Complex distal humerus trauma

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CHAPTER 3
Complex Fractures of the Medial Column
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Abstract

Purpose: Medial column fractures of the distal humerus are uncommon in adults. Among 26 patients identified in the English language literature, only 2 had articular fragmentation. We reviewed the experience of 2 trauma centers with isolated medial column fractures to evaluate our impression that these fractures often involve complex articular fragmentation.

Methods: There were 10 men and 4 women with an average age of 61 years (range, 44–86 years). The incidence was 3% of all distal humerus fractures at one institution with a prospective fracture database. The mechanism of injury was a fall from standing height in most patients. There was one B2.1 fracture, 3 B2.2 fractures, 9 B2.3 (multifragmentary), and 1 C3.2 fracture. All patients were treated surgically; 7 were treated with an olecranon osteotomy. Eight patients had 1 or more postoperative complications and 5 patients underwent subsequent surgeries.

Results: We observed 11 patients for an average of 8 years (range, 14 months to 21 years). The arc of ulnohumeral motion averaged 92°, average flexion was 118°, and average flexion contracture was 25°. According to the Broberg and Morrey Functional Rating Index, the result was excellent in 4 patients, good in 6, and fair in 1. Six patients had arthrosis (3 grade 1 and 3 grade 2) according to the radiographic criteria of Broberg and Morrey.

Conclusions: Surgeons should be aware that the relatively uncommon medial column adult distal humerus fracture usually features complex articular fragmentation, but that satisfactory results can be obtained after open reduction and internal fixation.

Type of study/level of evidence: Therapeutic IV.

Key words: Distal humerus; medial column; trauma
Background
Fractures involving the medial column of the distal humerus alone (ie, in which the lateral column remains intact; sometimes referred to as medial condyle fractures) are relatively uncommon, particularly in adults. Single column (unicondylar) fractures have been estimated to account for 3% to 5% of distal humeral fractures, or 21% of intra-articular distal humerus fractures. The lateral column is fractured more frequently than the medial column. We identified a total of 26 adult patients with a fracture of the medial column of the distal humerus reported in the English language literature, mostly in the form of case reports or small case series with a maximum of 7 patients in a single series. Only 2 of those fractures were noted to have articular fragmentation.

Considering the lack of published data available to help guide management of medial column fractures of the distal humerus in adult patients, in combination with our impression that these fractures often involve complex articular fragmentation, which may have been underrecognized in the past, we reviewed the experience of two level 1 trauma centers with medial column fractures. The purpose of this article is to document their presentation, fracture patterns, and prognosis.

Materials and Methods
Since 1974, all patients undergoing surgical fracture treatment at one of our institutions have been entered in a prospective database. Among a total of 173 distal humerus fractures entered during this time period, only 4 fractures were classified as type 13-B2, a medial column fracture according to the comprehensive classification of fractures of long bones, which represents 2.3% of distal humerus fractures, or 1 patient every 8.5 years (Fig. 1).

At the second institution, between 1997 and 2007, 2 surgeons treated an additional 10 patients with fractures of the medial column of the distal humerus, many of whom had been referred from other institutions. The medical records were reviewed under a protocol approved by the human research committee at each institution. Four patients returned for a free research-specific follow-up evaluation including radiographs, and the remaining 10 patients were evaluated from the medical record alone. The functional results are reported for the 11 of 14 patients who were evaluated a minimum of 10 months after injury. Injury characteristics are reported for all 14 patients.

There were 4 women and 10 men with an average age of 54 years (range, 22–79 years). The fractures occurred in 7 right elbows (4 dominant) and 7 left elbows (none dominant). At the time of the injury, 5 patients defined their occupation as desk-based work, 3 were laborers, 2 were unemployed, 3 were retired, and 1 had an unknown employment status. Of the 14 patients, 11 were evaluated for an average of 8 years (range, 14 months to 21 years).

The mechanism of injury was a fall from standing height in 8 patients (2 involving a slip on ice); a bicycle crash in 3 patients; and a motor vehicle crash, a crush
injury, and an attempted suicide by jumping in front of a train each in a single patient. One fracture was associated with an open wound (rated type 3 according to Gustilo and Anderson)\textsuperscript{16} with a brachial artery rupture. Three patients had associated ipsilateral elbow fractures: one had a posterior Monteggia-type fracture-dislocation of the proximal ulna\textsuperscript{17}, one an olecranon fracture, and one an anteromedial coronoid facet fracture. Two patients had an ipsilateral fracture of the distal radius, and one an ipsilateral fracture of the proximal humerus (Table 1).

We classified the fractures of the distal humerus based on their injury radiographs and intraoperative findings, according to the comprehensive classification of fractures of long bones\textsuperscript{15}. One patient had a subgroup B2.1 fracture, a nonfragmented transtrochlear fracture (Milch I\textsuperscript{7}). Three patients had a subgroup B2.2 fracture, a nonfragmented fracture of the medial column exiting between the trochlea and the capitellum (ie, the entire trochlea was part of the fracture fragment: Milch II). Nine patients had a subgroup B2.3 fracture, a multifragmentary transtrochlear fracture, and 1 patient had a subgroup C3.2 fracture, a complete articular multifragmentary, metaphyseal wedge fracture, which involved the medial column and the lateral articular surface, but not the lateral column (fig. 1, fig. 2 and fig. 3).
FIGURE 1. A 22-year-old male fractured his right, nondominant distal humerus in a bicycle crash. A The original anteroposterior radiograph taken just after injury (left), and anteroposterior (center) and lateral (right) radiographs immediately after open reduction and internal fixation. B An anteroposterior radiograph obtained 22 years after injury shows healing with the original postoperative malalignment (likely related to fracture complexity), but no avascular necrosis. C Lateral radiograph shows mild arthrosis. He had motion from 10° to 120° of flexion and works as a police officer.
<table>
<thead>
<tr>
<th>Case</th>
<th>Gender, Age (yr)</th>
<th>Fracture type</th>
<th>Treatment</th>
<th>Complication</th>
<th>Additional surgery</th>
<th>Duration of Follow-up</th>
<th>Extension (deg)</th>
<th>Flexion (deg)</th>
<th>Broberg and Arthrosis</th>
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<td>ORIF</td>
<td>Ulnar Neuropathy</td>
<td></td>
<td></td>
<td>18.2</td>
<td>40</td>
<td>120</td>
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<td></td>
<td></td>
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<td>157</td>
<td>35</td>
<td>120</td>
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<td>ORIF</td>
<td>Contracture</td>
<td>Capsulectomy and implant removal</td>
<td></td>
<td>73</td>
<td>20</td>
<td>95</td>
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<td>ORIF</td>
<td></td>
<td></td>
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<td>20</td>
<td>120</td>
<td>Good 0</td>
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<td>External Fixator à ORIF</td>
<td>Infection, heterotopic ossification and wound defect</td>
<td>Irrigation and debridement, skin graft, excision of heterotopic ossification and hardware removal</td>
<td></td>
<td>14.3</td>
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<td>Implant removal</td>
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<td>19.3</td>
<td>20</td>
<td>110</td>
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<td>9</td>
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<td>ORIF</td>
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<td></td>
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<td>ORIF</td>
<td>Ulnar Neuropathy</td>
<td></td>
<td></td>
<td>258.1</td>
<td>21</td>
<td>119</td>
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<td>13</td>
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<td></td>
<td></td>
<td></td>
<td>251.1</td>
<td>10</td>
<td>122</td>
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<td>14</td>
<td>F, 73 B2.3</td>
<td>ORIF</td>
<td>Urosepsis and non-union</td>
<td>ORIF nonunion</td>
<td></td>
<td>79.9</td>
<td>34</td>
<td>118</td>
<td>Good 2</td>
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</table>

ORIF, open reduction and internal fixation
**Treatment**
The average duration between the injury and surgery was 4 days (range, 0–11 days). Thirteen patients were initially treated with plate or screw fixation, or both. One patient with an open wound was initially stabilized with an external fixator and then converted to plate and screw fixation 5 days later. In 1 patient, a severe traumatic wound was used for exposure, and in 1 patient, the position of the incision was not documented. Among the remaining 12 patients, the skin incision was posterior in 8 patients and medial in 4. An olecranon osteotomy was used for exposure in 7 patients, 6 of whom had a complex (B2.3) fracture. The ulnar nerve was identified and protected but not transposed in 11 patients, and it was transposed anteriorly in 3 patients.

**Postoperative management**
The upper extremity was immobilized in a splint for an average of 11 days (range, 1–49 days). Once the fracture had healed, the patient was allowed unrestricted use of the limb. Three patients were treated with static progressive dynamic splint devices to address elbow stiffness, for an average of 30 days (range, 12–56 days).

**Complications and subsequent surgeries**
Eight patients had a total of 14 postoperative complications: There were 3 postoperative infections, 1 nonunion, 1 wound dehiscence, 1 contracture, and 4 ulnar neuropathies. One patient developed heterotopic ossification, 1 patient had urosepsis, and 2 patients reported prominent implants. Four patients had more than 1 complication.

Five patients underwent subsequent surgical procedures. In total, subsequent surgeries included 1 capsulectomy, 1 excision of heterotopic ossification, 1 irrigation and debridement, 1 skin graft, 4 implant removals, and 1 fixation of a nonunion. One patient had more than 1 subsequent procedure: irrigation and debridement, followed by a skin graft for a wound defect, and later excision of heterotopic ossification plus implant removal. Four patients had implant removal an average of 9 months after initial surgery. The implant was removed during a subsequent procedure in 2 patients, and because of implant prominence in 2 patients.

**Evaluation**
Two investigators who were not involved in the initial care evaluated 4 patients in a research-specific outpatient follow-up, and reviewed the medical records for the remaining 10 patients. Eleven patients evaluated at least 10 months after injury were evaluated according to the Broberg and Morrey Functional Rating Index after all surgical procedures.

An independent observer rated radiographic evidence of arthritis, according to the system of Broberg and Morrey, as grade 0 (a normal joint), grade 1 (slight joint-space narrowing with minimum osteophyte formation), grade 2 (moderate joint-space narrowing with moderate osteophyte formation), or grade 3 (severe degenerative change with gross destruction of the joint).
Results

Functional results
The arc of ulnohumeral motion averaged 92° (range, 70° to 120°) with an average flexion of 118° (range, 95° to 140°) and an average flexion contracture of 25° (range, 10° to 40°). The average arc of forearm rotation was 161° (range, 110° to 180°). All elbows were stable at the time of final follow-up or last office visit. According to the Broberg and Morrey Functional Rating Index, the result was rated as excellent in 4 patients, good in 6, and fair in 1 patient, with an average score of 88 (range, 73–97), which represents an average good score.

Six of 11 patients had arthrosis according to the radiographic criteria of Broberg and Morrey. Three patients had slight joint-space narrowing with minimum osteophyte formation (grade 1), and 3 patients had moderate joint-space narrowing (grade 2).

Discussion

Among the 26 adult patients with a fracture of the medial column of the distal humerus previously described in the English language literature, the result is known for 25, 18 of whom had good or excellent results and 7 of whom had fair or poor results. Twenty-three patients were treated surgically, of whom 3 had a poor result. Two patients were treated conservatively and both had a poor result. Among the 22 fractures described in enough detail to allow classification according to the Comprehensive Classification of Fractures, there were 8 B2.1 fractures, 12 B2.2 fractures, and only 2 B2.3 fractures (multifragmentary fractures) (Table 2). Both B2.3 fractures were treated in a resource-poor environment in India and both were treated with fragment excision: owing to significant delay (11 weeks) to presentation in 1 patient and to substantial fragmentation in the other. The final outcome was described as good in both cases. The 4 remaining patients had a B2 fracture, but a specific subclassification could not be derived from the articles.

The two fracture classification systems of which we are aware that are specific to single column fractures of the distal humerus do not account for the potential for complex articular fragmentation. Milch described the unicondylar fractures in 1964. The differentiated between simple fractures (in which the lateral wall of the trochlea remains attached to the humerus), type 1, or fracture dislocation (in which the lateral wall of the trochlear is part of the fracture fragment), type 2. Milch's emphasis was on the integrity of the lateral wall of the trochlea, which he felt was important for elbow stability. Jupiter and Mehne divided the distal humerus into medial and lateral columns and described fractures as either high or low on each column. The higher the fracture, the larger the trochlear fragment that separates with the column. A collateral ligament injury may also be associated with the fracture.

Shortcomings of this study include retrospective review (as is usually necessary for uncommon conditions), reliance on medical records, relatively short follow-up in most patients, and variability in the way patients were identified as well as the way that they were managed. Because this study was based on the medical record, we did not use a standardized examination or outcome questionnaire in
most patients; consequently, our understanding of the results of treatment should be considered incomplete. The value of our report lies principally in the observations regarding injury patterns, and we cannot make definitive statements about treatment or outcome. These patients were treated over 3 decades, and many of the treatment techniques used would not be recommended currently. We do not intend to promote or condone these older techniques but are merely reporting what was done. Our series differs from prior reports in the literature in that 10 of 14 fractures showed complex articular comminution and impaction. Because our hospitals are tertiary care referral centers, this complexity may not reflect the average medial column fracture of the distal humerus. Furthermore, some might dispute the inclusion of fractures that extend into the capitellum, but our purpose is to emphasize that even when there is no fracture of the lateral metaphyseal column, the articular fracture may extend into the capitellum. This observation has proved useful in the care of our patients. It would not intuitively be anticipated and is a valuable observation because it directly influences treatment options. Surgeons should be aware of the potential complexity of this fracture pattern. Despite the severity of the injury, most patients had a good to excellent outcome.

Computed tomography, particularly three-dimensional, can help define the fracture anatomy, including articular comminution and articular surface impaction, and facilitate the way surgery is planned. Three-dimensional computed tomography with the radius and ulna subtracted can help identify the number, size, and location of articular fragments, which will help with planning the surgery. If the articular fracture is straightforward, it can be realigned without the need for an olecranon osteotomy. Impacted fragments and more complex fragmentation may benefit from an olecranon osteotomy to improve visualization and exposure to the articular surface, particularly when buried implants are needed to repair the articular surface. As in other complex articular distal humerus fractures, open reduction and internal fixation remains the best treatment option in healthy, active patients, even when several surgeries are needed, because elbow function has been shown to be durable in the long term.
FIGURE 2. A 47-year-old male fractured his left, nondominant distal humerus in a fall from a standing height. A An anterior view of a 3-dimensional computed tomography reconstruction demonstrates medial column fracture of the distal humerus with complex articular injury. The articular fractures are stable and impacted, meaning that realignment will require the use of some force. There is an old medial epicondyle injury. B An end on (inferior) 3-dimensional computed tomography view shows additional detail. The capitellum and lateral column are intact. C Anteroposterior and D lateral radiographs taken 37 months after injury show healing in good alignment with minimal arthrosis. The patient's elbow flexion was 20° to 120°.

FIGURE 3. A 56-year-old male fractured his right, dominant distal humerus in a slip on the ice. A An anterior 3-dimensional computed tomography view shows fracture of the medial column of the distal humerus with complex articular comminution extending to the capitellum. B An end-on (inferior) view shows greater detail of the complex articular comminution. C A posteroanterior radiograph 182 months after surgery—and also following subsequent surgery for partial implant removal and capsular release—shows healing of the fracture without osteonecrosis nor arthrosis, and the complexity of the fixation with many buried headless screws. D The lateral radiograph shows complete loss of the normal anterior translation of the distal humerus with respect to the ulnar diaphysis. The patient's elbow flexed from 20° to 95°.
Acknowledgements
The authors are grateful to the AO Documentation Center in Davos, Switzerland, and to Dr. E.L.F.B. Raaymakers for managing the fracture database for the Departments of Orthopaedic Surgery and General Surgery at the Academic Medical Center in Amsterdam, The Netherlands, over the past decades. Four cases included in the study were identified through this database. The authors also thank the Departments of Surgery and Traumatology of the Academic Medical Center of Amsterdam for permission to use data from their patients.

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<th>First Author</th>
<th># Result</th>
<th>Procedure</th>
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<th>AO-Classification</th>
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<td>Wilson²⁴</td>
<td>1 Good</td>
<td>ORIF</td>
<td>Milch I</td>
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<tr>
<td>Aitken³</td>
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<td>ORIF</td>
<td>Unknown</td>
<td>B2.2</td>
</tr>
<tr>
<td>Berhman³</td>
<td>1 Good</td>
<td>ORIF</td>
<td>Milch II</td>
<td>B2.2</td>
</tr>
<tr>
<td>El Gawab¹⁰</td>
<td>1 Poor</td>
<td>ORIF</td>
<td>Milch II</td>
<td>B2.2</td>
</tr>
<tr>
<td></td>
<td>1 Good</td>
<td>ORIF</td>
<td>Milch II</td>
<td>B2.2</td>
</tr>
<tr>
<td>Harmer²⁵</td>
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<td>Non-operative</td>
<td>Unknown</td>
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<td></td>
<td>1 Good</td>
<td>ORIF</td>
<td>Milch I</td>
<td>B2.2</td>
</tr>
<tr>
<td>Jupiter¹</td>
<td>5 Good</td>
<td>ORIF</td>
<td>Milch II</td>
<td>B2.2</td>
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<tr>
<td></td>
<td>1 Poor</td>
<td>ORIF</td>
<td>Milch II</td>
<td>B2.2</td>
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</table>
| Nagi²⁰       | 6 Good   | ORIF      | Milch I 3x Trochlear comminuted | B2.3
|               |          |           | Milch I Compound     | B2.1              |
|               |          |           | Milch I Compound comminuted | B2.3              |
|               | 1 Poor   | Non-operative | Milch I              | B2.1              |
| Stimson²⁶    | 1 Unknown| Unknown   | Milch I              | B2.1              |
| Mitsunaga¹²  | 1 Poor   | ORIF      | Milch II             | B2.2              |
| Scharplatz²⁷ | 1 Good   | ORIF      | Milch I              | B2.2              |
|               | 2 Poor   | ORIF      | Milch II             | B2.2              |

ORIF, open reduction and internal fixation
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