

Hemiarthroplasty versus reverse shoulder arthroplasty: comparative study of functional and radiological outcomes in the treatment of acute proximal humerus fracture

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Abstract

Purpose To compare functional and radiographic results of reverse prosthesis versus hemiarthroplasty after complex displaced proximal humeral fractures in elderly patients when adequate ORIF cannot be achieved and prosthetic shoulder replacement is required.

Methods From 2008 to 2012, 67 patients were treated with hemiarthroplasty or reverse arthroplasty. We evaluated 53 cases with an average follow-up of 27.5 months (range 12–64). Twenty-eight patients with an average age of 71.4 years were treated with a hemiarthroplasty and 25 patients with an average age of 77.3 years with a reverse prosthesis. All patients were assessed before and after surgery by Constant–ASES–DASH score, strength in abduction, ER1, ER2, and X-rays.

Results In hemiarthroplasty group, we observed a mean Constant score of 42.3 pt, ASES score 51.3 pt, and DASH score 46.1, with an average strength of 1.3 lb in abduction and of 3.7 lb in ER1 and 1.8 lb in ER2. In reverse arthroplasty group, we measured a mean Constant of 56.2 pt, ASES 69.3 pt, and DASH score 40.4, with an average strength of 4.3 lb in abduction and of 3.3 lb in ER1 and 3.2 lb in ER2. Radiographically, it is interesting to observe that greater tuberosity healing rate was 37 % in

hemiarthroplasty group compared to 84 % in reverse arthroplasty group. About complications, the highest rate was recorded in the hemiarthroplasty group.

Conclusion Reverse shoulder arthroplasty indication is steadily increasing in acute displaced proximal humeral fracture. Pain and articular movement results appear better than those with hemiarthroplasty. Our data are similar to the international literature.

Keywords Hemiarthroplasty · Reverse shoulder arthroplasty · humeral proximal fracture

Introduction

Proximal humeral fractures account for nearly 5 % of all fractures and are the third most common fracture after hip fractures and distal radial fractures [1–4]. A large percentage of all proximal humeral fractures (80 %) are very stable and can be treated non-operatively. Displaced and unstable fractures (20 %) often require surgical treatment to avoid painful and dysfunctional malunion [5, 6]. There are numerous treatment strategies for displaced fractures: osteosynthesis and shoulder replacement [6–9]. Fixation strategies include percutaneous pinning [10] or cannulated screws, fixed angle locking plates [11, 12], and intramedullary nails [13]. Hemiarthroplasty and reverse total shoulder replacement are options for elderly patients with comminuted three- and four-part fractures with high rates of avascular necrosis (AVN9) [12, 14–25]. Nowadays these are indicated for four-part fractures, fracture dislocations, displaced fractures of the anatomic neck or impaction fractures of the humeral head involving more than 40 % of the joint surface [7]. The present study compared short-term clinical and X-ray results following treatment of four-

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Fig. 1 C.A., woman, 84 years: proximal humeral fracture on *right* side and, 8 months later, proximal humeral fracture on *left* side

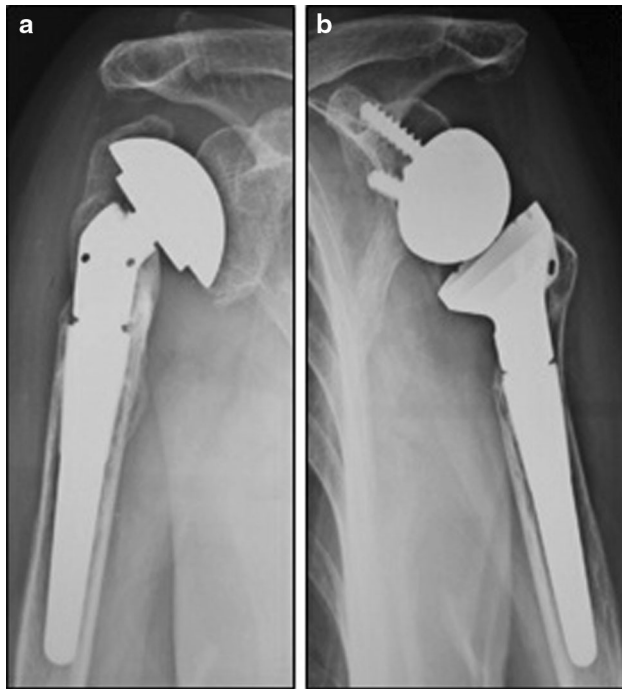
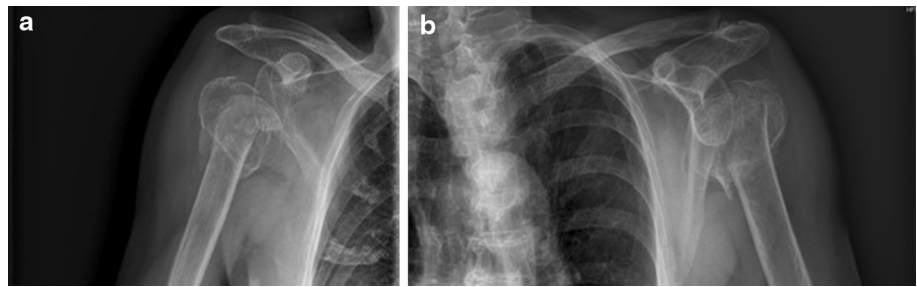


Fig. 2 C.A., woman, 84 years: result after treatment with hemiarthroplasty on *right* side and RSA on *left* side

part displacement fractures of the proximal humerus by hemiarthroplasty or by reverse prosthesis.

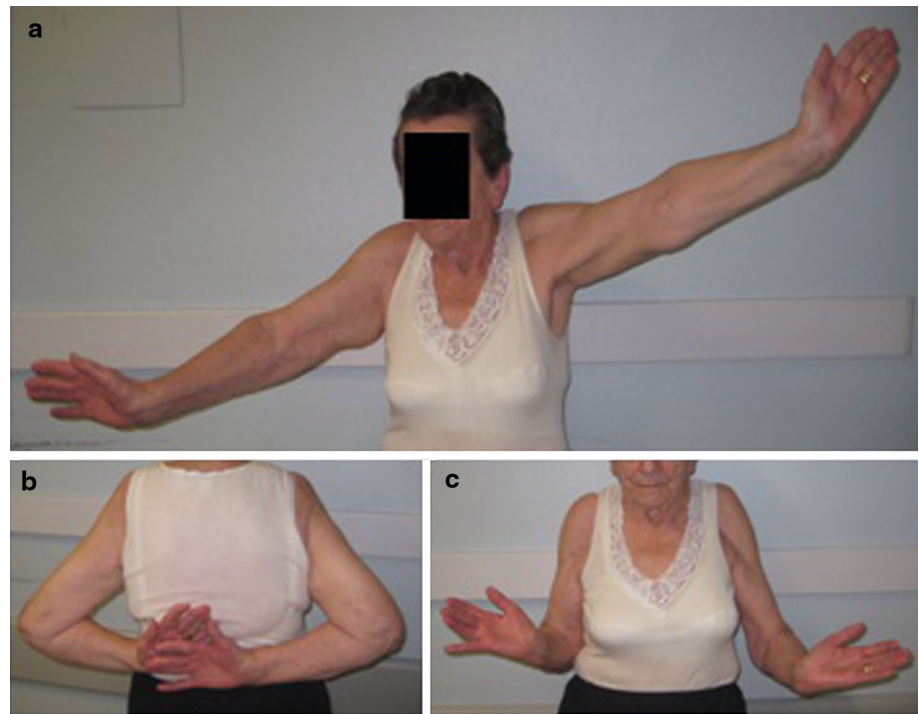
Materials and methods

From January 2008 to December 2012, 67 patients underwent shoulder replacement for three- or four-part displaced fractures of the proximal humerus at the Policlinico Hospital of Modena and the Ramazzini Hospital of Carpi (Mo). Of these 67 patients, 6 died for causes not related to surgery, and 8 were lost to follow-up. Therefore, 53 patients were reviewed: 28 with hemiarthroplasty and 25 with reverse shoulder arthroplasty (RSA); 1 patient was treated bilaterally: first on the right shoulder with hemiarthroplasty; and, 8 months later, she was treated with RSA for a fracture of the left proximal humerus (Figs. 1a, b, 2a, b, 3a–c). Before surgery, rotator cuff evaluation was

conducted indirectly for further diagnosis by CT scan examination, on 18 patients in the hemiarthroplasty group, and 20 in the RSA group. In these cases, muscle tropism was analyzed to identify indirect signs of cuff tear. An evaluation of the status of the rotator cuff was made intraoperatively for every patient.

The operations were performed under general anesthesia. The patients were disposed in the beach-chair position, and a deltopectoral approach was adopted on all patients. There were three surgeons for the hemiarthroplasty group and two for the reverse shoulder group. The patients were predominantly women (46 vs. 7) and 31 cases involved the dominant side. The RSA patients were significantly older than the hemiarthroplasty patients (at the time of surgery mean age, 77 vs. 70 years). The mean follow-up was 27 months: 26 months for the hemiarthroplasty group and 27 months for the RSA group. Surgical treatment was performed at a mean of 6.1 days following acute injury in the hemiarthroplasty group and 6.7 days in the RSA group. According to the Neer classification, the hemiarthroplasty group included eleven patients with a four-part varus fracture, nine with a four-part valgus fracture, and eight with humeral head dislocation. The RSA group included five patients with a four-part varus fracture, thirteen with a four-part valgus fracture, and seven with humeral head dislocation. In all cases, the tuberosities were reattached, when possible, using cerclage sutures to fix the tuberosities to each other, to the prosthesis, and to the shaft. Three types of prostheses were implanted in the hemiarthroplasty group: Aequalis Tornier®, Gerber Zimmer®, and SMR Lima; three types in the RSA group: Zimmer®, SMR Lima®, and Delta X-tend De-Puy®. The presence of rotator cuff tears was pre- or intra-operatively detected in five patients in the hemiarthroplasty group (five partial lesions according to the Gerber classification) and in nineteen patients in the RSA group (3 partial, 6 complete, and 10 massive lesions), which represents a statistically significant difference ($p < 0.05$). Postoperatively, patients were immobilized in Desault's bandages and started exercises on a passive range of motion (ROM) on the 24th postoperative day in the hemiarthroplasty group, and on the 15th day in

Fig. 3 C.A., woman, 84 years: clinical outcome after treatment with hemiarthroplasty on *right* side and RSA on *left* side



the RSA group. Patients of both groups were reviewed retrospectively by an independent assessor. All patients underwent clinical examination, comprising measurement of active joint amplitude in the operated shoulder, with Constant and Constant modified scores. Subjective assessment was made using the DASH functional score and p-ASES score. Strength was measured using an isokinetic dynamometer, and the strength ratio was calculated relative to the healthy contralateral side. All patients underwent standard X-ray examination, including a frontal shoulder view under the three rotations (neutral, external, and internal) and an axillary view, making it possible to evaluate whether the repaired tuberosities were consolidated, displaced, or reabsorbed. Statistical analysis was undertaken utilizing the Statistical Analysis Software STATA 11 (Policlinico, Modena). Continuous measurements were analyzed using the Student's *t* test, and categorical or ordinal data were analyzed using the Fisher's and χ^2 tests. *p* values < 0.05 were considered significant.

Results

The reverse total shoulder arthroplasty (RSA) group had a significantly greater active forward elevation and abduction (respectively, mean $131^\circ \pm 36^\circ$ and $128^\circ \pm 36^\circ$) than the hemiarthroplasty group (respectively, mean $89^\circ \pm 44^\circ$ and $82^\circ \pm 40^\circ$). This difference was statistically significant (*p* < 0.05). Active external rotation was $15^\circ \pm 11^\circ$ for the reverse total shoulder arthroplasty

group and $23^\circ \pm 15^\circ$ for the hemiarthroplasty group. There was no significant difference between the RSA and hemiarthroplasty groups for internal rotation (respectively, 3.3 vs. 3). Mean Constant, Constant modified, and p-Ases scores (Table 1) were significantly better for the RSA group (respectively, 56.2 ± 14.9 vs. 42.3 ± 16.6 , 81.5 ± 22.3 vs. 58.1 ± 22.5 , and 69.3 ± 15.0 vs. 51.3 ± 25.4 ; *p* < 0.05). The two groups did not significantly differ in mean DASH scores even if the RSA group had a better result (40.4 ± 25.0 vs. 46.1 ± 27.9). In the RSA group, there were no patients under 65 years old and the different results between the two types of prostheses were amplified in older patients. In patients >65 and <75 years old (Table 2), mean Constant score and modified mean Constant score were better for the RSA group than the hemiarthroplasty group (respectively, 61.3 ± 15.2 vs. 37.2 ± 11.2 and 86.3 ± 22.2 vs. 52.8 ± 17.2 ; *p* < 0.05). Abduction and flexion were better in RSA (respectively, $136.1^\circ \pm 36.7^\circ$ vs. $66.7^\circ \pm 20.4^\circ$ and $135.6^\circ \pm 35.4^\circ$ vs. $76.7^\circ \pm 27.3^\circ$; *p* < 0.05). External rotation was better in the RSA group ($18.9^\circ \pm 10.8^\circ$ vs. $15.0^\circ \pm 5.5^\circ$). DASH score and p-ASES score were better in the RSA group (respectively, 33.7 ± 22.6 vs. 54.0 ± 28.3 and 73.9 ± 13.3 vs. 48.3 ± 23.2). In patients >75 years old (Table 3), mean Constant score, modified mean Constant score, and p-ASES score were better for the RSA group than the hemiarthroplasty group (respectively, 52.1 ± 14.2 vs. 40.3 ± 17.8 , 77.9 ± 23.0 vs. 59.1 ± 26.7 , and 66.7 ± 16.3 vs. 46.2 ± 24.0 ; *p* < 0.05). Abduction and

Table 1 Summary of clinical outcome comparing

	No. of patients	Mean constant \pm SD	Mean constant modified \pm SD	Mean constant pain	Mean constant ADL	Mean constant strength	Mean constant ROM	Mean DASH \pm SD	Mean p-Ases \pm SD
HA	28	42.3 \pm 16.6 [#]	58.1 \pm 22.5 [#]	9.1 \pm 4.3 [#]	11.9 \pm 4.4	2.1 \pm 3.4 [#]	19.6 \pm 8.2 [#]	46.1 \pm 27.9	51.3 \pm 25.4 [#]
RSA	25	56.2 \pm 14.9 [#]	81.5 \pm 22.3 [#]	13.6 \pm 2.7 [#]	14.9 \pm 4.5	3.8 \pm 2.6 [#]	24.0 \pm 8.4 [#]	40.4 \pm 25.0	69.3 \pm 15.0 [#]
Total	53	48.8 \pm 17.1	69.1 \pm 25.1	11.2 \pm 4.3	13.3 \pm 4.7	2.9 \pm 3.1	21.7 \pm 8.5	43.4 \pm 26.5	59.8 \pm 22.9

[#] Student's *t* test, *p* < 0.05

RSA reverse shoulder arthroplasty, HA hemiarthroplasty, SD standard deviation, ROM range of movement, ADL activity daily living

flexion were better in the RSA group (respectively, 119.6° \pm 33.7° vs. 80.4° \pm 38.8° and 125.3° \pm 34.6° vs. 83.3° \pm 42.9°; *p* < 0.05). External rotation was better in the hemiarthroplasty group (22.9° \pm 15.0° vs. 13.7° \pm 9.7°). The DASH score was slightly better in the RSA group (44.1 \pm 27.1 vs. 47.8 \pm 24.3).

The strength ratio (relative to the healthy contralateral side) was better in the RSA group: In abduction, the strength recovery of the operated shoulder was 15 % in the hemiarthroplasty group and 79 % in the RSA group; in external rotation, the strength recovery was 50 % in the hemiarthroplasty group and 60 % in the RSA group. Under X-ray examination, tuberosity consolidation was judged good in 10 patients (37 %) in the hemiarthroplasty group and in 21 patients in the RSA group (84 %). This difference was statistically significant (*p* < 0.05). In the other cases, there was resorption or dislocation of the tuberosity. Six complications were verified in the hemiarthroplasty group: Two patients had a septic mobilization of humeral stem, one had pulmonary embolism, and three had severe rigidity. In the RSA group, there was only one case of transitory axillary palsy (already present before surgery).

Discussion

Osteosynthesis with preservation of the humeral head is indicated when adequate reduction and stable conditions for revascularization can be obtained [26, 27]. If osteosynthesis is not possible, especially in older, uncompliant patients with osteopenic bone and comminuted fractures, shoulder arthroplasty seems to be a viable alternative [5, 28, 29]. Traditionally, the most common arthroplasty for proximal humeral fractures has been hemiarthroplasty [21, 22, 30, 31]. However, long-term results have demonstrated limits with this procedure in terms of pain relief, range of motion, and complications [31–34]. The reverse shoulder prosthesis, originally introduced for the resolution of rotator cuff arthropathy [4, 35, 36], has been suggested as an alternative in the treatment of acute fractures. Reverse

prostheses may be recommended in elderly patients with risk factors for poor results in hemiarthroplasty: poor tuberosity status, preoperative rotator cuff tears, or inability to support prolonged immobilization and specific rehabilitation (necessary after hemiarthroplasty) [23–25, 37–40]. There are only a few comparative reports in literature. Young et al. [41] evaluated a consecutive series of 10 patients treated with hemiarthroplasty and 10 with reverse total shoulder arthroplasty. They reported no statistical differences in the evaluated (p-ASES) and ROM scores, although it was stated that there were several weaknesses in the study: its non-randomized nature, a relatively small number of participants, and discrepancy in mean follow-up times between the two groups. Gallinet et al. [42] observed poor results after hemiarthroplasty (17 patients), resulting in a statistically significant difference when compared with reverse total shoulder arthroplasty (16 patients). Better results in RSA were detected in abduction (91° vs. 60°), anterior elevation (97.5° vs. 53.5°), and pain resolution while external rotation was better in the hemiarthroplasty group (13.5° vs. 9°). Aldegheri et al. [43] reported better results in the RSA group (17 patients, mean constant score 75) versus the hemiarthroplasty group (33 patients, mean constant score 63). These results differ especially in strength, activity, daily living, and ROM. Sirveaux et al. [7] reported that hemiarthroplasty results were bimodal and dependent on tuberosity healing, especially as regards range of motion. Gallinet et al. [44] also analyzed the effect of tuberosity repair in complex fractures of the proximal humerus treated by reverse shoulder arthroplasty to restore rotation and thus improve the functional outcome. Shoulder rotational ability was improved by systematically repairing the tuberosities around the implant. When anatomic consolidation is obtained, the functional result is better. In the present study, it was noticed that for patients treated of ages between 65 and 74 years, the RSA group exhibited a better clinical outcome than the hemiarthroplasty group for all types of movement, and Constant, ASES, and DASH scores were also better in the RSA group. As demonstrated in recent literature [41, 45], these findings are directly related to tuberosity healing, which was identified in the

Table 2 Patients treated of ages between 65 and 74 years

Age 65–74 years old	No. of patients	Mean constant \pm SD	Mean constant modified \pm SD	Mean DASH \pm SD	Mean p-Ases \pm SD	Mean anterior elevation \pm SD	Mean abduction \pm SD	Mean external rotation \pm SD	Mean internal rotation \pm SD
HA	6	37.2 \pm 11.2 [#]	52.8 \pm 17.2 [#]	54.0 \pm 28.3	48.3 \pm 23.2	76.7 \pm 27.3 [#]	66.7 \pm 20.4 [#]	15.0 \pm 5.5	2.7 \pm 1.0
RSA	9	61.3 \pm 15.2 [#]	86.3 \pm 22.2 [#]	33.7 \pm 22.6	73.9 \pm 13.3	135.6 \pm 35.4 [#]	136.1 \pm 36.7 [#]	18.9 \pm 10.8	3.4 \pm 1.8

[#] Student's *t* test, $p < 0$

Table 3 Patients treated of ages over 75 years

Age >75 years old	No. of patients	Mean constant \pm SD	Mean constant modified \pm SD	Mean DASH \pm SD	Mean p-Ases \pm SD	Mean anterior elevation \pm SD	Mean abduction \pm SD	Mean external rotation \pm SD	Mean internal rotation \pm SD
HA	12	40.3 \pm 17.8 [#]	59.1 \pm 26.7 [#]	47.8 \pm 24.3	46.2 \pm 24.0 [#]	83.3 \pm 42.9 [#]	80.4 \pm 38.8 [#]	22.9 \pm 15.0*	3.4 \pm 1.3*
RSA	16	52.1 \pm 14.2 [#]	77.9 \pm 23.0 [#]	44.1 \pm 27.1	66.7 \pm 16.3 [#]	125.3 \pm 34.6 [#]	119.6 \pm 33.7 [#]	13.7 \pm 9.7*	2.7 \pm 1.4*

[#] Student's *t* test, $p < 0.05$

* χ^2 test, $p < 0.05$

final X-ray examination of seven cases in the RSA group. In the hemiarthroplasty group, only one case of healed tuberosity was identified in the final X-ray examination. The small number of cases and low follow-up rates possibly represent weaknesses in this study, and an increased number of patients could confirm the results.

Seven complications were observed in this study, six in the hemiarthroplasty group and one in the RSA group. In the former group, one patient developed a pulmonary embolism (resolved with medical therapy), and two patients generated deep infection with mobilization of the humeral stem and were subjected to surgical debridement and subsequently revision with RSA within 2 years of initial surgery. Finally, three hemiarthroplasty patients showed severe rigidity or pseudoparesis of the shoulder with resorption of the tuberosities and underwent a second surgical revision with RSA within 2 years of the initial treatment. In the RSA group, one case of transitory axillary palsy was observed, already present before the surgery, with gradual improvement at subsequent checks. No patients in the RSA group were subjected to any revision procedures. Similar percentages of complications and revision procedures were also noted in a recent study by Cuff and Pupello [46]: In this study, 53 proximal humeral fracture patients were treated with shoulder arthroplasty by the authors. Cuff et al. focused attention on the importance of tuberosity healing for an improved clinical outcome: In the same study, 30 % of the patients that exhibited resorption of tuberosities were treated with revision procedures. The present authors found comparable results: 14 patients in the hemiarthroplasty group exhibited tuberosity resorption, and in five cases (two deep infections and three pseudoparesis), surgical revision of the implant was necessary.

This study suffers from a few weaknesses: It is retrospective and not prospective, and the types of prostheses

used in both groups are not the same, with three similar systems being used in both groups. Finally, the surgeon was not the same for every intervention, although surgical treatment was always performed by three experienced shoulder surgeons in the hemiarthroplasty group and two in the RSA group.

Conclusions

Shoulder arthroplasty for proximal humerus fracture is an operation to be planned in detail, taking into account not only the kind and severity of the fracture but also the patient and any comorbidities. Preoperatively, it is important to consider the key factors of age, fracture type, bone quality, rotator cuff tears, tuberosity comminution, and functional demands of the patient. Before surgery, a CT scan is very useful in order to carefully determine the fracture type, other concomitant and unnoticed fractures, and any fatty muscle degeneration. For patients under 65 years of age, hemiarthroplasty is the gold standard and good results have been obtained especially in patients who performed specific rehabilitation. Over 65 years of age, reverse shoulder arthroplasty is a valid alternative in patients who are uncompliant and with complete or massive rotator cuff tearing. A low incidence of complications, and a better range of movement and shoulder scores in the reverse shoulder arthroplasty group are encouraging results. However, differences in the complication and revision rates between the two groups should be interpreted with caution because of the short follow-up. Nowadays, improvements in shoulder arthroplasty techniques, instrumentation, and implants, have made available a modular prosthesis system, which the authors recommend using.

Conflict of interest P. Baudi, G. Campochiaro, F. Serafini, G. Gazzotti, G. Matino, C. Rovesta, F. Catani declare that they have no conflict of interest.

Informed Consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). All patients provided written informed consent to enrolment in the study and to the inclusion in this article of information that could potentially lead to their identification.

Human & Animal Studies The study was conducted in accordance with all institutional and national guidelines for the care and use of laboratory animals.

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