Coronal shear fracture of the humeral trochlea

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ABSTRACT

Purpose. To review records of 5 patients with anterior coronal trochlear fractures.

Methods. Four men and one woman aged 25 to 46 (mean, 34) years underwent cancellous screw (n=3) or Kirschner wire (n=2) fixation for anterior coronal fractures of the humeral trochlea after falling on a flexed elbow. Patients were operated on through a medial approach. Three patients who had a large osteochondral fragment underwent fixation using 4-mm AO partially threaded cancellous screws. Two patients who had a small un-amenable osteochondral fragment (with articular cartilage damage) underwent fixation using Kirschner wires. Patients were evaluated using the Mayo Elbow Performance Index (MEPI) based on pain, arc of motion, stability, and functional disability.

Results. The mean time from injury to surgery was 7 (range, 5–10) days. The mean follow-up period was 2.7 years. No patient had any wound-related problems, postoperative neurovascular compromise, or avascular necrosis. Radiographic union was noted after a mean of 14 weeks. Outcome was excellent in 4 patients and good in one. The mean arc of flexion-extension was 101º and the mean arc of supination-pronation was 130º. The mean MEPI was 92. The MEPI was relatively low in the 2 patients with a small osteochondral fragment who underwent Kirschner wire fixation. One patient with articular cartilage damage developed mild degenerative changes and had to change his occupation. The remaining 4 patients were pain-free and had returned to their occupations within 4 months.

Conclusion. Open reduction and screw fixation restores articular congruency and enables early mobilisation. Small coronal shear fractures of the trochlea not amenable to screw fixation should be fixed with Kirschner wires.

Key words: bone screws; bone wires; elbow joint; humeral fractures

INTRODUCTION

Coronal shear fractures of the distal humerus usually involve the capitellum and a variable part of trochlea.1
The trochlea rarely fractures in isolation, because it has no muscular or ligamentous attachments, and the ulnohumeral joint is not subjected to shear force, which is a common mechanism of injury in the radiocapitellar joint. Because of its deep location within the elbow joint, the trochlea is inaccessible to direct trauma. The isolated fracture of the trochlea (also known as Laugier’s fracture) is rare and usually associated with elbow dislocation, ligamentous injuries, capitellar fracture, radial head fracture, and/or olecranon fracture. There is no consensus about its management, which is based on transarticular distal humeral fractures. Posterior splint immobilization for 3 weeks is recommended if the fracture is undisplaced. If there are small unamenable osteochondral fragments, excision followed by early elbow movement is the treatment of choice. Displaced fractures should be anatomically reduced to restore articular congruency, using headless Herbert screws or bioabsorbable screws. We reviewed records of 5 patients with anterior coronal trochlear fractures.

**MATERIALS AND METHODS**

Between 2004 and 2010, 4 men and one woman aged 25 to 46 (mean, 34.2) years underwent cancellous screw (n=3) or Kirschner wire (n=2) fixation for isolated anterior coronal fractures of the humeral trochlea after falling on a flexed elbow in a prone position. The patients presented with a painful swollen elbows with restriction of movements. The medial aspect of the elbow joint was tender, but no tenderness was elicited on the lateral aspect. There was no distal neurovascular deficit. Anteroposterior radiographs of the elbow joint did not reveal any bony injury, but lateral radiographs revealed a semilunar trochlear fragment that was displaced anterosuperiorly (Figs. 1–3). Computed tomography with 3D reconstruction showed an isolated coronal trochlear fracture with an intact posterior bony ridge (Figs. 1 and 2). No associated elbow dislocation or radial head or neck fracture was detected.

Patients were operated on through a medial approach in the supine position under general anesthesia. A ‘half-moon-shaped’ trochlear fragment lying anteriorly, a humeral trochlear fracture and a chip fracture of the coronoid process, and bone union without any degenerative changes one year after open reduction and internal fixation with 4-mm AO-partially threaded cancellous screws.

**Figure 1** (a) A ‘half-moon-shaped’ trochlear fragment lying anteriorly, (b) a humeral trochlear fracture and a chip fracture of the coronoid process, and (c) bone union without any degenerative changes one year after open reduction and internal fixation with 4-mm AO-partially threaded cancellous screws.

**Figure 2** (a) A coronal shear fracture of the trochlea, (b) a small osteochondral trochlear fracture, and (c) bone union with mild degenerative changes 3 years after fixation with Kirschner wires.
anaesthesia. A curved 10 to 12 cm long incision over the medial epicondyle was made, and the medial antibrachial cutaneous nerve was protected. Dissection was made between the brachialis and triceps proximally, and between the brachialis and pronator teres distally. If necessary, a part of the flexor/pronator origin was detached from the medial epicondyle and the capsule was incised to expose the anterior surface of the distal humerus. The anterior osteochondral trochlear fragment was displaced superiorly, and the posterior part of the trochlea was intact and its anatomic relation with the remaining part of the distal humerus was maintained. Three patients who had a large osteochondral fragment underwent fixation using 4-mm AO partially threaded cancellous screws. The heads of the screws were buried inside the articular surface. Two patients who had a small un-amenable osteochondral fragment (with articular cartilage damage) underwent fixation using Kirschner wires. The Kirschner wires were cut close to the articular surface or kept exposed to the skin surface for future removal. The elbow joint was then examined for any ligamentous instability.

In patients with screw fixation, a broad arm sling was applied for 2 weeks. Elbow mobilisation was allowed as soon as the pain and swelling subsided (at day 2 or 3). In patients with wire fixation, a back slab was used for 3 weeks. Gradual mobilisation was started after its removal. At week 4, Kirschner wires were removed in one patient (Fig. 3). All patients were followed up at week 6, month 3, month 6, year 1, and then annually. They were assessed for pain, range of motion, and return to work. Functions were evaluated using the Mayo Elbow Performance Index (MEPI) based on pain, arc of motion, stability, and functional disability. Scores of >90 were considered excellent, 75 to 89 as good, 60 to 74 as fair, and <60 as poor.

**RESULTS**

The mean time from injury to surgery was 7 (range, 5–10) days. The mean follow-up period was 2.7 years. No patient had any wound-related problems, postoperative neurovascular compromise, or avascular necrosis. Radiographic union was noted after a mean of 14 weeks. Outcome was excellent in 4 patients and good in one (Table). The mean arc of flexion-extension was 101º and the mean arc of supination-pronation was 130º. The mean MEPI was 92. The MEPI was relatively low in the 2 patients

<table>
<thead>
<tr>
<th>Sex/age (years)</th>
<th>Dominant extremity</th>
<th>Fixation</th>
<th>Follow-up (years)</th>
<th>Range of motion (flexion-extension arc)</th>
<th>Mayo Elbow Performance Index score</th>
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<tr>
<td>M/29</td>
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<td>4-mm AO screws</td>
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<td>85</td>
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<tr>
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<td>95</td>
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<tr>
<td>M/46</td>
<td>No</td>
<td>Kirschner wires</td>
<td>2.6</td>
<td>20º–120º</td>
<td>90</td>
</tr>
</tbody>
</table>

Figure 3  (a) A trochlear fracture (the ‘double arc’ sign on the lateral radiograph), (b) open reduction and internal fixation with Kirschner wires, and (c) bone union with no evidence of osteonecrosis or degenerative changes after one year.
with a small osteochondral fragment who underwent Kirschner wire fixation.

One patient with articular cartilage damage developed mild degenerative changes and had to change his occupation owing to pain after heavy manual work (Fig. 2). The remaining 4 patients were pain-free and had returned to their occupations within 4 months.

DISCUSSION

Isolated trochlear fractures are rare because the trochlea is well shielded within the olecranon process of the ulna, unlike the capitellum which is subject to shear forces. Axial loads directed along the radial shaft produce a tangential force on the capitellum causing a vertical shear fracture or an isolated fracture of the capitellum. Isolated trochlear fractures occur as a result of axial loading when the elbow is in extension, such as a fall on an outstretched hand, and the force transmits through the palm and along the ulna. A role of varus stress with axial loading in isolated trochlear fractures is also suggested. In our patients, the force was transmitted axially through the wedge-shaped trochlear ridge during a fall on a flexed elbow. It is unclear what caused the trochlear rather than the entire articular capitellotrochlear block to fracture. As the anterior part of the trochlea is subjected to the force from the coronoid process of the ulna in a flexed-elbow position, it selectively causes the coronal shear fracture of the trochlea. In coronal shear fractures of the distal humerus after a fall on an outstretched hand, the radial head and coronoid impact the distal articular surface and shear off a variable amount of the osteochondral surface of the distal humerus.

Regarding the classification of capitellar fractures, type 1 (Hahn-Steinthal) involves the entire anterior capitellum, type 2 (Kocher-Lorenz) involves the entire anterior cartilaginous surface, and type 3 refers to a comminuted fracture. In addition, type 4 indicates an extension into the lateral trochlea. In another classification, type 1 involves the capitellum alone, type 2 involves both the capitellum and lateral trochlea, and type 3 involves the entire distal articular surface with comminution. Nonetheless, both classifications do not include the isolated anterior trochlear fractures, which should be regarded as type 4, as they have a different injury mechanism, management principles, and prognosis. Based on fracture morphology, isolated trochlear fractures can be classified as complete or anterior coronal fractures. Axial loading in an extended elbow best explains the complete fracture, whereas axial loading on the anterior part of the trochlea in a flexed elbow attributes to anterior coronal trochlear fractures (with anterior osteochondral fragments).

It is difficult to detect isolated trochlear fractures on anteroposterior radiographs. Lateral radiographs may show a half-moon-shaped osteochondral fragment, which is difficult to differentiate from capitellar fractures. Correlation of irregularities at the trochlear-olecranon articulation on anteroposterior radiographs may indicate the trochlear fracture. Computed tomography outlines the fracture pattern and helps to rule out other bony injury, but cannot reveal the articular cartilage damage, which is a major predictor of outcome.

The medial approach enables a good visualisation of the anteromedial aspect of the distal humerus for fixation of trochlear and/or medial epicondylar fractures. It avoids the need for the more extensive posterior approach combined with olecranon osteotomy. The lateral approach has limited exposure and cannot fix fractures extending into the capitellum. Therefore, preoperative computed tomography is essential. For fractures involving the capitellum with a part of trochlea, the lateral approach or the posterior approach with an olecranon osteotomy is recommended. The trochlear fractures can be fixed using the olecranon osteotomy, which many surgeons may be familiar with. The medial approach enables direct access to the trochlear fracture (particularly anterior coronal fractures), preserves the blood supply, and avoids additional surgical morbidity and complications from olecranon osteotomy. The vascular supply to the trochlea is through its posterior surface. Thus, the posterior approach may disrupt these vessels and increase the risk of avascular necrosis. In anterior coronal trochlear fractures, the posterior part of the trochlea remains intact and vascularity is preserved, unlike what prevails in complete trochlear fractures.

The trochlea is an articular surface of the elbow joint and acts as a pulley on which hinged motion of the ulnohumeral joint occurs. Non-operative treatment or excision of coronal shear fractures leads to stiffness or instability of the elbow joint. In a cadaveric study, trochlear excision leads to considerable instability of the elbow joint. Both the capitellum and trochlea have an important role in stability; excision of the trochlea results in multiplanar instability of the ulnohumeral and radiocapitellar joints. Excision of an irreparable capitellum fragment may be considered if collateral ligaments are intact, but excision of some or all of the trochlea is not recommended. Stable internal fixation using various materials including Kirschner
wires or AO-compression screws combined with early range of motion exercises can achieve optimal results.\textsuperscript{7,8,11,15} The mode of fixation largely depends on the fragment size and comminution. Screw fixation enables rigid stability and early movement. Wire fixation can fix small osteochondral fragments not amenable to screw fixation. Postoperative movement is delayed to allow fracture healing. The prognosis of coronal trochlear fractures is poor when there is articular cartilage damage (particularly small coronal osteochondral fractures).\textsuperscript{6}

Associated osteochondral damage, inability to achieve rigid fixation, and delayed rehabilitation are responsible for the poorer outcome in coronal shear fractures of the humeral trochlea. Posterior comminution in transarticular fractures is also associated with poorer outcome, because there is a higher chance of nonunion, malunion, and damage to the posterior vascular supply. The outcome of anterior coronal trochlear fractures is expected to be better than that of complete trochlear fractures, because the posterior bony ridge of the trochlea remains intact, unless there is severe articular cartilage damage.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES