCF type. Two of the patients with type III OCFs were examined for stability by anteroposterior flexion and extension and lateral flexion under fluoroscopic guidance. Both were apparently stable and were subsequently treated conservatively, without untoward results.

Discussion

Normal Anatomy

The two most important ligamentous structures relative to OCFs and their stability are the tectorial membrane and the alar ligaments (3). The tectorial membrane is a strong band of longitudinally oriented fibers attached to the dorsal surfaces of the C-3 and C-2 vertebral bodies and the body of the dens. As the ligament ascends, it widens and attaches to the anterior occipital bone (Fig 2). The tectorial membrane is essentially a cephalad extension of the posterior longitudinal ligament. Its function is to check extension, flexion, and vertical translation. Hyperflexion is also checked by contact between the anterior foramen magnum and the odontoid process.

The other important structures relative to OCF, the alar ligaments, arise from the odontoid process and attach to each of the occipital condyles (Fig 2). Their function is to check lateral flexion and rotation, limiting rotation of the cranium with respect to the atlas. In adults, the alar ligaments are very strong and the bone will frequently fail before the ligaments do.

Other ligaments, of somewhat less impor-

tance, include the apical ligament of the dens and the upper band (rostral crus) of the transverse atlantal ligament. The apical ligament of the dens is a slender band of fibers extending from the tip of the odontoid process to the anterior margin of the foramen magnum (basion). Its function is to anchor the odontoid to the basion. The transverse ligament of the atlas arches across the atlas ring, maintaining the odontoid process in place relative to the anterior atlas arch. A strong band of vertical fibers (rostral crus or superior longitudinal band) extends cranially to attach to the basion, while a smaller band of fibers (caudal crus or inferior longitudinal band) extends caudally to attach to the posterior surface of the axis body (Fig 2). Collectively, the transverse atlantal ligament, the rostral crus, and the caudal crus are referred to as the cruciate ligament. The cruciate ligament limits both flexion at the craniovertebral junction and anterior displacement of the atlas.

Additional anatomic considerations pertinent to a discussion of OCFs are the proximity of the hypoglossal canal and the jugular foramen to the occipital condyle (Fig 3). Fractures of the occipital condyle may extend to involve either the hypoglossal canal, located at the base of the occipital condyle, or the jugular foramen, lateral to the condyle, causing palsy of one or more of the lower four cranial nerves (3, 4). The cranial nerve palsy may not be present immediately but may manifest months after trauma, possibly as a result of fragment migration or callus formation (24).

Fig 4. Type I OCF. Axial CT scans in a 33 year-old man who was a restrained passenger in a car hit by a truck. The patient presented with a delayed right hypoglossal nerve palsy.

A, CT scan shows comminuted fracture of the right occipital condyle with displacement and rotation of multiple fragments (*dots*).

B, CT scans shows proximity of the largest fragment (*large dot*) to the hypoglossal canal (*arrowheads*).

A   **B**
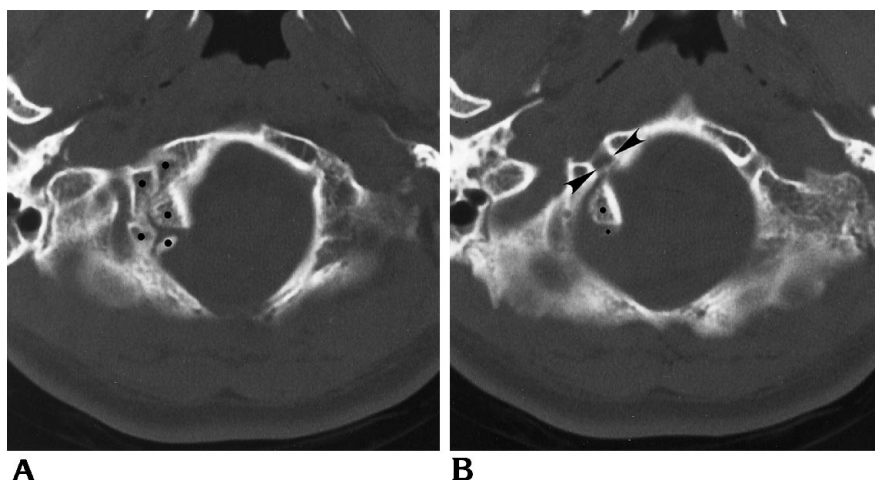
Fracture Types

OCFs have been divided into three fracture types (3) (Fig 1). Type I is an impaction-type fracture of the condyle associated with an axial load injury, although some have suggested there may be a more complex mechanism, such as an element of ipsilateral flexion (5). This results in a comminuted fracture, with or without fragment displacement (Fig 4). Type II is a basilar skull fracture that transgresses the occipital condyle (Fig 5). This injury generally results from direct trauma to the skull. Intact tectorial membrane and alar ligaments preserve stability. Type III is an avulsion fracture of the inferomedial aspect of the condyle, usually with medial displacement of the fracture fragment, associated with partial or complete disruption of the tectorial membrane and contralateral alar ligament (Fig 6). The type III fracture results from forced rotation and lateral bending. Some have suggested that the type III OCF is on a spectrum with atlantooccipital dislocation (6–9).

Treatment

Type I and II OCFs are considered stable injuries, because the tectorial membrane and contralateral alar ligament are not disrupted (3, 10, 11). Therefore, these injuries are typically treated conservatively, usually with a semiconstrained cervical orthosis. Type III OCFs are thought to result from lateral flexion and rotation, disrupting the attachment of the ipsilateral
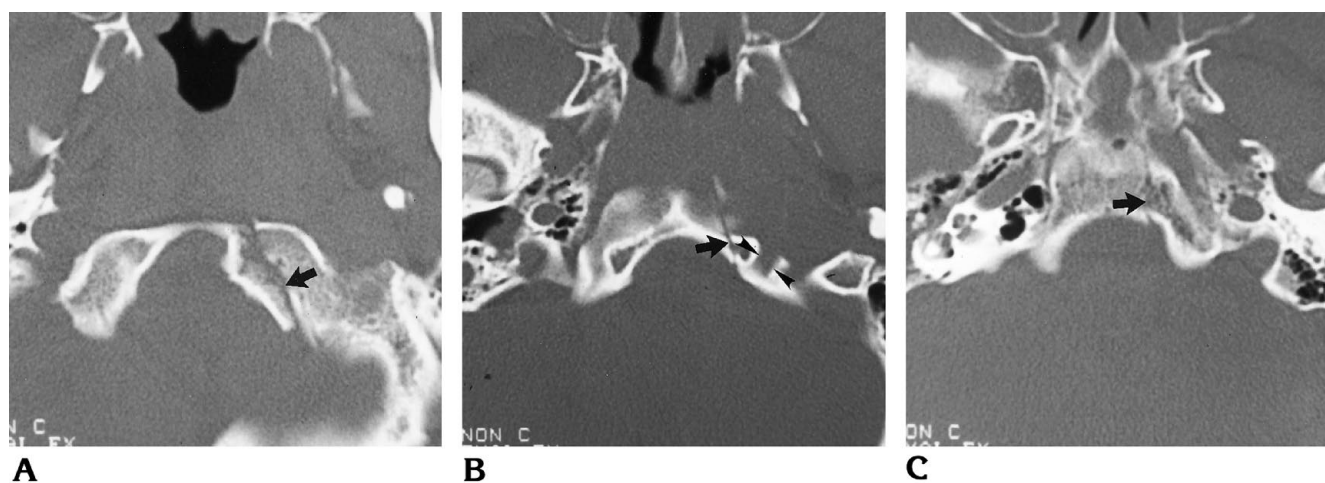
A   **B**   **C**

Fig 5. *A–C*, Type II OCF. Axial CT scans in a 32 year-old man who was driving a van at 65 mph when it ran into a tree. A skull base fracture traverses the left occipital condyle close to the left hypoglossal canal (*arrowheads* in *B*) and extends anteriorly through the clivus (*arrows*).
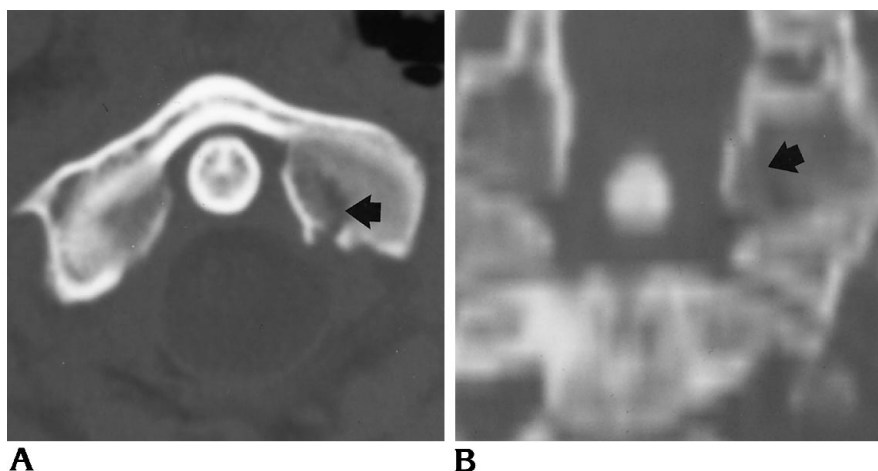
A   B

Fig 6. Type III OCF. Axial (*A*) and coronal (*B*) reformatted CT scans in a 17-year-old girl involved in a high-speed motor vehicle accident. There is an avulsion fracture of the inferomedial aspect of the left occipital condyle with minimal medial displacement (*arrows*).

alar ligament, with partial or complete disruption of the tectorial membrane and contralateral alar ligament. Therefore, they are potentially unstable injuries and may require rigid cervical orthosis (3, 5, 9–12).

Two of the five patients with type III fractures in our study were examined for stability, and both proved to be stable. It would seem reasonable to treat type III OCFs as unstable until fluoroscopic evaluation in anteroposterior flexion and extension, and lateral flexion can be performed. If the injury proves to be unstable, then rigid cervical orthosis may be required to prevent neurologic compromise. If no evidence of instability is present, these patients could likely be treated conservatively with a semiconstrained cervical orthosis.

The need for surgical therapy is controversial. There are at least three reports of surgical intervention for OCFs with mixed results (13, 14). Most believe surgery may be indicated for one of two reasons: neurovascular decompression and/or stabilization (13–16), although one group of investigators has suggested that nonsurgical therapy will suffice, even when brain stem compression is present (10).

Conclusion

Although OCFs are rare, they will be encountered by radiologists who see a significant amount of trauma. Some authors have suggested instituting a search for OCFs in the presence of unexplained neck pain, lower cranial nerve palsy, torticollis, and prevertebral soft tissue swelling, or in the setting of upper cervical spine or skull base fracture following trauma (10, 12, 14–22). In our experience, the clinical findings are inconsistent, at best; cranial nerve palsy is uncommon and additional causes of neck pain and soft tissue swelling are not uncommon. We suggest that any patient who has sustained significant trauma is at risk for OCF. Many of these patients have CT to assess for potential intracranial injury. We believe, as do others, that CT should be initiated at the ring of C-1 to include the occipital condyles (6). It would behoove radiologists to become familiar with the types of OCF and the fact that the type III fracture has the greatest propensity for instability.

References

1. Bell C. Surgical observations. *Middlesex Hospital J* 1817;4:469–470
2. Kissinger P. Luxationsfraktur im atlantooccipitalgelenke. *Zentralbl Chir* 1900;37:933–934
3. Anderson PA, Montesano PX. Morphology and treatment of occipital condyle fractures. *Spine* 1988;13:731–736
4. Bolender N, Cromwell LD, Wendling L. Fracture of the occipital condyle. *AJR Am J Roentgenol* 1978;131:729–731
5. Bettini N, Malaguti MC, Sintini M, Monti C. Fractures of the occipital condyles: report of four cases and review of the literature. *Skeletal Radiol* 1993;22:187–190
6. Mann FA, Cohen W. Occipital condyle fracture: significance in the assessment of occipitoatlantal stability. *AJR Am J Roentgenol* 1994;163:193–194
7. Bucholz RW, Burkhead WZ. The pathological anatomy of fatal atlanto-occipital dislocations. *J Bone Joint Surg (Am)* 1979;61-A:248–250
8. Adams VI. Neck injuries. I. Occipitoatlantal dislocation: a pathologic study of twelve traffic fatalities. *J Forensic Sci* 1992;37:556–564
9. Jones DN, Knox AM, Sage MR. Traumatic avulsion fracture of the occipital condyles and clivus with associated unilateral atlantooccipital distraction. *AJR Am J Neuroradiol* 1990;11:1181–1183
10. Young WF, Rosenwasser RH, Getch C, Jallo J. Diagnosis and management of occipital condyle fractures. *Neurosurgery* 1994;34:257–260

11. Bettini N, Malaguti MC, Sintini M, Monti C. Fractures of the occipital condyles: report of four cases and review of the literature. *Skeletal Radiol* 1993;22:187–190

12. Mody BS, Morris EW. Fracture of the occipital condyle: case report and review of the world literature. *Injury* 1992;23:350–352

13. Sharma BS, Mahagan RK, Bhatia S, Khosla VK. Collet-Sicard syndrome after closed head injury. *Clin Neurol Neurosurg* 1994;96:197–198

14. Bozboga M, Unal F, Hepgul K, Izgi N, Turantan I, Turker K. Fracture of the occipital condyle. *Spine* 1992;17:1119–1121

15. Spencer JA, Yeakley JW, Kaufman HH. Fracture of the occipital condyle. *Neurosurgery* 1984;15:101–103

16. Leventhal MR, Boydston WR, Sebes JI, Pinstein, ML, Watridge CB, Lowrey R. The diagnosis and treatment of fractures of the occipital condyle. *Orthopedics* 1992;15:944–947

17. Clayman DA, Sykes CH, Vines FS. Occipital condyle fractures: clinical presentation and radiological detection. *AJNR Am J Neuroradiol* 1994;15:1309–1315

18. Raila FA, Aitken AT, Vickers GN. Computed tomography and three-dimensional reconstruction in the evaluation of occipital condyle fracture. *Skeletal Radiol* 1993;22:269–271

19. Desai S, Coumas JM, Danylevich A, Hayes E, Dunn EJ. Fracture of the occipital condyle: case report and review of the literature. *J Trauma* 1990;30:240–241

20. Mariani PJ. Occipital condyle fracture presenting as retropharyngeal hematoma. *Ann Emerg Med* 1990;19:1447–1449

21. Harding-Smith J, MacIntosh PK, Sherbon KJ. Fracture of the occipital condyle. *J Bone Joint Surg (Am)* 1981;63-A:1170–1171

22. Bridgman SA, McNab W. Traumatic occipital condyle fracture, multiple cranial nerve palsies, and torticollis: a case report and review of the literature. *Surg Neurol* 1992;38:152–156

23. Deeb ZL, Rothfus WE, Goldberg AL, Daffner RH. Occult occipital condyle fractures presenting as tumors. *CT J Comput Tomogr* 1988;12:261–263

24. Orbay T, Aykol S, Seckai Z, Ergun R. Late hypoglossal nerve palsy following fracture of the occipital condyle. *Surg Neurol* 1989;31:402–404

25. Bucholz RW, Burkhead WZ, Graham W, Petty C. Occult cervical spine injuries in fatal traffic accidents. *J Trauma* 1979;19:768–771

26. Goldstein SJ, Woodring JH, Young AB. Occipital condyle fracture associated with cervical spine injury. *Surg Neurol* 1982;17:350–352

27. Stroobants J, Seynaeve P, Fidlers L, Klaes R, Brabnats K, Van Hoye M. Occipital condyle fracture must be considered in the pediatric population: case report. *J Trauma* 1994;36:440–441

28. Olsson R, Kunz R. Fracture of the occipital condyle as an incidental finding during CT-evaluation of a maxillary fracture. *Acta Radiol* 1994;35:90–91

29. Anderson LD, D'Alonzo RT. Fractures of the odontoid process of the axis. *J Bone Joint Surg (Am)* 1974;56-A:1663–1674