Advancements in classification, treatment and outcome of radial head fractures
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Part IV: Outcome

CHAPTER 7
Incidence and Risk Factors for the Development of Radiographic Arthrosis After Traumatic Elbow Injuries

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Introduction
Radiographic arthrosis is a common sequela of elbow trauma resulting from direct cartilage injury, instability, and articular incongruity. It is understood that over the long term, many patients develop radiographic signs of osteoarthrosis after elbow trauma, although symptoms vary and few patients present for treatment. There is a limited relationship between radiographic evidence of arthrosis and impairment or disability. Not much has been published regarding risk factors for radiographic arthrosis after elbow injury, especially in the long term. Data from multiple long-term follow-up studies of injured elbows provided the opportunity to assess the risk factors for posttraumatic elbow arthrosis on radiographs. Our null hypothesis was that different types of elbow injuries have rates of radiographic arthrosis (independent of function or outcome) that are comparable at equivalent follow-up times.

Patients and Methods
Patients
During a 5-year period (2005–2010), we collected radiographs and clinical data from a research-specific, long-term evaluation of patients who had surgical treatment of displaced and unstable elbow fractures between 1975 and 1998 as part of 7 retrospective studies. All 7 studies were performed at one institution in The Netherlands and were approved by the institutional review board. Inclusion criteria for the present study were: (1) surgically treated elbow fracture, (2) age greater than 18 years at the time of injury, and (3) date of evaluation more than 10 years after the initial injury or surgery. Among the 235 patients in the prior studies, 139 satisfied the inclusion and exclusion criteria and made up the study cohort.

There were 81 men and 58 women, with a mean age of 38 years at the time of injury (range, 18–73 years). The dominant arm was involved in 69 patients. Twenty-nine patients were employed as laborers at the time of injury; 110 were nonlaborers. Injuries included fracture–dislocation of the elbow in 29 patients, distal humerus columnar fracture in 29, isolated radial head fracture in 20, proximal ulna/olecranon fracture in 54, and capitellum/trochlear fracture in 7. According to the AO comprehensive classification of fractures, 2 distal humerus columnar fractures were classified as type B and 27 as type C. Among the capitellum fractures, there were 7 type B. Among the olecranon fractures, there were 49 type B and 5 type C, according to the AO classification. All isolated radial head fractures were type 2 (partial articular, displaced more than 2 mm), according to the Broberg and Morrey modification of Mason’s classification. Among fracture dislocations of the elbow, there were 13 posterior olecranon, 6 anterior olecranon, and 10 dislocations with associated fracture of the radial head (2 with concomitant fracture of the coronoid—see so-called terrible triad).
Patients were injured in a fall from a standing height in 52 cases, in a fall from a greater height in 37 cases, in a bicycle accident in 16 cases, from a direct blow in 8 cases, and in a motor vehicle collision in 26 cases. A total of 129 patients had open reduction and plate and screw fixation and 10 had excision of a radial head fracture.

**Evaluation**

Investigators who were not involved in patients’ care evaluated each radiograph at a mean of 19 years (range, 10–34 y) after the injury. Two independent observers (both orthopedic surgeons) evaluated anteroposterior and lateral radiographs of the involved elbow once for radiographic arthrosis, according to the system of Broberg and Morrey: grade 0 indicates no radiographic arthrosis, grade 1 indicates slight joint-space narrowing with minimum osteophyte formation, grade 2 indicates moderate joint-space narrowing with moderate osteophyte formation, and grade 3 indicates severe degenerative change with gross destruction of the joint. The senior author reviewed all discrepancies in a blinded manner and made a final determination. We did not measure interobserver variability as part of this study.

**Statistical Analysis**

Continuous data are presented as the mean when they are normally distributed; otherwise, the median and interquartile range are reported. The number of patients in the severe group was too small (n = 9) and we thought that pooling moderate or severe and mild or no grades was a more reasonable approach for analysis of factors associated with the development of radiographic arthrosis. We compared independent variables such as demographics and fracture characteristics one at a time between patients with moderate or severe and mild or no radiographic arthrosis by bivariate analysis to examine associations, including unpaired Student’s t-test for age, Mann-Whitney U test for follow-up time (owing to skewness), and Fisher’s exact test or Pearson chi-square for categorical data such as injury type, and injury mechanism. We entered variables into multivariable analysis using stepwise logistic regression (backward selection) to identify factors that were independently associated with moderate or severe arthrosis. We used the Wald test (distributed as chi-square) to assess significance of predictors and the Hosmer-Lemeshow test to examine model fit to the data. Odds ratios were calculated with the 95% confidence interval for significant predictors. Power analysis indicated that a minimum sample size of 80 patients with radiographic arthrosis provided 80% power (α = 0.05, β = 0.20) to identify significant predictors based on the odds ratio and for evaluating 8 variables using multivariable logistic regression. Two-tailed values of p < 0.05 were considered statistically significant.

**Results**

Among the 139 patients, 32 had moderate or severe radiographic arthrosis and 107 had mild or no radiographic arthrosis on final radiographs. Median follow-up was not significantly different among patients with moderate or severe radiographic arthrosis and with mild or no radiographic arthrosis (18 vs 19 y; p = 0.23). Duration of follow-up was not significantly different between injury types (p = 0.10). Bivariate analysis indicated an association between the presence of moderate or severe radiographic arthrosis and injury type (p < 0.001). Mechanism of injury, age, gender, follow-up time, occupation, and limb dominance were not associated with severe or moderate radiographic arthrosis (Table I).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Moderate or Severe Arthrosis (N = 32)</th>
<th>Mild or No Arthrosis (N = 107)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, (y)</td>
<td>40.2 ± 15.5</td>
<td>37.1 ± 14.1</td>
<td>0.27</td>
</tr>
<tr>
<td>Gender</td>
<td>Male 19 (59)</td>
<td>62 (58)</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>Female 13 (41)</td>
<td>45 (42)</td>
<td></td>
</tr>
<tr>
<td>Dominant, (n [%])</td>
<td>18 (56)</td>
<td>51 (48)</td>
<td>0.43</td>
</tr>
<tr>
<td>Nondominant</td>
<td>14 (44)</td>
<td>58 (52)</td>
<td></td>
</tr>
<tr>
<td>Occupation, (n [%])</td>
<td>23 (72)</td>
<td>87 (81)</td>
<td>0.32</td>
</tr>
<tr>
<td>Nonlaborer</td>
<td>9 (28)</td>
<td>20 (19)</td>
<td></td>
</tr>
<tr>
<td>Laborer</td>
<td>9 (28)</td>
<td>82 (77)</td>
<td></td>
</tr>
<tr>
<td>Injury Type, (n [%])</td>
<td>0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal ulna/olecranon</td>
<td>5 (16)</td>
<td>44 (41)</td>
<td></td>
</tr>
<tr>
<td>Distal humerus fracture</td>
<td>13 (41)</td>
<td>16 (15)</td>
<td></td>
</tr>
<tr>
<td>Elbow dislocation with fracture</td>
<td>10 (31)</td>
<td>19 (18)</td>
<td></td>
</tr>
<tr>
<td>Capitellum/trochlea fracture</td>
<td>3 (9)</td>
<td>4 (4)</td>
<td></td>
</tr>
<tr>
<td>Radial head fracture</td>
<td>1 (3)</td>
<td>19 (18)</td>
<td></td>
</tr>
<tr>
<td>Mechanism, (n [%])</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall–standing height</td>
<td>11 (35)</td>
<td>41 (38)</td>
<td></td>
</tr>
<tr>
<td>Fall–greater height</td>
<td>10 (31)</td>
<td>27 (25)</td>
<td></td>
</tr>
<tr>
<td>Motor vehicle accident</td>
<td>9 (28)</td>
<td>15 (14)</td>
<td></td>
</tr>
<tr>
<td>Bicycle accident</td>
<td>1 (3)</td>
<td>13 (12)</td>
<td></td>
</tr>
<tr>
<td>Direct blow injury</td>
<td>1 (3)</td>
<td>7 (7)</td>
<td></td>
</tr>
<tr>
<td>Follow-up, (y)</td>
<td>Median 18</td>
<td>19</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Interquartile range 14–22</td>
<td>15–24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full range 10–31</td>
<td>10–34</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant.
Figure 1 illustrates the number of patients with moderate or severe radiographic arthrosis and the injury type. Multiple logistic regression confirmed that injury type was the only factor independently associated with radiographic arthrosis (p<.001). The odds of moderate or severe radiographic arthrosis were greater for distal humerus fractures, capitellum/trochlea fractures, and fractures–dislocations than for isolated fractures of the radial head or olecranon (Table II).

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal ulna/olecranon (reference category)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Distal humerus fracture</td>
<td>8.0</td>
<td>2.5–25.8</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Elbow dislocation with fracture</td>
<td>5.2</td>
<td>1.8–17.0</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Capitellum/trochlea fracture</td>
<td>7.3</td>
<td>1.5–42.6</td>
<td>0.02*</td>
</tr>
<tr>
<td>Radial head fracture</td>
<td>0.5</td>
<td>0.1–4.7</td>
<td>0.6</td>
</tr>
</tbody>
</table>

* Statistically higher risk of moderate or severe arthrosis than proximal ulna/olecranon reference group. Analysis is adjusted for age, gender, dominance, occupation, mechanism of injury, treatment, and length of follow-up (all p > 0.10).

Table II. Multivariate Analysis: Type of Injury is Predictive of Moderate or Severe Arthrosis

Discussion

Injury type was the only significant independent predictor of moderate or severe radiographic arthrosis. Different injury types may lead to more severe degrees of articular surface injury and realignment. Distal humerus fractures and capitellum/trochlea fractures create the greatest articular injury and were associated with the greatest risk of radiographic arthrosis. Radial head fractures and proximal ulna/olecranon fractures were associated with lower incidence of radiographic arthrosis. Unfortunately, we could not accurately or reliably measure intra-articular displacement and comminution from records available decades after treatment of these injuries. These findings are all consistent with the previous literature on posttraumatic elbow radiographic arthrosis, which notes that intra-articular distal humerus fractures are a common source of posttraumatic elbow radiographic arthrosis.

Consistent with prior data, none of these patients requested surgery specifically to address radiographic arthrosis. Most patients develop radiographic signs of posttraumatic radiographic arthrosis after elbow trauma, but only a few present for treatment.

Radiographic arthrosis was not related to follow-up time, age, hand dominance, occupation, gender, or mechanism of injury. This suggests that postinjury activities and occupation are not important risk factors for the development or advancement of radiographic arthrosis. This finding is reassuring and enabling, although counterintuitive.

The limitations of this report include the fact that we have only cross-sectional (rather than longitudinal) data and that we did not address symptoms and dysfunction. We based assessment of arthrosis on radiographs alone, and we acknowledge the known limited relationships among radiographic evidence of arthrosis and symptoms, impairment, and disability. Interobserver variability for the radiographic arthrosis rating was not measured. Unfortunately, available reproductions of the initial injury radiographs and initial postoperative radiographs were inadequate to quantify articular incongruity, intra-articular comminution, or fracture severity, and we do not have sufficient numbers to analyze the influence of subclassification of each injury type (eg, most of the injuries in each category were of a single AO type). For instance, nearly all of the columnar distal humerus fractures were type C according to the AO classification, and we did not feel confident about measures of articular incongruity. In addition, there were a large number of surgeons involved and fixation was often performed with older techniques that would be considered nonstandard at this time.

Consequently, this study looks broadly at general types of injuries rather than at the influence of articular incongruity or fracture pattern and concludes that isolated fractures of the radial head and olecranon are less prone to moderate or se-
vere radiographic arthrosis in the long term than fractures of the distal humerus and fracture-dislocations. This finding is expected; nevertheless, the data objectively document and quantify the differences using long-term evaluations that are hard to come by.

References