 Acta Chir Orthop Traumatol Cech. 87, 2020, No. 4
p. 278–284

ORIGINAL PAPER
PŮVODNÍ PRÁCE

Improved Functional Outcomes with Reverse Shoulder Arthroplasty Compared to Hemiarthroplasty after Proximal Humeral Fractures in the Elderly

Lepší funkční výsledky reverzní artroplastiky ramena ve srovnání s hemiartroplastikou u zlomenin proximálního humeru u starších pacientů

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ABSTRACT

PURPOSE OF THE STUDY

Unsatisfactory functional results following hemiarthroplasty (HA) are seen in the treatment of 3- and 4-part proximal humeral fractures due to tuberosity healing problems and rotator cuff tears. Reverse shoulder arthroplasty (RSA) has been popular for improving functional outcomes. This study compares the results of HA and RSA in the treatment of comminuted proximal humeral fractures in the elderly.

MATERIAL AND METHODS

Patients over 60 years of age with three- or four-part proximal humeral fractures were included in the study. Twenty-five patients were treated with HA and 33 patients with RSA. The patients were evaluated with/using the American Shoulder and Elbow Surgeons (ASES) and Constant scores, active and passive ranges of motions of the shoulders and muscle strength measurements of HA and RSA patients were compared.

RESULTS

The mean age of the patients was 66 (60-85) years in the HA group and 73 (60-83) years in the RSA group. The mean ASES and Constant scores were 44.6 and 70 (p=0.06), 24 and 49 (p=0.022), respectively. The mean active abduction was measured as 50° and 90° (p=0.001), flexions as 70° and 120° (p=0.02), and external rotation as 30° and 50° (p=0.210), respectively.

CONCLUSIONS

In the treatment of three- or four-part proximal humeral fractures of the elderly, RSA gives significantly better functional results compared to HA.

Key words: proximal humeral fractures, hemiarthroplasty, reverse shoulder arthroplasty.

INTRODUCTION

Proximal humeral fractures (PHFs) are the most common fractures after hip and distal radius fractures (12). They occur as a result of high-energy trauma in young patients and may develop as a result of low energy trauma in elderly and osteoporotic patients. Eighty percent of proximal humerus fractures can be treated non-surgically. Surgical treatment is often required in displaced three- or four-part fractures (3, 24).

The patient's age, bone quality, fracture type, and time to surgery were reported to affect the functional outcomes (13). Arthroplasty is thought to be a surgical option in patients with osteoporosis, three- or four-part fractures, four-part fracture-dislocations, crush fractures involving chronic anterior and posterior dislocation and more than 40% of the joint face of the humeral head, split fractures separating the humerus head into small pieces, pathological fractures, and in neck fractures that cannot be treated by open reduction and internal fixation (10, 20).

Arthroplasty options include hemiarthroplasty (HA) and reverse shoulder arthroplasty (RSA). Both applications have superior or incomplete aspects in terms of functional results and complications.

In this study, mid-term clinical and functional outcomes of HA and RSA performed on patients over 60 years of age with three- and four-part PHF were compared.

Our hypothesis is to obtain similar clinical results in patients treated with HA and RSA.

MATERIAL AND METHODS

This study was approved by the local ethics committee. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the Declaration of Helsinki of 1964 and its later amendments or comparable ethical standards. Informed consent was obtained from all patients who participated in the study.

HA and RSA patients over 60 years of age with a diagnosis of three- and four-part proximal humerus non-pathological closed fracture were selected as the target group. Patients over 60 years of age with a three- and four-part fracture or fracture-dislocation of the proximal humerus who had undergone hemiarthroplasty or RSA at least 12 months ago were included in the study.

Exclusion criteria were as follows: patients with pathological fractures and open fractures, American Society of Anesthesiologists Score (ASA) 4 patients, patients with preoperative or postoperative neurovascular injury, and patients who did not attend routine physiotherapy programs.

Forty patients with HA and 40 patients with RSA were selected. After excluding the patients who had been lost to follow-up for any reason and those who did not comply with the standard rehabilitation program, the study was completed with 25 patients with HA and 33 patients who had undergone RSA.

Six patients in the HA group, 4 patients in the RSA group were lost to follow-up, and three patients in each of the groups were not included in the study because they did not comply with the routine physiotherapy program due to their comorbidities.

All patients underwent CT (scan, examination) with shoulder anteroposterior and scapula Y radiographs at the emergency department. The patients' fractures were evaluated according to the Neer classification.

Surgical technique and patient selection process

One surgeon (KB) performed all surgeries, which were performed under general anesthesia on a shoulder table in the beach chair position. A cefazolin sodium prophylaxis (1 g) was used. HA and RSA sets were available in all cases. A deltopectoral approach was used in all patients. In all patients, tenodesis was performed for the long head of the biceps tendon at the pectoralis major insertion. Fractured tubercles were released after opening the rotator interval between the subscapularis and supraspinatus tendons. The tuberculum minus and subscapularis tendon were excised together with the help of two 5-point Ethibond® sutures from the tendon/bone junction. The tuberculum majus, which was generally displaced posteriorly, was detected by three 5-point Ethibond® sutures from the tendon/bone junction. After tubercle fixation, the humeral head was removed.

To achieve randomization in patient selection, the last digit of the patient's ID number was used according to being odd or even. Patients with even ID numbers were treated with hemiarthroplasty, patients with odd ID numbers with RSA. Four patients with cuff tears were treated with cuff repair in the hemiarthroplasty group.

The head was set aside for prosthetic neck measurements and spongious grafts. A modular head of appropriate size was selected when HA was performed on the patient. In cases where the humeral head was comminuted, the size of the humeral head was adjusted according to the glenoid size. The biceps groove was drilled on two sides, approximately one cm distal to the fracture line, and Ethibond® sutures were inserted.

Humeral medulla rasping was performed in the 30° retroversion position in the HA (Depuy, Johnson) group, and the 20° retroversion position in the RSA (Depuy, Johnson) group, and the humeral components were placed in those positions. Tubercle fixation was performed in both the HA and RSA groups after the prosthesis was placed.

Before the tubercle fixation, previously removed chondral portions were cleaned as a head graft. Spongiose bones could be used as small pieces or as a block graft with the shaping of the bone obtained from the humeral head (Fig. 1).

After the grafts were placed, the tuberculum majus was temporarily fixed to the neck of the humeral stem with the appropriate tension. After the tuberculum minus was reduced, both tubercles were fixed according to the "Nice knot" technique, and horizontal stability was achieved (5). The sutures, which were placed on both sides of the biceps previously, were placed in a vertical configuration with the sutures in both tubercles in cross-configuration. The rotator interval was closed in HA and left open in RSA (Fig. 2, 3).

The tightness, stability and block motion of the tubercles with prostheses were controlled, and the deltopectoral interval and skin were closed.

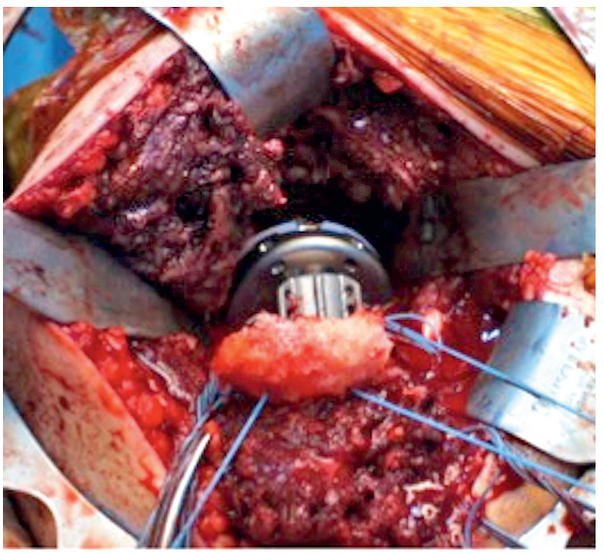

Fig. 1. Humeral head grafting and tubercle fixation.

Fig. 2a. Preoperative X-ray of a patient with proximal humerus fracture.

Fig. 2b. Mid-term follow-up X-ray of the patient undergoing shoulder hemiarthroplasty.

Fig. 2c. Clinical results of the patient.

Postoperative rehabilitation and functional assessment

The patients were rehabilitated with isometric exercises on the day following the procedure with a physiotherapist and continued until the second week. At the outpatient-clinic control/check performed two weeks later, the patients' stitches were removed, and passive elbow movements and pendulum exercises were started. After the fourth week, passive shoulder movements, and if there was radiological evidence of union, active exercises, were started in the sixth week with the physiotherapist.

Functional and radiological evaluations of the patients who were followed for 12 months to 66 months were performed. Functional results were evaluated using Constant and ASES scores by a shoulder surgery fellow who was blinded to the surgery.

In the postoperative follow-up, the patients were evaluated by taking the shoulder AP, shoulder true AP, scapula-Y, and axillary radiographs. Postoperative CT was routinely used to better assess tubercle union.

Statistical evaluation

Statistical analysis was performed using SPSS version 12 (SPSS Inc., Chicago, IL). Means, standard deviations and frequencies were calculated to summarize the study data. Normal distributions were investigated using the Shapiro-Wilk test. Continuous variables were compared by a Mann-Whitney U test, and a χ^2 test was used for categorical variables. The threshold for significance was set at $p < 0.05$.

RESULTS

A total of 58 patients (25 in the HA group vs 33 in the RSA group) were evaluated at the final follow-up. In the HA group, 22 patients had a proximal humerus fracture following a simple fall, two had a traffic accident and one had an epileptic seizure. In the RSA group, 30 patients had a simple fall, two had a traffic accident and

Fig. 3a. Preoperative X-ray of a patient with proximal humerus fracture.

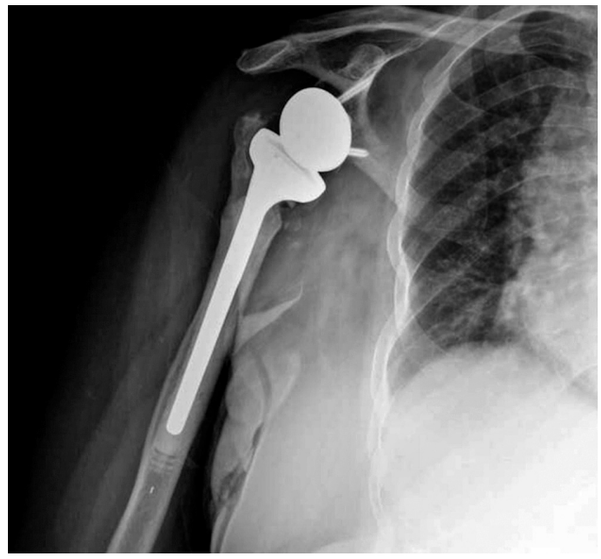

Fig. 3b. Mid-term follow-up X-ray of the patient undergoing reverse shoulder arthroplasty.

Fig. 3c. Clinical results of the patient.

one was admitted following a fall from a certain height. No significant demographic differences were observed between the HA and RSA groups with regard to gender, dominant side, associated pathologies, and smoking. The RSA patients were significantly older, and the mean follow-up was longer in the HA group ($p < 0.05$). Four-part fracture types were most common in both groups (Table 1).

The rate of anatomic union of the greater tuberosity was observed in 12 patients in the HA group and in 20 patients in the RSA group. The overall complication rates were 36% and 13% in the HA and RSA groups, respectively ($p < 0.05$) (Table 2).

The patients in the RSA group achieved significantly greater degrees of abduction and forward elevation in both passive and active movements and passive external rotation in 90-degree abduction than the HA group ($p < 0.05$). In the other directions, the range of motion was similar in both groups. The external rotation strength was better in the RSA group; however, the forward elevation and abduction strength did not reveal a significant difference. In the clinical results, the mean Constant scores were significantly better in the RSA group ($p < 0.05$), while no difference was observed in the mean ASES scores (Table 3).

DISCUSSION

The principal findings of this study showed that the patients in the RSA group had better functional outcomes compared to the HA patients in the treatment of 3- and 4-part proximal humerus fractures.

The treatment modalities of the proximal humerus in the displaced fractures of the proximal humerus have always been open to discussion. In young patients with good bone quality, osteosynthesis should be tried in such fractures, which often occur with high-energy trauma, despite the high probability of necrosis of the head. However, arthroplasty may be considered primarily in the osteoporotic fractures of low-energy trauma, especially in the elderly. In these patients, the results of arthroplasty performed after osteosynthesis attempts resulting in necrosis of the head, nonunion, and poor union were shown to be unsuccessful in comparison to primary arthroplasty after fracture (14, 19). For this reason, arthroplasty options may be considered a priority in the fracture-fracture dislocations of the proximal humeral and fractures of the head.

Table 1. Patient demographic data

	HA group n = 25	**RSA group** n = 33	***P***
Age (years)*	66 ± 7.8	73 ± 6.4	<0.05
Follow-up (months)*	52 ± 15.4	27 ± 6.1	<0.05
Gender	18 female	21 female	0.51
Dominant extremity	16 (48,5%)	20 (60.6%)	0.62
Associated disease	11 (44%)	18 (54.5%)	0.46
Smoking	3 (12%)	3 (9.1%)	0.71
Neer type 3 Neer type 4	11 (44%) 14 (56%)	7 (21%) 26 (79%)	0.68

*Statistically significant difference

Table 2. Postoperative radiographic outcomes and complication rates

	HA group	**RSA group**	***P***
Healing of the greater tuberosity complete union malunion nonunion resorption	12 (48%) 5 (20%) 3 (12%) 5 (20%)	20 (606%) 4 (12.1%) 3 (9.1%) 6 (18.2%)	0.33
Complications none* periprosthetic infection soft-tissue infection subscapularis deficiency superior escape glenoid osteolysis stem loosening periprosthetic fracture	16 (64%) 1 (4%) 1 (4%) 2 (8%) 4 (16%) 1 (4%) - -	29(87%) 1 (3%) 1 (3%) - - - 1 (3%) 1 (3%)	<0.05

*Statistically significant difference

In the literature, there are studies showing that HA is successful in terms of pain relief but insufficient in terms of providing movement range (21, 23). It was determined that the problem was caused by technical errors in the prosthesis application.

For successful treatment with shoulder arthroplasty after PHFs, the tubercles should be fixed in the appropriate position. Boileau P et al., in a multicenter study, reported poor clinical outcomes in approximately half of the patients who underwent HA after three- and four-part acute PHFs. The cause of poor results was tubercle malposition, which caused the migration of the prosthesis to the superior, causing stiffness or weakness and permanent pain. As the cause of failure of tubercle osteosynthesis, the prosthesis was overly elevated and retroverted, and the malposition of the tuberculum majus and osteoporosis was shown (4). Another important factor affecting the functional outcome of HA in addition to tubercle healing is the condition of the rotator cuff. Gronhagen et al. reported that deterioration of rotator cuff integrity would lead to functional failures (11). Shah N et al. reported that HA results were directly related to rotator cuff quality and integrity, irrespective of age and sex (18). Robinson et al. reported that the presence of tubercles in the retracted position is a sign of poor prognosis and that early tubercle displacement is a cause of revision (16). In their ultrasound study, Westhoff et al.

Table 3. Summary of clinical outcomes

	HA group	**RSA group**	***P***
Passive ROM, mean degree (range) internal rotation	60 (0–100)	60 (20–90)	0.63
external rotation	40 (10–100)	60 (20–100)	0.15
abduction*	70 (40–170)	90 (20–170)	<0.05
forward elevation*	90 (50–170)	130 (70–180)	<0.05
external rotation in 90-degree abduction*	20 (0–94)	40 (10–76)	<0.05
Active ROM, mean degree (range)			
internal rotation	50 (0–90)	40 (10–80)	0.19
external rotation	30 (0–90)	50 (0–90)	0.21
abduction*	50 (30–160)	104 (40–180)	<0.05
forward elevation*	70 (40–170)	120 (60–160)	<0.05
External rotation in 90–degree abduction	10 (0–74)	30 (0–60)	0.09
Strength, mean kg, (range) forward elevation abduction external rotation*	 2.7 (1–8.1) 2 (0.3–7.5) 1.1 (0–8.3)	 2.8 (0–6.6) 2.3 (0–6.1) 3.4 (0–7.8)	 0.11 0.44 <0.05
ASES (range)	44,6 (17,5–98,3)	70 (11,6–88,3)	0.06
Constant* (range)	24 (9–90)	49 (13–78)	<0.05

*Statistically significant difference

did not find rotator cuff pathology in patients with excellent results according to the Constant score, but they found pathologic changes in soft tissues, especially rotator cuff tears, in patients with poor outcomes (22). Similarly, in most studies, instability, which is secondary to tubercle and rotator cuff problems, has been reported as the most common complication (2, 15). In our study, the tubercle union ratio in the appropriate position was higher in the RSA group, but we did not find any statistically significant difference.

RSA extends the moment arm of the deltoid muscle by shifting the shoulder rotation center medially and inferiorly. Thus, the active forward flexion and abduction movement of the shoulder is ensured by the strength of the deltoid muscle. RSA, which works relatively independently from rotator cuffs, has gained a significant place in the treatment of elderly comminuted fractures in recent years. Theoretically, the long-term survival of HA is superior to non-anatomical RSA because it is an anatomical design where the tubercles and rotator cuff are robust and functional. However, the fact that the early results of the RSA in terms of pain and functional gains are promising has led to an advantageous position among treatment options. From the beginning of RSA, several complications have been reported, including hematomas, infections, acromion stress fractures, early implant failures/loosening, scapular fractures and neurological injuries (7, 8). It is not possible to mention a specific complication of RSA in fractures. The most commonly reported postoperative complication is instability with an incidence of 4.7% (9, 25).

Although scapular notching is a frequently discussed complication, the effect of this finding on functional scores is controversial. In our study, RSA was superior to HA in terms of complication rates. Superior escape and subscapularis deficiency seen in the hemiarthroplasty group are the most frequently reported complications in the literature and negatively affect the functional outcomes (17). In our study, superior escape was seen in 4 patients, and subscapularis deficiency was observed in 2 patients.

In the current literature, there is no proven study describing the optimal rehabilitation program after RSA. Acevedo et al. reported that the neutral rotation position and the abduction pad reduced the risk of tubercle displacement by reducing stress on the greater tubercle. Two weeks later, they allowed the patient to remove the sling for simple household chores at the shoulder level. At the end of six weeks, they used a pulley assembly at home to remove the sling and recover passive movements. At this stage, they allowed the patient to use the shoulder as much as the patient could. They did not routinely practice a strengthening exercise program. They initially reported that restricting the patient's movements for a period of time was necessary for tubercle healing (1). In our routine practice, we restricted the joint motion for/of our patients until the tubercle healed.

Since the publication of studies comparing RSA and HA, these initial results of TOA have been promising for fractures. It was noted that arthroplasty was not able to provide pre-traumatic shoulder functions, especially in three- to four-part PHFs; the HA results were much more affected from tubercle healing than patients treated with RSA. It has been reported that RSA is faster, more reliable and predictable and is successful in abduction, forward flexion and pain control, but insufficient for rotation and survival (scapular notching). If these two negativities of RSA can be eliminated, it can be safely used in patients younger than 70 years (6). In the literature, there was a significant difference in favor of RSA in forward flexion, abduction and functional scores compared to HA in our study.

Our study has certain limitations. First, the study included a relatively small number of patients. Although the selection of patients was randomized, rotator cuffs of the patients might not be in the same condition.

CONCLUSIONS

In our study, the ASES and Constant scores, forward flexion, abduction, external rotation, muscle strength measurements and patient satisfaction were found to be superior in the RSA group and internal rotation was superior in the HA group.

Level of evidence: *level 2, prospective comparative study*

Compliance with ethical standards: *all authors in this study declare that they have no conflict of interest. No benefits have been or will be received from a commercial party related directed or indirectly to the subject matter of this article.*
This article does not contain any studies with animals performed by any of the authors. This study had an ethical committee approval from the local institution (no: 54132726-000-6237).
Informed consent was obtained from all individual participants included in the study.

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