Osteotomy of the head of the radius for partial articular malunion

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Between 1995 and 2006, five intra-articular osteotomies of the head of the radius were performed in patients with symptomatic healed displaced articular fractures. Pre-operatively, all patients complained of persistent painful clicking on movement. Only patients with mild or no degenerative changes of the radial head and capitellum were considered for osteotomy. The operations were performed at a mean of 8.2 months (4 to 13) after injury and the patients were reviewed at a mean of 5.5 years (15 months to 12 years) after the osteotomy.

The average Mayo Elbow Performance Index Score improved significantly from 74 before to 88 after operation, with four patients rated as good or excellent (p < 0.05). The subjective patient satisfaction score was 8.4 on a ten-point scale. All osteotomies healed and there were no complications.

In this small series intra-articular osteotomy of the head of the radius was a safe and effective treatment for symptomatic intra-articular malunion without advanced degenerative changes.

Undisplaced fractures of the radial head are treated non-operatively in a sling and early active movement is encouraged.1,2 The management of displaced fractures, however, is controversial.1,3-10 In the majority of patients without a block to forearm rotation, early active movement can also be associated with good results.3,5 However, a minority have significant residual pain, stiffness and early arthritis following non-operative treatment.11 Such fractures can be managed successfully with excision of the head3 with or without a replacement arthroplasty.6,12 Although reconstruction of malunited intra-articular fractures has been shown to be successful in many joints,13-20 reconstruction of the head by osteotomy is rarely performed. We found only one case report of a patient successfully treated in this way.21

The purpose of this study was to review the clinical and radiographic outcomes of a series of patients who were treated by intra-articular osteotomy of the head of the radius for a symptomatic, healed but displaced partial articular fracture.

Patients and Methods

The hospital records and radiographs of all five patients who underwent osteotomy for a symptomatic, healed but displaced partial articular fracture of the head of the radius were reviewed. They were treated between 1995 and 2006 at a tertiary referral centre by the senior author (GJWK). Patients with persistent painful clicking were given the option of an osteotomy as an alternative to excision of the radial head or arthroplasty, with the understanding that they might require excision if the osteotomy was impracticable or failed. Patients with degenerative changes of the radial head or capitellum of Broberg and Morrey grade 2 or above3 were excluded. Pre-operative CT scans were taken to assess the displacement of the fractured fragment, its percentage of the radial head, the amount of bone healing and the degree of secondary degenerative changes.

Operative technique. A midline posterior incision was made, just lateral to the tip of the olecranon, and a full-thickness lateral fasciocutaneous flap was elevated on the deep fascia.22,23 Deep dissection to expose the radial head was through splitting the extensor digitorum communis7 in two patients or through the Kocher interval24 between anconeus and extensor carpi ulnaris in three. In both approaches the forearm was pronated to protect the posterior interosseous
nerve and the lateral collateral and annular ligament were sectioned anterior to the lateral ulnar collateral ligament to prevent iatrogenic posterolateral rotatory instability. During the study, the preferred approach became through splitting extensor digitorum communis, as it protects the lateral ulnar collateral ligament and provides better access to the anterolateral aspect of the radial head, which was the usual site of the malunion.

The anterior half of the lateral collateral ligament and the overlying extensor muscles were elevated anteriorly off the lateral epicondyse in three patients. In the other two a Kocher approach was used and the lateral collateral ligament was completely detached from the lateral epicondyle to improve the exposure. In one patient a diagnostic arthroscopy preceded the operation to assess the quality of the articular surface of the radial head and capitellum, and to determine whether the former could be salvaged. In two other patients concomitant debridement of synovitis and of an articular chondral flap of the capitellum was carried out prior to the osteotomy. Following exposure of the radial head, the fracture site was defined by removing the fibrocartilage with small curettes. Working from the joint surface, osteotomes were used to recreate the original fracture. Care was taken to mobilise the depressed fragment gently, without disturbing the tenuous periosteal blood supply from the neck of the radius.

The fragments were reduced using smooth Kirschner wires as ‘joysticks’ and for provisional fixation. Definitive fixation was by Herbert screws (Zimmer, Warsaw, Indiana) in one patient and 3 mm cannulated AO screws (Synthes, Missisauga, Ontario) in four (Fig. 1). Care was taken to avoid penetration of the screws through the opposite cortex and to countersink the screw heads, thereby avoiding any block to rotation of the forearm or irritation of the annular ligament. The reduction and fixation were confirmed both visually and under fluoroscopy. The annular and lateral collateral ligaments were repaired by reattaching their anterior portions to the intact posterior portions. In the two cases where the lateral ligament was completely detached, a formal repair was done either with suture anchors or through bone tunnels in the lateral epicondyle.

The muscle interval was closed and the elbow splinted anteriorly off the lateral epicondyle in three patients. In the other two a Kocher approach was used and the lateral collateral ligament was completely detached from the lateral epicondyle to improve the exposure. In one patient a diagnostic arthroscopy preceded the operation to assess the quality of the articular surface of the radial head and capitellum, and to determine whether the former could be salvaged. In two other patients concomitant debridement of synovitis and of an articular chondral flap of the capitellum was carried out prior to the osteotomy. Following exposure of the radial head, the fracture site was defined by removing the fibrocartilage with small curettes. Working from the joint surface, osteotomes were used to recreate the original fracture. Care was taken to mobilise the depressed fragment gently, without disturbing the tenuous periosteal blood supply from the neck of the radius.

The muscle interval was closed and the elbow put through a complete arc of flexion to evaluate stability in pronation, neutral and supination. Active movement was initiated once the osteotomy had healed adequately, usually by six to 12 weeks. Two patients were given indometacin, 25 mg three times daily for three weeks to prevent heterotopic ossification.

Following Review Board approval, all five patients consented to participate in the study and none was lost to follow-up. They were interviewed and examined by an independent reviewer (CY) who assessed the subjective and objective clinical outcome using standardised protocols. Grip strength28 and range-of-motion29 were tested using the NK Hand Evaluation System (NK Biomechanical Engineering, Minneapolis, Minnesota). The former was corrected for hand dominance as suggested by Solgaard, Kristiansen and Jensen.

The Biodex System 3 (Biodex Medical Systems Inc., Shirley, New York) was used for isometric strength testing of elbow flexion, extension, pronation and supination with the patient seated in a sturdy chair, the shoulder in the neutral position and the elbow flexed at 90°. Initial and standardised follow-up radiographs were reviewed. Reduction was assessed, along with evidence of any degenerative changes, fracture healing, loosening or prominence of hardware, avascular necrosis and signs of heterotopic ossification, which, if present, was graded according to Brooker et al.33 The degree of degenerative change was classified according to Broberg and Morrey,3 as grade 0 (normal), grade 1 (slight joint space narrowing and minimum osteophyte formation), grade 2 (moderate joint space narrowing and osteophyte formation) or grade 3 (severe changes with gross destruction of the joint).

Subjective outcomes were assessed using self-reporting scales to evaluate different health perspectives, including general health (Short Form(SF)-36 Health Survey),34,35 Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH),36,37 pain and disability (patient rated elbow evaluation)38 and the American Shoulder and Elbow Surgeons (ASES) self-report form.39 The Mayo elbow performance index40 was calculated using the self-reported responses to five specific questions on the patient evaluation that are mapped to Mayo index items.

Statistical analysis. Data were entered into SPSS 16.0 (SPSS Inc., Chicago, Illinois) and manual checking and descriptive data analyses were conducted to verify accuracy and normality. Student's paired t-test was used to compare the strength and movement elbow scores of affected and unaffected sides at the time of final follow-up (α = 0.05) and the pre- and post-operative movement and Mayo performance index scores on the operated side.

Results
There were three men and two women, with a mean age of 29 years (20 to 39). The dominant arm was involved in four patients. Two had been injured in a fall from a standing height, two fell from a greater height, and one was involved in a road traffic accident. Two patients were injured at work and had unresolved compensation claims. Two had associated injuries to the ipsilateral limb, namely a scaphoid fracture and a blunt injury to the shoulder. Both of these additional injuries were treated conservatively. The osteotomies were performed at a mean of 8.2 months (4 to 13) after injury, and the patients were reviewed after at a mean of 5.5 years (15 months to 12 years).

All the osteotomies were performed successfully and none required excision of the head or arthroplasty. All the original fractures were closed and no patient had any associated ligament injuries to the elbow or forearm.
All the fractures were classified as Mason type II. There were two displaced fragments in two patients, and one displaced fragment in each of three patients. The mean amount of articular displacement was 3.4 mm (2.5 to 6) and the fragments comprised a mean of 44% (40% to 50%) of the articular surface. All the patients reported pain, crepitus and weakness pre-operatively.

There were no complications. One patient had arthroscopic debridement and synovectomy of his elbow 13 months after the osteotomy because of persistent pain. He changed his occupation as a car hauler because of residual discomfort but continued to suffer mild to moderate pain in his upper arm, which originated mainly from his shoulder injury and for which he took analgesics on a regular basis.

One university student was unable to return to competitive swimming but continued to swim recreationally. At follow-up, four of the five patients reported no pain or only an occasional mild ache in their elbow with weather change or heavy use. None was symptomatic enough to require radial head excision or arthroplasty.

On review of the radiographs, anatomical reduction was achieved and maintained until healing. There were no signs of osteonecrosis or loosening of hardware. Two elbows developed grade 1 heterotopic bone formation, but there was no clinical deficit at final follow-up. One of these patients was treated with indometacin for prophylaxis against heterotopic bone formation. Radiographs of all the elbows showed conversion from no arthritis pre-operatively, to grade 1 changes at the latest follow-up.
The pre-operative movements of the injured elbows were a mean of 134° of flexion (120° to 150°), with a mean fixed flexion deformity of 14° (4° to 40°), a mean pronation of 78° (70° to 80°) and a mean supination of 86° (70° to 90°).

Post-operative movements of the injured elbows were a mean of 139° of flexion (130° to 150°) with a mean fixed flexion deformity of 7° (4° to 19°), a mean pronation of 83° (76° to 85°) and a mean supination of 75° (61° to 87°).

The only significant difference between the pre- and post-operative movements was reduction in supination by a mean of 11° (3° to 19°) (p < 0.05).

The only significant differences between the affected and unaffected elbows at final follow-up were reduced elbow extension (mean 10°, 1° to 19°) and supination (mean 7°, 2° to 10°, p < 0.05). There were no significant differences in grip strength, isometric strength in all directions and cubitus valgus between injured and uninjured elbows (p > 0.05) (Table I).

**Discussion**

Osteotomy of the head of the radius provided good results in four of five patients in this series, with a higher Mayo elbow performance index score, and better patient rated elbow evaluation and DASH scores than previous reports of delayed radial head excision or arthroplasty.3,6,9,12

Improvements in pain and function were noted and there were no complications.

Whereas there is some consensus regarding the conservative treatment for non-displaced head fractures,1,2 and operative treatment of comminuted non-reconstructable radial head fractures associated with a complex injury,6,8,10,42,43 there is a need to define the optimal treatment for the wide spectrum of fractures that fall between these extremes. There are no well-defined criteria to predict which patients will have residual symptoms following non-operative treatment of displaced fractures. Those that remain symptomatic have historically been treated by delayed excision of the head with or without arthroplasty, with satisfactory results.3,6,12 The outcome of delayed excision does not seem to differ clinically from early resection of the head, and therefore delayed excision can be a salvage procedure.9 Nevertheless, Broberg and Morrey3 showed that mild to moderate osteoarthritis was present in 77% of the patients who had delayed resection for failed non-operative treatment of fractures of the head of the radius after a mean of 15 years. Shore et al12 reported that metallic replacement arthroplasty for the treatment of post-traumatic elbow disorders is a safe and durable procedure that provides functional movement and pain relief, with an average Mayo elbow performance index score of 83 at eight years. A subgroup of patients who had failed non-operative treatment for fractures followed by arthroplasty fared worse than the other subgroups, with an average

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**Table I. Outcome measurements**

<table>
<thead>
<tr>
<th>Measure*</th>
<th>Observations</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>29 to 57</td>
<td>47 (11)</td>
</tr>
<tr>
<td>Mental</td>
<td>50 to 60</td>
<td>56 (4)</td>
</tr>
<tr>
<td>DASH</td>
<td>0 to 40</td>
<td>11 (16)</td>
</tr>
<tr>
<td>MEPI</td>
<td>65 to 85</td>
<td>74 (8)</td>
</tr>
<tr>
<td>Post-operative MEPI</td>
<td>70 to 100</td>
<td>88 (12)</td>
</tr>
<tr>
<td>ASES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>0 to 28</td>
<td>13 (11)</td>
</tr>
<tr>
<td>Function</td>
<td>21 to 36</td>
<td>32 (6)</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>5 to 10</td>
<td>8 (2)</td>
</tr>
<tr>
<td>PREE</td>
<td>0 to 59</td>
<td>22 (23)</td>
</tr>
<tr>
<td>Grip strength (kg)</td>
<td>36 to 51/33 to 55</td>
<td>42 (6)</td>
</tr>
<tr>
<td>Elbow strength (Nm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>19 to 58/19 to 58</td>
<td>33 (16)</td>
</tr>
<tr>
<td>Extension</td>
<td>28 to 55/22 to 59</td>
<td>43 (11)</td>
</tr>
<tr>
<td>Pronation affected</td>
<td>3 to 8/2 to 11</td>
<td>5 (2)</td>
</tr>
<tr>
<td>Supination affected</td>
<td>7 to 14/7 to 13</td>
<td>9 (3)</td>
</tr>
</tbody>
</table>

* SF-36, Short Form-36 Health Survey; DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; MEPI, Mayo Elbow Performance Index; ASES, American Shoulder and Elbow Score; PREE, Patient Rated Elbow Evaluation
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Mayo elbow performance index score of 73; most patients had fair and poor results. However, most of the patients in that subgroup had more complex injuries than those in the current series.

In our experience, intra-articular osteotomy of the head for symptomatic healed displaced fractures gave better outcome scores than any reported alternative. Our patients were young and had no significant associated bony or soft-tissue injuries. They are therefore likely to represent a different group than in previous studies of late excision or arthroplasty. The follow-up was relatively short at 3.5 years, with marked variability in duration of follow-up (15 months to 12 years), thereby making assessment of degenerative changes difficult. Furthermore, this was a retrospective review lacking a detailed pre-operative questionnaire. Further long-term surveillance of these patients is needed to determine whether their residual symptoms, upper limb function and radiological evidence of arthritis will worsen. CT scans might further improve the assessment with regard to residual malalignment and the presence of degenerative changes. The radiological signs of early osteoarthritis in all the elbows in this series might be attributed to the initial injury causing chondral damage and the prolonged time when the capitellum articulated with the non-congruent radial head.

There is only one previous report of a single case of symptomatic healed displaced fracture of the head of the radius treated by intra-articular osteotomy.21 This was also performed at our centre and suggests that this treatment option is not standard practice. The current series, which includes the longer term outcome of this patient and four others, suggests that intra-articular osteotomy for symptomatic healed displaced partial articular fracture of the head of the radius is a feasible and safe option to improve symptoms and function. Should it fail, excision of the head, with or without arthroplasty, could be considered.

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References


