

# Coronoid Fracture Patterns

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**Purpose:** It has been suggested that specific types of coronoid fractures are associated strongly with specific patterns of traumatic elbow instability. This hypothesis was tested in a review of a large consecutive series of patients with a fracture of the coronoid as part of a fracture–dislocation of the elbow.

**Methods:** One surgeon repaired 67 coronoid fractures as part of a fracture–dislocation of the elbow over a 7-year period. Each coronoid fracture was characterized on the basis of surgical exposure. Pearson chi-square analysis was used to evaluate the association of the coronoid fracture type with 1 of 4 common patterns of elbow fracture–dislocation.

**Results:** The coronoid fracture was associated with an anterior (6 patients) or posterior (18 patients) olecranon fracture–dislocation in 24 patients, an elbow dislocation and radial head fracture in 32 patients, and a varus posteromedial rotational instability pattern injury in 11 patients. Among the 24 patients with olecranon fracture–dislocations 22 had large coronoid fractures and 2 had small (<50%) coronoid fractures. All 32 patients with terrible-triad injuries had small (<50%) coronoid fractures with 1 of these being a fracture of the anteromedial facet of the coronoid. Among patients with varus posteromedial rotational pattern injuries 9 had small fractures of the anteromedial facet and 2 had larger fractures. The association of coronoid fracture type with injury pattern was strongly statistically significant for both classification systems.

**Conclusions:** The following strong associations were confirmed by this study: large fractures of the coronoid process with anterior and posterior olecranon fracture–dislocations, small transverse fractures with terrible-triad injuries, and anteromedial facet fractures with varus posteromedial rotational instability pattern injuries. An awareness of these associations and their exceptions may help guide the optimal management of these injuries. (*J Hand Surg* 2006;31A:45–52. Copyright © 2006 by the American Society for Surgery of the Hand.)

**Type of study/level of evidence:** Therapeutic, Level IV.

**Key words:** Coronoid, elbow, fracture, injury patterns.

When Regan and Morrey<sup>1</sup> studied coronoid fractures in 1989 they analyzed fragment size and noted that larger fractures were associated with worse results, albeit in patients treated nonsurgically. Since that time it has been noted that large coronoid fractures usually are associated with fracture–dislocations of the olecranon and relatively good results are achieved after successful repair.<sup>2,3</sup> In contrast some injuries associated with small coronoid fractures (eg, the so-called terrible triad: dislocation of the elbow associated with fractures of the radial head and coronoid) and varus posteromedial rotational pattern injuries can be challenging to treat effectively.<sup>4–8</sup> It also has been recognized that coronoid fractures and elbow fracture–dislocations both occur in identifiable patterns and the hypothesis has been offered that specific coronoid

fracture patterns are associated with specific patterns of fracture–dislocation.<sup>8,9</sup> We studied this hypothesis by analyzing a consecutive series of patients with traumatic elbow instability treated by a single surgeon.

## Materials and Methods

Between 1997 and 2004 a single surgeon performed surgery on 66 consecutive patients with 67 fractures of the coronoid as part of a fracture–dislocation of the elbow. The medical records and radiographs were reviewed under a protocol approved by our Human Research Committee.

### Patient Demographics

There were 43 men and 23 women with an average age of 48 years (range, 18–85 y). The left arm was involved

in 32 patients (including 3 left-handed patients) and the right in 35 patients (including 18 right-handed patients). Thirty-eight patients were injured in a fall from a standing height; 20 patients were injured in a fall from a greater height, down stairs, or during sports participation; and 9 patients were injured in a motor vehicle collision. Six patients had open fractures including 5 of 6 patients with anterior olecranon fracture–dislocations and 1 patient with a posterior olecranon fracture–dislocation. According to the system of Gustilo and Anderson,<sup>10,11</sup> 2 fractures were type I, 3 were type II, and 1 was a type IIIA injury. Two patients had concomitant compartment syndrome on presentation and 2 patients presented with associated carpal tunnel syndrome.

Fifty-two patients had avulsion of the lateral collateral ligament from the lateral epicondyle. All 32 patients with a terrible-triad pattern injury and all 18 patients with posterior olecranon fracture–dislocations had an associated radial head fracture, classified according to Mason<sup>12</sup> as type 2 (involving part of the head) in 27 patients and as type 3 (a comminuted fracture involving the entire head) in 23 patients.

Twelve patients had ipsilateral upper-extremity injuries including 5 fractures of the distal radius (1 with a concomitant fracture of the scaphoid), 2 perilunate fracture–dislocations of the wrist (1 trans-scaphoid), 1 scaphoid fracture, 1 triquetral fracture, 1 fracture of the diaphyseal radius, 1 fracture of the diaphyseal ulna, and 1 rotator cuff injury. Nine patients had injuries to the contralateral arm including 5 fractures of the distal radius (1 with a concomitant fracture of the scaphoid), 1 contralateral elbow fracture–dislocation (the patient with bilateral coronoid fractures), 1 contralateral posterior Monteggia injury, 1 fracture of the radial head, and 1 patient with fractures of the clavicle and scapula. Twelve patients had injuries to the head, chest, abdomen, or leg.

#### Patterns of Elbow Fracture–Dislocation

The injuries were classified into 1 of 4 patterns of elbow fracture–dislocation: (1) anterior or transolecranon fracture–dislocation (Fig. 1A), defined as a fracture of the olecranon with anterior displacement of the forearm and an intact radial head<sup>2,13</sup>; (2) posterior olecranon fracture–dislocation (Fig. 1B) or type A posterior Monteggia injury according to the system of Jupiter et al.,<sup>14</sup> defined as a fracture of the olecranon and coronoid process with posterior displacement of the radius and fracture of the radial head; (3) the terrible-triad fracture–dislocation of the elbow (Fig. 1C, 1D), defined as a posterior dislocation of the elbow with fractures of the radial head and the coronoid process<sup>15</sup>; and (4) varus posteromedial rotational instability (Fig. 1 E–G), defined as a varus subluxation of the elbow with fracture of the coro-

noid (associated injuries may include the lateral collateral ligament or a fracture of the olecranon).<sup>8</sup>

#### Classification of Coronoid Fractures

The coronoid fractures were evaluated using standard radiography in all patients and with computed tomography in 22 patients (with 3-dimensional reconstructions in 12 patients), but ultimately the fractures were characterized based on surgical exposure. The fractures were classified according to the systems of Regan and Morrey<sup>1</sup> (excluding A and B subtype classifications that indicate the presence or absence of associated elbow dislocation)<sup>1</sup> and the fracture types (but not the subtypes) described by O'Driscoll et al.<sup>8</sup>

Regan and Morrey<sup>1</sup> classified coronoid fractures based on the size of the fragment: type I involves avulsion of the tip of the coronoid process, type II involves a single or comminuted fragment involving 50% of the process or less, and type III involves a single or comminuted fragment involving more than 50% of the process (Fig. 2).<sup>1</sup> Because the definitions of type I and type II are relatively vague they are open to interpretation. Because anatomic studies have shown that the capsule inserts an average of 5 mm distal to the tip of the coronoid<sup>16</sup> we considered any fracture that included the capsular insertion to be more than just the tip and therefore a type II fracture.

O'Driscoll et al.<sup>8</sup> suggested classifying coronoid fractures as follows: type 1 involves transverse fractures of the tip of the coronoid, type 2 involves a fracture of the anteromedial facet of the coronoid process, and type 3 involves a fracture of the coronoid at its base (Fig. 3).

The lateral collateral ligament was assessed in all of the terrible-triad, varus posteromedial, and posterior olecranon fracture–dislocation injuries but was not explored routinely in anterior olecranon fracture–dislocations.

#### Statistical Analysis

Pearson chi-square analysis was used to evaluate the association between the overall pattern of the elbow fracture–dislocation and the classification of the fracture of the coronoid process of the ulna according to the system of Regan and Morrey<sup>1</sup> and that of O'Driscoll et al.<sup>8</sup> A 2-tailed p value of less than .05 was considered statistically significant. This corresponds to a chi-square test statistic greater than 7.81 (3 *df*) and 12.59 (6 *df*).<sup>17</sup> Data analysis was conducted using statistical software (SPSS software package version 12.0; SPSS Inc., Chicago, IL). Power analysis showed that a minimum sample size of 6 patients in each of the 4 injury pattern groups would provide 80% power to detect an association

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