Complex Coronal Shear Fractures of the Distal Humerus

Howard J. Goodman, M.D., and Jack Choueka, M.D.

Abstract

This is a retrospective review of nine coronal shear fractures of the distal humerus. Two were isolated fractures and seven were associated with other peri-articular elbow injuries, termed “complex” coronal shear fractures. All cases underwent immediate open reduction and internal fixation (ORIF) and were then followed for an average of 14 months (range: 6.5 to 23 months) with outcomes evaluated using the Mayo Elbow Performance Scoring system. There was a significant difference found between injuries limited to the radiocapitellar (RC) joint (isolated coronal shear fractures, or those associated only with radial head fractures) and the complex injuries extending beyond the RC joint. Scores for the RC injuries were 100 and other complex injuries had an average score of 69 (range: 35 to 95; p = .025). All complications were limited to the group with the complex injuries, including stiffness, nonunion, pain, and gross instability. Much of the current thinking in treatment of this fracture was upheld in this study: computed tomography aids in diagnosis, ORIF is a necessity, and there is a need for anatomic reduction. When a coronal shear fracture is complicated by a concomitant injury outside the RC joint, both the surgeon’s and patient’s expectation need to be adjusted accordingly.

Coronal shear fractures of the distal humerus have recently been identified as a “new” type of fracture, with its own mechanism of injury, treatment rationale, and operative methodology. McKee,¹ in 1996, was the first to identify this fracture. It occurs with a fall from a height and results in the radial head impacting on the anterior articular cortex of the distal humerus, shearing off the capitellum and the lateral ridge of the trochlea. He described the “double arc sign” on the lateral radiograph (Fig. 1), discussed the importance of computed tomography as an aid in diagnosis, and had excellent results with all fractures following open reduction and internal fixation (ORIF). Ring and colleagues² proposed a classification for this fracture with five increasingly complex subtypes. Both investigators recommended special attention to these fractures in gaining adequate exposure, anatomic alignment, and preservation of the articular surface.

Ring’s series and subclassification illustrates that coronal shear fractures are often not isolated injuries and can occur with other associated injuries, both bony and ligamentous. Until now, there has been no recognition in the literature of coronal shear fractures with associated injuries as being a separate entity with varying diagnostic modalities and treatment rationale. The purpose of this review is to examine both isolated coronal shear fractures and more complex injuries associated with other fractures about the elbow. By investigating outcome scores and complication profiles it is believed that a difference will be found between simple and complex injuries.

Methods

Eight patients who sustained coronal shear fractures were treated between 2002 and 2004 and were subsequently followed over the next 23 months. The factors examined included patient gender, age at injury, concomitant associated injuries, time to latest follow-up examination, and functional elbow outcomes based on the Mayo Elbow Performance Score at latest follow up. All short-term and long-term complications were also recorded and assessed. The demographic data and other injury factors are listed in Table 1. As can be seen, two patients had isolated coronal...
shear fractures, and two patients had associated radial head fractures. These were considered “injuries limited to the radiocapitellar (RC) joint.” The other patients’ associated fractures are also listed.

All elbows were immediately tested for stability in the operating room and immobilized in a temporary splint. Rehabilitation was based on the injury type and stability with range of motion exercises started no later than two weeks postoperatively.

**Surgical Technique**

Operative fixation is the only reported methodology for treatment of these fractures and was the only treatment offered in this series. After presenting to the emergency department, patients underwent appropriate radiographic studies, with a CT scan often used to delineate the fracture and assist in preoperative planning. As soon as was medically feasible, the patients underwent ORIF for anatomic realignment of the distal humeral articular surface. In the more complex injuries, the concomitant injuries must also be rigidly fixed, allowing for early motion.

When injuries are isolated to the RC joint, the lateral approach to the elbow provides excellent exposure to visualize the articular surfaces. Stamatis and Imatani both approached all cases by this modified extensile lateral Kocher approach. While this might be sufficient for fixation of a simple capitellum fracture, the coronal shear fracture requires a more extensile exposure of the anterior humeral articular surface. When using the lateral approach, the lateral collateral ligament (LCL) can be released from its humeral insertion and reflected posteriorly allowing lateral subluxation of the elbow joint in order to provide excellent exposure of all articular fragments. With this approach, placement of the articular screws (see Fig. 4) and bone grafting can be more easily achieved. Upon completion of the articular reduction and repair with Acutrac™ articular screws (Acumed, Hillsboro, OR), the LCL is repaired to bone through drill holes, restoring this important elbow stabilizer. Alternatively, suture anchors can be placed in the lateral condyle for repair of the ligament.

A posterior approach was found useful in the complex injuries outside of the RC joint, especially in reducing olecranon fractures and medial column injuries. If an olecranon fracture is not present, an olecranon osteotomy is practical for getting to the joint from the posterior approach. Posterior approach without osteotomy allowing reflection to the lateral or medial aspects of the elbow is also reasonable if future procedures are anticipated.

Because of the shearing component of the injury, there was often associated bone loss found on the posterior

---

**Table 1  Patient Demographics and Injury Data, with Complications**

<table>
<thead>
<tr>
<th>Patient Number</th>
<th>Gender</th>
<th>Age (Years)</th>
<th>Other Injury</th>
<th>Time to Latest Follow-up (months)</th>
<th>Mayo Score</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>69</td>
<td>Radial Head Fracture</td>
<td>18</td>
<td>100</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>80</td>
<td>Isolated Coronal Shear Fracture</td>
<td>23</td>
<td>100</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>76</td>
<td>Radial Head Fracture</td>
<td>19</td>
<td>100</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>64</td>
<td>Olecranon fracture</td>
<td>14.5</td>
<td>35</td>
<td>Ulnar nerve paresthesias, severe pain, instability and loss of ADLs</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>33</td>
<td>Lateral Condyle Fracture</td>
<td>12.5</td>
<td>80</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>31</td>
<td>Olecranon and Lateral Condyle Fracture</td>
<td>9</td>
<td>95</td>
<td>Mild pain and moderate decreased arc of motion</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>76</td>
<td>Medial Column Fracture</td>
<td>9.5</td>
<td>65</td>
<td>Moderate decreased arc of motion</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>18</td>
<td>Isolated Coronal Shear Fracture</td>
<td>6.5</td>
<td>100</td>
<td>Ulnar nerve paresthesias, painful hardware</td>
</tr>
<tr>
<td>Average Female</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td>14</td>
<td>84.4</td>
</tr>
</tbody>
</table>

*Patient was converted to a total elbow arthroplasty; ‡Patients underwent return trip to the operating room
aspect of the fracture fragment. With articular reduction of the fragment, a large defect was often found in this area. Bone graft was used to elevate the fracture fragment, without which the subsidence of the fragment would have led to alterations in joint congruity and elbow instability. Figure 4 illustrates the need for and location of the bone graft.

Following reduction and fixation, all elbows are examined under anesthesia for stability and then placed in immobilization.

**Patient Assessment**

At the time of the follow-up examinations, the Mayo Elbow Performance Score was used to quantify the outcome of the surgery and fixation. The Score is based in four domains: Pain (none, mild, moderate, and severe for a total of 45 points), Motion (total arc of less than 50º, 50º to 100º, and more than 100º for a total of 20 points), Stability (stable, moderately unstable, grossly unstable for a total of 10 points), and Function (25 points). The total (and highest) score is 100 points. 

**Analysis**

Regression analysis was then carried out between the cases with and without concomitant injuries. Groups were also compared between those with injuries limited only to the RC joint and injuries outside of the joint. Student’s t-test for two-variables and ANOVA (Analysis of Variance) was used to compare the two groups.

**Results**

Mayo scoring showed that patients with isolated fractures and those with concomitant radial head fractures had scores of 100, with little to no pain, full functioning, normal to nearly normal range of motion, no instability, and no disability in their activities of daily living. The other patients with more complex injuries had varying scores from 35 to 95 points. One patient, scoring 35 points, had gross instability, severe pain, and inability to do any of her activities of daily living. This patient failed initial ORIF and was later converted to a total elbow arthroplasty.

Between all of the patients, the average elbow score was 84 points. Those injuries limited to the RC joint had excellent outcomes, all scoring 100, while the other four patients fared worse with a mean of 69 points. Regression showed a significant difference between the four patients with only RC involvement as opposed to those extending beyond the RC joint (p = .025). Figure 2 shows the individual Mayo scores.

Complications were found only in the group with injuries extending beyond the RC joint and are listed by patient number in Table 1. Two patients were taken back to the operating room, one for removal of painful hardware associated with paresthesias, and one who was progressed to a total elbow replacement to address gross instability and pain.

**Discussion**

**Diagnosis**

Coronal shear fractures of the distal humerus have been gaining increasing recognition in the literature. Differentiation from the classic capitellum fracture is essential in both diagnosis and treatment. Historically, capitellum fractures have been subdivided into three types:

Type I, the Hahn-Steinthal fracture, involves a large part of the capitellum and rarely extends medially into the trochlea; Type II, or the Kocher-Lorenz fracture, has very little subchondral bone attached to the fracture fragment; and Type III is a fracture with severe comminution of the distal fragment. Treatment options for the three types include closed reduction, excision, or ORIF.

McKee proposed a new type of fracture at the distal humerus, the “Coronal Shear Fracture.” This fracture has recently been subdivided into five categories, with increasingly complicated peri-articular injuries. The pathognomonic lesion of this fracture is extension beyond the capitellum into the trochlear ridge, giving rise to both of the double arcs seen on the lateral radiographs of the elbow (see Fig. 1). The larger arc is the subchondral bone of the capitellum and the smaller is the lateral ridge of the trochlea. The double arc sign should be the surgeon’s first indicator of this injury, differentiating it from a capitellum fracture. Computed tomography is also helpful in diagnosis, especially in its ability to see the extension into the trochlea and comminution of the fragments. This current series also demonstrated the unique ability of CT scanning with three-dimensional reconstruction to show fragment morphology and positioning (Fig. 3).

In addition to diagnostic differences, treatment for coronal shear fractures can differ from capitellum fracture. While there is a role for fragment excision in certain capitellum fractures with very little subchondral...
bone remaining (as in Type II fractures), or even closed reduction in some Type I fractures, coronal shear fractures offer no such option. With extension into the lateral trochlea, failure to obtain an anatomic reduction will lead to instability and marked joint incongruity. Furthermore, in our current series, the fragments were often found displaced and rotated beyond the joint, making this a fracture-dislocation with its inherent instability and potential complications. Without fastidious attention to the type of fracture, misdiagnosis as a simple capitellum fracture may lead to incorrect treatment planning and poor patient outcome.

**Patient Outcomes**

The current series of patients had results that were similar to those previously published. Patients, in general, had good outcomes. All patients with isolated coronal shear fractures or even coronal shear fractures with associated radial head fractures had Mayo scores of 100. More complex injuries, with peri-articular injuries extending outside the RC joint, resulted in worse outcomes, scoring a mean of 69. Furthermore, complications occurred only in the complex group outside of the RC joint. While there appear to be many complications, it should be noted that patient 4, (with the lowest Mayo score) had many of the complications, including, pain, paresthesias, and gross instability. Her lateral injury film (Fig. 5) shows the extent of her injuries. This patient was returned to the operating room and converted to an elbow arthroplasty.

As with all other reports in the literature, this current series shows excellent outcomes associated with immediate ORIF of coronal shear fractures, even when associated with radial head fractures. However, it also illustrates that even with proper diagnosis and treatment more complex peri-articular injuries do not achieve the outcomes of the lower energy isolated fractures.

One limitation of this study was the small number of patient observed. With increasing recognition and differentiation of this type of fracture from capitellum fractures, larger numbers are likely to be reported. Furthermore, the average follow-up in this series was 14 months. While it is clear that complications such as pain and instability show up early, longer follow-up is essential to assess the development of posttraumatic arthritis.

With the realization that the coronal shear fracture previously described can now be thought of as either simple or complex, several conclusions are evident. Concurring with previous studies, special attention needs to be given to the “double arc” sign on the lateral radiographs, while investigating any concomitant injuries about the elbow. Computed tomography is useful in both showing the extent of associated complex injuries as well as showing the morphology of the intra-articular fracture fragments. Accurate diagnosis is essential, because simple or complex, there is no role for nonoperative treatment or fragment excision in any coronal shear fracture, and this fracture can have devastating effects on the elbow. Surgical fixation of the inter-articular fragments may
need to be supported by bone graft posterior to the fracture fragment. Lastly, both patient and practitioner must have lower expectations for the complex injuries extending outside of the RC joint, with a mind toward more potential complications. Accurate diagnosis, adequate radiography, anatomic surgical reconstruction, and appropriate expectations will help the orthopaedic surgeon and the patient best handle this complex injury.

References