Radial head fracture: a potentially complex injury
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Chapter 10

Results of the cemented and press-fit bipolar radial head prosthesis in 33 elbows with a minimal follow-up of 2 years

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Submitted
ABSTRACT

Introduction: The bipolar Judet radial head prosthesis can be used in unreconstructable, comminuted radial head fractures and is available in two types: cemented and press-fit. The goal of this study was to describe the results of both implant types. Patients and methods: 33 patients with a Judet prosthesis (17 cemented, 16 press-fit) were retrospectively reviewed, with a median follow-up of 33 (range: 24-62) months. Results: Nineteen patients scored excellent, 10 scored good, 1 fair and 3 poor on the Mayo Elbow Performance Index, with a median of 100. The median Elbow Function Assessment score was 94. The median functional range of motion was 130° (range: 80°-145°). Median supination was 70° and median pronation also 70.0°. Complications occurred in 13 elbows. Eleven of the 16 elbows with a press-fit implant showed osteolysis proximal radius. In the cemented implant group periprosthetic lucencies were found in 2 of 19 patients. Discussion: The short-term functional results of the Judet radial head prosthesis are good or excellent in 88% of the cases. Osteolysis of the proximal radius was found in the majority patients with a press-fit prosthesis, without any impact on the clinical outcome. The exact cause and clinical implications of this osteolysis requires further investigation. Level of evidence: Level IV. Key words: Radial head, fracture, bipolar prosthesis, press-fit, cemented, elbow, trauma.
INTRODUCTION

Radial head prostheses are available in two broad designs: unipolar implants\(^1-3\) and bipolar prostheses.\(^4\) Bipolar radial head prostheses have a symmetric head, that articulates in a semiconstrained fashion with a fixed stem. The rationale of this design, is that the additional freedom of movement reduces stress at the implant-bone interface and increases the contact area at the radiocapitellar joint.\(^4,5\) Moreover, in reconstruction of longstanding posttraumatic deformities, malalignment of the proximal radius in relation to the capitellum can be overcome by the bipolar design.\(^6\) The floating radial head prosthesis is a bipolar prosthesis and is available in two types: a long-stemmed cemented prosthesis with an stem/neck angle of 15 degrees and short-stemmed press-fit prosthesis. The press-fit system possibly allows easier revision, which may be required in young, demanding patients and it is easier to insert, as the stem is shorter and straight. To our knowledge no results of the more recent, press-fit bipolar floating radial head prosthesis have been published. The goal of this retrospective study was to describe the results of the cemented and press-fit floating radial head prosthesis in patients with post traumatic disorders of the elbow after a radial head fracture.

PATIENTS AND METHODS

Patients
Data of all 34 patients, 13 male and 21 female, in which a bipolar radial head prosthesis was implanted in the period between March 2005 and July 2009 were retrospectively reviewed. One patient was lost to follow-up and was excluded for analysis: a seasonal worker who was treated for a posterolateral elbow dislocation, with a Mason-Mayo type III fracture and a lateral collateral ligament rupture (LCL). The median age of the remaining 33 patients available for follow-up was 52 (range: 24-70) years. The dominant side was affected in 19 cases. Twelve patients were treated with an un-reconstructable radial head fracture within three weeks after trauma, which were considered to be acute. Associated injuries were present in 9 of these patients. Sixteen patients had failed previous surgery to the radial head, such as radial head excision, ORIF or radial head arthroplasty. Delayed surgery after failed initial conservative treatment was performed in 7 patients.

Implant
The implant used in these patients (RHS, Tornier SA, Saint-Ismier, France) is in two parts: the head is made from high-density poly-ethylene (PE) encased in cobalt-chrome, which articulates in a semi-constrained manner with the spherical end of a cemented cobalt-chrome intramedullary stem. Half-way the selected period the short stem uncemented
A prosthesis was introduced. The switch to the press-fit implant was made for several reasons: in literature reported periprosthetic radiolucencies of the proximal radius; the short, straight stem allows easier implantation in the curved proximal radius; potentially allows easier revision; and operating time is reduced. In 17 patients a cemented prosthesis was implanted and 16 patients received a press-fit prosthesis. Patient characteristics for both groups were similar, except for follow-up, which was significantly longer for cemented implants (Table I).

<table>
<thead>
<tr>
<th></th>
<th>Cemented (n=17)</th>
<th>Press-fit (n=16)</th>
<th>Total (n=33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53 (36-70)</td>
<td>52 (24-61)</td>
<td>52 (24-70)</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>6/11</td>
<td>6/10</td>
<td>12/21</td>
</tr>
<tr>
<td>Dominance</td>
<td>8</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>Follow-up (months)</td>
<td>36 (25-62)*</td>
<td>28 (24-40)*</td>
<td>33 (24-62)</td>
</tr>
<tr>
<td>Indication for surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute trauma</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Failed conservative</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Revision surgery</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Complications</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>MEPI (range)</td>
<td>100 (55-100)</td>
<td>90 (60-100)</td>
<td>100 (55-100)</td>
</tr>
<tr>
<td>EFA (range)</td>
<td>95 (76-100)</td>
<td>93 (60-100)</td>
<td>94 (76-100)</td>
</tr>
</tbody>
</table>

Table I: Summary of patient group characteristics, complications and functional results after follow-up. MEPI = Mayo Elbow Performance Index. EFA = Elbow Function Assessment score. * = statistically significant difference (P = 0.01).

Surgical procedures and rehabilitation

31 of 33 patients were treated by a single experienced elbow surgeon, the other two patients were treated by an experienced traumatologist. The radial head was exposed through a posterolateral Kocher incision. In 27 patients adjuvant surgical procedures were performed, such as collateral ligament reconstruction, arthrolysis and osteosynthesis of associated fractures of the elbow. Postoperatively, 28 patients performed active assisted motion exercises with the help of a physiotherapist. After 6 weeks, active and passive stretching was allowed and strengthening exercises were started. An elbow cast because of severe post-operative swelling was applied for 1 to 3 weeks postoperatively in 5 patients, before mobilization was allowed.

Follow-up

Range of motion (ROM), varus and valgus stability and the pivot shift test were evaluated before surgery (except for acute patients) and during the regular follow-up at 6 months after surgery and yearly follow-up. Elbow function was evaluated with use of the Mayo Elbow Performance Index (MEPI) and Elbow Function Assessment (EFA) scale. Post-operative
complications were noted. Evaluation of standard anteroposterior (AP) and lateral elbow radiographs consisted of assessment and quantification of periarticular ossifying disease (PAOD) according to the Hastings and Graham classification, and degenerative changes according to the Broberg and Morrey classification (table II). Changes of the proximal radius (including radiolucent lines and osteolysis of the proximal radius) for cemented implants were classified, according to the method previously described by Popovic et al., dividing the proximal radius into seven zones (figure 1). For the press-fit implants a
modification of this classification was used, as the stem of this design is much shorter (figure 2). Ulnohumeral joint space, capitellar osteopenia and erosion were also assessed.

Statistical analysis
Statistical analysis was performed using SPSS 16.0 (SPSS, Chicago, Il). The Chi-square test (or Fishers exact test) was used for comparing dichotomous values of baseline characteristics. The Mann-Whitney U test was performed for small sample sizes and skewed distributions. In case of skewed distribution, a median was provided instead of a mean. A P-value below 0.05 was considered to be a significant result.

RESULTS

The median follow-up of all patients was 33 (range: 24-62) months. The median MEPI was 100 (range: 55-100) points. Nineteen patients scored excellent, 10 scored good, 1 fair and 3 poor. The median EFA was 94 (range: 60-100) points. Median elbow flexion was 140° (range: 120-150), with a median extension deficit of 5° (range: 0-50). Median supination was 70° (range: 20-90) and pronation 70.0° (range 30-90). The median functional range of motion was 130° (range: 80°-145°). Separate results of the cemented and the press-fit prosthesis are provided in table I. One or more complications (symptomatic instability, persistent pain, wound infection, revision surgery, overstuffing) occurred in a total of 13 patients (7 cemented and 6 press-fit) (table III). Radiological assessment showed no peri-prosthetic fractures. Four patients had a PAOD with radiographical assessment, of which it was present before surgery in 2 patients. The other 2 patients developed a grade I PAOD.
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Post-traumatic degenerative osteoarthritis of the elbow joint was seen in 15 elbows: 10 patients had a Broberg and Morrey grade II, of which 4 were progressive. A grade I osteoarthritis was seen in 3 patients. Two patients had a stable pre-existent grade III osteoarthritis. Overstuffing was found in 2 patients, and both patients had progressive grade II degenerative osteoarthritis of the elbow and 1 had capitellar erosion. Osteopenia of the capitellum or lateral condyle was seen in 10 elbows, of which 8 patients developed osteopenia after radial head implantation (figure 3). Radiographic changes of the proximal radius were seen in 13 patients. Eleven of the 16 elbows with a press-fit implant showed osteolysis of the cortex distal to the collar of the implant in zone 1 and/or 7 (figure 3), compared to only 1 in the cemented group. In the cemented implant

### Table IV: Summary of radiological findings after follow-up. PAOD: periarticular ossifying disease.

<table>
<thead>
<tr>
<th>Radiological findings</th>
<th>Cemented (n=17)</th>
<th>Press-fit (n=16)</th>
<th>Total (n=33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAOD</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Degenerative arthritis</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Osteopenia lateral condyle</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Erosion of capitellum</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Radiolucence around stem</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Osteolysis proximal radius</td>
<td>1</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Overstuffing</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 3: A right elbow 14 months after radial head replacement surgery. Note the evident osteolysis of the proximal radius (arrow 1 and 2) and the osteopenia of the capitellum (arrow 3).
group periprosthetic (balloon-shaped) lucencies in a variety of zones around the stem were found in 1 of 19 patients. Radiographic findings are summarised in table IV.

DISCUSSION

Several case series on the clinical results of the cemented bipolar Judet radial head implant have been published over the past years. To our knowledge, this is the first report in which results of the press-fit bipolar Judet radial head implants are presented. Our results of both implants are comparable to those reported in the literature for the cemented bipolar implant: success rates (with functional scores of good to excellent) range from 67% to 100%\(^4,7,13-20\), compared to 88% in this series. However, a good comparison is difficult, as the included patient characteristics, like type of injury, associated injuries and revision surgery highly vary between studies. The number of patients with revision surgery is high in our case series, which might cause the relatively high number of complications in our series. We did not compare the results of the cemented implant versus the press-fit implant, as there was a large difference in duration of follow-up. No dislocation of the prosthesis head, which has been described in several case reports, was seen in this series.\(^6,21,22\)

Periprosthetic (balloon-shaped) lucencies in a variety of zones, around the stem was found in 1 of 19 patients with a cemented implant (figure 4). Popovic et al.\(^7\) described three different types of radiographic changes around the prosthetic stem in their report on results of the cemented bipolar Judet prosthesis: complete or incomplete radiolucent

![Figure 4: Balloon shaped osteolysis (arrows) of the proximal radius in zone 1 and 7 after implantation of a cemented bipolar Judet prosthesis 18 months after surgery.](image)
lines, balloon-shaped radiolucent zones, and proximal bone resorption at the radial neck. 53% of their 51 elbows had radiographic evidence of periprosthetic lucency within the medullary canal of the radius after a mean follow-up of 8.4 years. They state that this could be caused by PE wear or an altered load transmission. However, these results are not confirmed by other studies: Burkhardt et al.\textsuperscript{13} state that the results by Popovic et al. can be explained by insufficient cementing techniques, as they did not find any osteolysis of the proximal radius in their series of 19 cemented Judet prosthesis with a follow-up of 8.8 years. It is also less frequently (0 to 6.3%) described in other available studies with short to medium-term follow-up.\textsuperscript{14, 16, 20, 23} In our study, proximal osteolysis in the cemented group was caused by an insufficient cementing technique in at least 1 elbow.

Eleven of our 16 patients (69%) with a press-fit implant had partial or complete osteolysis with cortical atrophy of the proximal radius (zones 1 and 7), whereas the distal end of the prosthesis remained rigidly fixed in the bone. A possible cause this osteolysis can be wear of the PE: histological evidence of PE wear in bipolar implants was reported by O’Driscoll and Herald.\textsuperscript{22} However, it is unlikely as the mean follow-up period of these patients (29.5 months) is too short to cause significant wear debris and it was not seen in the elbows with a cemented implant, of which the mean follow-up period was significantly longer (39.2 months). In our opinion it is highly likely that stress shielding is the most important factor for the osteolysis of the proximal radius in the press-fit group: The short, thick, and hence more rigid stem of the press-fit design is more prone to stress shielding, compared to the long, thinner and likewise more flexible stem of the cemented implant.\textsuperscript{24} Furthermore, Chanlalit et al.\textsuperscript{25} recently reported of “many cases” of proximal osteolysis in non-cemented Anatomic Radial Head implants (Acumed, Hillsboro, OR), which they also attribute to stress shielding. The clinical relevance of the proximal osteolysis is unknown, but may eventually lead to failure of the implant. The bone loss of the proximal radius will also make a revision of the implant difficult. We advise regular radiographic control for the patients with a press-fit Judet prosthesis and medium- and long-term reports on the press-fit design are in demand to assess the clinical relevance of this radiographic finding.

Asymptomatic osteopenia of the capitellum and/or lateral humeral condyle was seen in 10 of 33 elbows. This osteopenia might be caused by a decreased load through the capitellum and has been reported after radial head resection and radial head arthroplasty.\textsuperscript{26-28} As it does not occur in all elbows after radial head replacement, mechanical factors like understuffing or subsidence of the implant might play a role.\textsuperscript{29} Remission of the osteopenia was observed in 1 post-radial head excision elbow after radial head replacement, possibly after restoring the normal load pattern after implantation of the prosthesis. Moro et al. reported asymptomatic capitellar osteopenia in 78% of 24 patients with a metal spacer after a mean follow-up of 39 months.\textsuperscript{28} Popovic et al.,\textsuperscript{7} Celli et al.\textsuperscript{14} and Burkhardt et al.\textsuperscript{13} do not report on capitellar osteopenia in their case series of the Judet prosthesis. Although many patients with capitellar osteopenia remain asymptomatic, it can have clinical implications:
van Riet et al.\textsuperscript{27} report on capitellar erosion after radial head replacement in a patient with capitellar osteopenia and overstuffing. Weaknesses of this study are the retrospective character of this case series, the variety in indications for radial head replacement, and the two different designs used. However, we believe that despite these weaknesses important conclusions can be drawn from this study:

**CONCLUSIONS**

The functional results of the Judet radial head prosthesis, cemented and press-fit, are good or excellent in 88% of the cases. The number of patients with revision surgery is high in our case series, which might cause the relatively high number of complications in our series. Osteolysis of the proximal radius was found in the majority patients with a press-fit prosthesis. The exact cause and clinical implication of this osteolysis requires further investigation. Careful follow-up of these implants is indicated.
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REFERENCE LIST


