The forgotten condyle: the appearance, morphology, and classification of occipital condyle fractures.

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

E. R. Noble and W. R. K. Smoker

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, Glasgow 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 impact fracture of the occipital condyle. The type II OCF refers to a basilar skull fracture that extends to involve the occipital condyle. 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-
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, Glasgow 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
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 patients examined by CT had other CT evidence of intracranial injury, including subdural hematoma, epidural hematoma, subarachnoid hemorrhage, and/or intraxial 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 fractures 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-

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

Note.—CHI = closed head injury; GCS = Glasgow Coma Scale; MVA = motor vehicle accident; SAH = subarachnoid hemorrhage; SDH = subdural hematoma.
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 importance, 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).
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...
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 non-surgical 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