Functional outcome of reverse shoulder arthroplasty for acute proximal humeral fractures and fracture sequelae: with or without previous surgery

<table>
<thead>
<tr>
<th>Journal:</th>
<th><em>International Orthopaedics</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuscript ID:</td>
<td>Draft</td>
</tr>
<tr>
<td>Manuscript Type:</td>
<td>Original Paper</td>
</tr>
<tr>
<td>Date Submitted by the Author:</td>
<td>n/a</td>
</tr>
<tr>
<td>Complete List of Authors:</td>
<td>Cicak, Nikola; Akromion Special Hospital for Orthopaedics and Traumatology, Klobucar, Hrvoje; Akromion Special Hospital for Orthopaedics and Traumatology, Medancic, Nenad; Akromion Special Hospital for Orthopaedics and Traumatology,</td>
</tr>
<tr>
<td>Keywords:</td>
<td>reverse shoulder arthroplasty, proximal shoulder fractures, fracture sequelae</td>
</tr>
</tbody>
</table>
Purpose. The purpose of the study was to evaluate functional outcomes of reverse shoulder arthroplasty (RSA) in patients with acute fracture and sequelae of the proximal humeral fractures.

Material and Methods. Thirty seven patients were treated with RSA for acute fracture and sequelae of a proximal humeral fracture. The average age was 73 years (range 50-87 years). Twenty one patients had had no previous surgery, seven patients had acute fractures and fourteen patients had chronic fractures. Sixteen patients had had previous surgery. Active range of motion and Constant score were evaluated at a minimum follow-up of 2 years.

Results. Active elevation was 102°, external rotation 24°, internal rotation up to L4 in all patients. In the group of patients without previous surgery treated with RSA, elevation was 116°, external rotation 24°, internal rotation up to L3. In the group of patients with previous surgery treated with RSA, elevation was 84°, external rotation 19°, internal rotation up to L4.
In the group of patients with acute fracture treated with RSA, elevation was 124 °, external rotation 28°, internal rotation up to L4. In the group of patients with chronic or sequel of the fractures treated with RSA elevation was 114 °, external rotation 28, ° internal rotation up to L3. Constant score in all patients was 54. Constant score in patients without previous surgery treated with RSA was 68 and with previous surgery was 42.

**Conclusion.** Patients without previous surgery treated with RSA had better functional results than patients who had undergone previous surgery.

**Keywords:** reverse shoulder arthroplasty, proximal shoulder fractures, fracture sequelae
Introduction

Most fractures of the proximal humerus without displacement or with minimal displacement can be successfully treated without surgery. Complex proximal humeral fractures, four-part fractures, three-part fractures in osteoporotic bone, fracture-dislocations, head-splitting fractures, and impression fractures involving more than 50% of the articular surface can be treated by hemiarthroplasty or reverse shoulder arthroplasty [5,6,7,8].

Proximal humerus fractures treatment by shoulder hemiarthroplasty does not show consistent results even when performed by the most experienced surgeons. Long-term studies showed limitations of this surgery as the result primarily depends on tuberosities healing [15,20,25].

Over the last years reverse shoulder prosthesis has been mostly used in case of proximal humerus fractures, both acute in elderly patients and chronic fractures in patients of any age. Reverse prosthesis application is based on the function of the deltoid muscle. Consequently, in such cases when the rotator cuff is missing or there was a malunion or nonunion of the proximal humerus, reverse arthroplasty enables the solution of the problem [3,14]. Usage of the reverse shoulder prosthesis in patients with acute fractures is well described in the literature. On the contrary, reverse arthroplasty in case of proximal humerus fractures, malunions or nonunions or previous surgeries has been poorly analyzed in the literature. The main goal of this study is to compare functional results and the shoulder range of motion after acute proximal humerus fractures and in chronic cases, both treated surgically and not.
Materials and Methods

From October 2008 till November 2012 forty patients were treated with reverse shoulder arthroplasty for acute fracture and sequelae of proximal humeral fracture by the single surgeon in our hospital. The average age was 73 years (range 50-87 years). The average age of the patients with no previous surgeries (21 patient) was 75,5 years ( range 56-87), and of the patients who had undergone previous surgical treatment (16 patients), was 66,3 ( range 50-81). Three patients were lost to follow-up, leaving 37 patients for evaluation. There were 31 female and 6 male patients. The average follow-up period was 45 months (range 24-72 months). Thirty four patients suffered the fracture after the fall, and 3 patients in a car crash.

Twenty one patients had no previous surgery, seven patients had acute fractures and 14 patients had chronic fractures (more than one month). The average time between the fracture and the time of the reverse shoulder arthroplasty in 14 patients with chronic fracture that had not been surgically treated before was 13 months (from 1 to 144 months). Out of those 14 patients there were 10 with malunions, 3 with nonunions and one patient with shoulder dislocation and greater tuberosity fracture. Sixteen patients had previous surgeries, internal fixation with a plate and screw or intramedullary rod or percutaneous fixation with the K-wire. Three patients had more than 2 operations. In one of those patients after osteosynthesis a humeral head extirpation was performed in the second act. Active range of motion and Constant score were evaluated at a final follow-up, minimum 2 years after surgery.

Surgical Technique

Deltopectoral approach was used in all patients and was performed by the single surgeon who used identical implants (Anatomical Shoulder Reverse, Zimmer, Inc.). Surgeries were performed depending on the fracture type and on consistency of the bony structures. In acute fractures humeral body was cemented, tuberosities were fixed together, and to the humeral
body. Supraspinatus tendon was resected. In case of nonunions of the humeral surgical neck or malunion, only humeral tuberosities were left and fixed like in acute fractures, or when that was not possible they were fixed together or sometimes only one of them. In greater tuberosity malunions osteotomy was not performed if there was a possibility of the prosthesis implantation, or if the tuberosity position did not restrain external rotation of the arm.

Standard retroversion was 30 degrees. In chronic cases and fracture sequelae, soft tissue release was performed so that the adequate approach and movability could be achieved. Postoperatively patients were immobilized in sling for 3 weeks although using the treated arm as much as they could tolerate. Passive range of motions was allowed on the first postoperative day. For patients who underwent tuberosity reconstructions, sling was used in the neutral arm position. Active motions and elevation started 6 weeks after the surgery, and exercises for muscle strengthening were allowed 8 weeks after the surgery.
Results

The functional outcome and range of motion for patients included in this study are presented in Table 1,2,3. Our results show that group of patients treated with RSA without previous surgery in comparison with patients treated with RSA after previous surgery had better functional results.

Active elevation was 102°, external rotation 24°, internal rotation up to L4 in all patients. In patients without previous surgery treated with RSA, elevation was 116 °, external rotation 24°, internal rotation up to L3. In patients with previous surgery treated with RSA, elevation was 84°, external rotation 19°, internal rotation up to L4. These findings are not statistically significant on the level of significance of 95%.

In patients with acute fracture treated with RSA elevation was 124 °, external rotation 28°, internal rotation up to L4. In patients with chronic or sequelae of the fractures treated with RSA elevation was 114 °, external rotation 28°, internal rotation up to L3. Differences between these two groups are not significant on the level of significance of 95%.

Constant score in all patients was 54. Constant score in patients without previous surgery treated with RSA was 68 and with previous surgery was 42.

There were no intra-operative complications. One revision was performed because of the instability in the humeral part of the prosthesis in a patient who had previously undergone internal fixation with plate and screws. Primarily RSA was implanted without the bony support of the tuberosity and humeral metaphysis. At revision a long humeral stem was implanted and cemented. After the revision elevation was 90 degrees. There were no dislocation or infection after RSA.
Discussion

Malunions and nonunions of the proximal humerus result in significant shoulder dysfunction [12,13]. Preserving surgical techniques for this condition include corrective osteotomies, acromioplasty, arthroscopic and open shoulder adhesiolysis [18]. Biological surgeries have higher potential and better long-term functional result in comparison to arthroplasty.

Corrective osteotomies can improve arm function. Valgisation osteotomy in case of varus position of the proximal humerus bring perfect results [9,11,17,23]. Corrective osteotomy may improve rotation in case of malunions of the proximal humerus fracture. Acromioplasty, either open or arthroscopic, is performed in case of a malunion of the greater tuberosity which migrated cranially and causes a subacromial impingement during elevation. When the greater tuberosity healed with posterior displacement external rotation is blocked or is highly limited because of the impingement of the greater tuberosity with the posterior glenoid edge. In such cases osteotomy and reconstruction of the greater tuberosity with the rotator cuff leads to the improvement of elevation and external rotation of the arm.

One of the consequences of a conservative proximal humerus fracture with minimal displacement is stiff shoulder. In most cases there is an isolated greater tuberosity fracture or within a matter of anterior shoulder dislocation. In those patients arthroscopic joint capsule release, subacromial bursectomy or decompression give great results [21,22]. Other methods like shoulder arthrodesis are not recommended due to the fact that shoulder arthroplasty gives better functional results.

Functional results of hemiarthroplasty in case of proximal humeral fractures primarily depend on the tuberosity healing [6,20]. Because of inconsistent results after hemiarthroplasty, reverse shoulder arthroplasty found its spot in treatment of proximal humerus fractures. There are numerous reports that compare hemiarthroplasty to reverse shoulder prosthesis in acute fractures. Boyle and other co-workers report that five years follow up after surgeries
showed that reverse shoulder prosthesis implanted in patients with acute proximal humerus fractures had brought better functional result than hemiarthroplasty [5]. Cuff and co-authors inform of better clinical results of the RSA in older patients with the proximal humerus fracture compared to the patients after hemiarthroplasty [8]. Tuberosity healing was better in the RSA group in relation to hemiarthroplasty: 83% compared to 61%. Furthermore, forward elevation was also better in RSA group, 139 degrees in correlation to 100 degrees after hemiarthroplasty. ASES and SST scores were as well better in RSA group. Authors conclude that patients with RSA got more consistent and better results than those after hemiarthroplasty irrespective of the tuberosity healing. Patients after RSA whose tuberosity had healed had better elevation and external rotation. Patients with malunion or nonunion with incongruent glenohumeral joint cannot be effectively treated by soft tissue and bone correction surgeries [9].

That kind of patients need arthroplasty so that the damaged glenohumeral joint can be replaced. RSA has an advantage in comparison with hemiarthroplasty or total shoulder arthroplasty. Hemiartroplasty and TSA depend on soft tissue, primarily on the rotator cuff and bone abnormality degree. Shortening of the soft tissue as well as osteotomies of the great tuberosity lead to bad functional results [1]. Boileau points out that patients who underwent greater tuberosity osteotomy have bad outcome whilst they couldn’t reach 90 degrees of active elevation. Authors conclude that the main reason for a bad functional result was the greater tuberosity osteotomy and they suggest to avoid osteotomy if possible [4]. Boileau and co-authors prefer RSA over TSA in case of severe proximal humeral malunions [2]. RSA results depend on a good deltoid muscle function, rather than on rotator cuff function or on the glenohumeral joint integrity. The truth is that functional results are better if tuberosities of the humerus are preserved.
Poor outcomes of revision surgery are related to indications, bone quality and muscle balance [19]. Previously surgically treated patients had scar tissue, shortening of the soft tissue and malunion bone abnormalities.

Muh et al., reported a negative correlation between postoperative ASEC scores and increasing number of prior surgical procedures [16]. As against, Ek and co-authors (et al) have not found significant difference between patients that did not have previous surgeries and those that had at least one surgery [10]. Warner and co-authors report of an enhanced forward elevation in patients with reverse shoulder arthroplasty after prior surgery [24]. Warner i Muh state that the average forward elevation in patients with prior surgeries didn’t exceed 100 degrees Both authors report about prior surgeries performed on the rotator cuff. Our results as well show poor active forward elevation, 84 degrees in patients that had previous surgery, but as previous surgeries we regard proximal humerus fractures and their treatment, not surgeries on the rotator cuff or subacromial decompressions. In comparison to them patients with acute proximal humeral fractures after RSA had 124 degrees of forward elevation. Patients without previous operations but with malunions and non-unions also had much better forward elevation which reached 114 degrees. Results of this study confirm results of other authors’ analysis where patients that had previous operations, after RSA developed forward elevation under 100 degrees comparison to those that didn’t have operations before the RSA. Average forward elevation in patients with proximal humerus fracture without previous operations, after RSA was around 116 degrees, compared to 84 degrees of patients that had previous operations. Constant score was better as well in patients without previous operations. Constant score in a patients without previous surgery treated with RSA was 68 and with previous surgery was 42.
Reverse prosthesis are recommended in first intention in elderly patients, a population at risk of failure of hemiarthroplasty. Reverse prosthesis are contraindicated in young patients, except in specific situations, or in infection or axillary nerve injury [20].

We have three patients under age of 60 years, treated with RSA after unsuccessful previous surgical treatment. All of them had poor functional results, active forward flexion was under 100 degrees.
Conclusion

Our results show that patients treated with RSA without previous surgery in comparison with patients treated with RSA with previous surgery had better functional results. This study shows that RSA results are better in acute proximal humeral fractures than in fracture sequelae. The authors recommend implantation of reverse shoulder prosthesis as the first choice in elderly patients with acute proximal humeral fracture and in young patients as exception.
References:


16 Muh SJ et al. (2013) Early follow up of reverse total shoulder arthroplasty in young patients sixty years of age or younger JBJS Am 95:1877-83 doi: 10.2106/JBJS.L.10005


10.1016/j.otsr.2010.07.001


10.1016/j.ocl.2013.03.006
FIGURES:

Figure 1. 54 years old patient with fracture sequelae of the proximal humeral fracture after previous surgeries. A. X-ray before reverse shoulder arthroplasty (RSA). Osteosynthesis of the proximal humerus with plate and screws. Lack of the humeral head with glenoid damage. B. X-ray of the shoulder 2 years after RSA. Active abduction (C) and internal and external rotation 2 years after RSA (D and E).

Figure 2. 74 years old patient with fracture sequelae of the proximal humeral fracture without previous surgery. A. X-rays 7 months after four-part fracture of the proximal humerus. B. X-ray 3 years after reverse shoulder arthroplasty (RSA). Tuberosity healing around humeral body of the prosthesis. Active elevation (C), external (D) and internal rotation (E) 3 years after RSA. Ultrasound appearance of the infraspinatus tendon (F) and the subscapularis tendon after RSA with tuberosity healing (G).
TABLES:

Table 1. Indication for reverse shoulder arthroplasty

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-operative treatment</td>
<td></td>
</tr>
<tr>
<td>acute fracture</td>
<td>7</td>
</tr>
<tr>
<td>malunion</td>
<td>10</td>
</tr>
<tr>
<td>non-union</td>
<td>3</td>
</tr>
<tr>
<td>anterior shoulder dislocation with greater tuberosity fracture</td>
<td>1</td>
</tr>
<tr>
<td>Operative treatment</td>
<td></td>
</tr>
<tr>
<td>osteosynthesis</td>
<td>13</td>
</tr>
<tr>
<td>2 or more surgeries</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2. Range of motion after reverse shoulder arthroplasty

<table>
<thead>
<tr>
<th></th>
<th>Elevation</th>
<th>External rotation</th>
<th>Internal rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-operative treatment</td>
<td>116</td>
<td>24</td>
<td>L3</td>
</tr>
<tr>
<td>Operative treatment</td>
<td>84</td>
<td>19</td>
<td>L4</td>
</tr>
</tbody>
</table>

Table 3. Range of motion after reverse shoulder arthroplasty for patients without previous surgery

<table>
<thead>
<tr>
<th></th>
<th>Elevation</th>
<th>External rotation</th>
<th>Internal rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-operative treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>acute fracture</td>
<td>124</td>
<td>28</td>
<td>L4</td>
</tr>
<tr>
<td>fracture sequelae</td>
<td>114</td>
<td>24</td>
<td>L3</td>
</tr>
</tbody>
</table>
Nikola Cicak, MD, PhD

“Akromion”, Special Hospital for Orthopaedic Surgery

Ljudevita Gaja 2, 49217, Krapinske Toplice, Croatia,

Email: nikola.cicak@akromion.hr

20.11.2014.

COVER LETTER for “The Shoulder Issue”

Cover letter for manuscript “Functional outcome of reverse shoulder arthroplasty for acute proximal humeral fractures and fracture sequelae: with or without previous surgery.”

With this letter, I, professor Nikola Cicak, MD, PhD, warrant that this article is an original work, has not been published before, and is not being considered for publication elsewhere in its final form.

Hereby, I also declare that me and my co-authors do not have any conflict of interests. We didn't receive any fundings for publishing this case report. All authors have read and approved the contest of the manuscript.

Prof. Nikola Cicak, MD, PhD