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Reverse shoulder arthroplasty for fracture sequelae: How the initial fracture treatment influences the outcomes of joint replacement

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ABSTRACT

Objective: The aim of this study was to analyze and compare the results of reverse shoulder arthroplasty (RSA) in proximal humeral fracture sequelae (PHFS) in fractures initially treated conservatively versus those initially treated with open reduction and internal fixation (ORIF).
Methods: It is a retrospective study that includes all PHFS treated with a RSA from September 2006 to December 2013. Twenty-seven patients met the inclusion criteria. There were 9 patients (7 females and 2 males; mean age: 79.11 years) treated with RSA due to a fracture sequelae following conservative treatment and 18 patients (15 females and 3 males; mean age: 76.83 years) treated with a RSA owing to a fracture sequelae after ORIF.
The functional outcome was recorded with the aid of the pre-surgery Constant Score and at the latest follow-up (minimum of two years). All the patients included underwent an imaging study that included plain X-Rays and a CT scan prior to surgery and plain X-Rays after surgery. All complications and reoperations during follow-up were also recorded.
Results: Both groups had significantly increased Constant Scores after surgery ($p < 0.0001$), but the patients in the conservative group had significantly better outcomes for the total Constant Score ($p = 0.024$), for forward elevation ($p = 0.026$) and for external rotation ($p = 0.004$).
A total of 4 complications (14.8%) were present during the follow-up period. In the conservative group, 1 patient developed an infection and there were 2 dislocations and 1 infection in the ORIF group.
Conclusion: The use of RSA in the treatment of PHFS results in a limited outcome improvement but with an acceptable complication rate. Patients developing PHFS after conservative treatment may expect better outcomes and fewer complications than those developing PHFS after ORIF.
Level of evidence: Level IV, Therapeutic Study.

Introduction

The management of complex proximal humeral fractures is still a controversial topic. While some authors are in favor of conservative treatment, especially in the elderly, others advocate for surgical treatment that includes a diversity of options. Open reduction and internal fixation (ORIF), hemiartroplasty or reverse shoulder arthroplasty (RSA) are some of them (Fig. 1).

Despite of the treatment chosen, some patients evolve to persistent pain and dysfunction requiring further surgery. Several different complications have been described with the use of ORIF. They include mal-unions, non-unions, cephalic avascular necrosis, a loss of reduction and hardware complications.[1–4] Surgery of fracture sequelae is challenging and usually leads to limited functional results and may also result in a high complication rate.[5–23]

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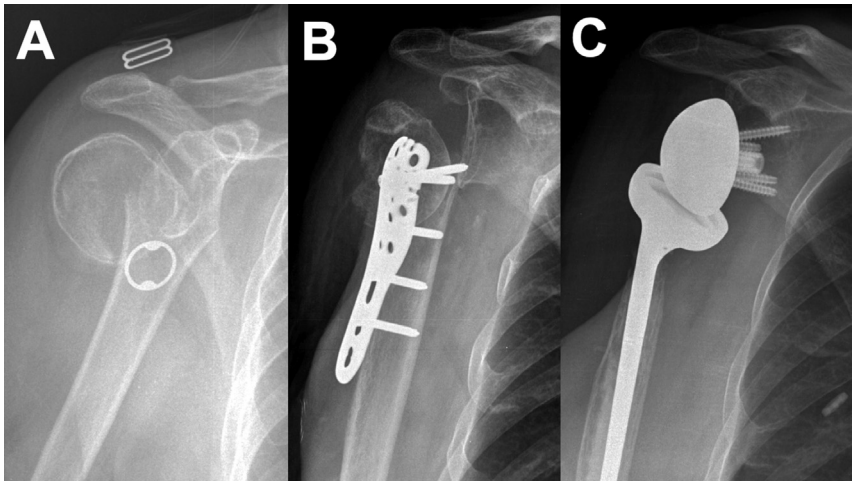

Fig. 1. Example of a case with a surgical neck 2-part proximal humeral fracture (A) undergoing open reduction and internal fixation with humeral head collapse secondary to osteonecrosis and a subsequent screw cut-out (B), treated with a reverse shoulder arthroplasty (C).

Reverse shoulder arthroplasty has recently emerged as the treatment of choice for proximal humeral fracture sequelae (PHFS), especially in elderly patients. Slightly better functional results have been reported with the use of RSA when compared to those obtained with hermiarthroplasty.[5] However, less than optimal outcomes are the rule and complications are still high.[9–12,15–17,19–24] Few studies address the topic of the treatment of fracture sequelae with RSA and they mainly cover outcomes after failed ORIF or hemiarthroplasty and the comparison of outcomes between acute fractures and fracture sequelae when treated with RSA.

The objective of this study is to analyze and compare the results obtained with RSA in PHFS in fractures initially treated conservatively versus those initially treated with ORIF. It was hypothesized that the outcomes of RSA in patients with PHFS would be better in the absence of previous ORIF.

Material and methods

It is a retrospective study that includes all PHFS treated with a RSA from September 2006 to December 2013. Inclusion criteria were PHFS treated with RSA, with the initial treatment for the proximal humeral fracture being either conservative or ORIF with a minimum follow-up of two years. Some patients undergoing initial conservative treatment had been treated in an outside hospital (referred as a fracture sequelae) or refused initial surgical treatment. Patients treated with hemiarthroplasty or developing an infection after ORIF were excluded.

During the study period, a total of 40 patients underwent RSA treatment for a PHFS. There were 9 patients undergoing hemiarthroplasty as the initial treatment for the proximal humeral fracture and 4 patients developing infection after ORIF who were excluded from this study.

Twenty-seven patients met the inclusion criteria. There were 9 patients treated with RSA due to a fracture sequelae following conservative treatment and 18 patients treated with a RSA owing to a fracture sequelae after ORIF.

In the conservatively treated group, there were 7 females and 2 males and 15 females and 3 males in the ORIF group. The mean age of the conservative group was 79.11 years and 76.83 years in the ORIF group. Thus, there were no significant differences between the groups in terms of age. ($p = 0.541$).

The Boileau et al classification system was used to classify fracture sequelae. Two categories of fracture sequelae can be distinguished. Category 1 is characterized by intracapsular/impacted fracture sequelae associated with either cephalic collapse or necrosis (type 1) and chronic dislocation or fracture-dislocation (type 2). In category 2, we see extracapsular/disimpacted fracture sequelae associated with both surgical neck non-unions (type 3) and severe tuberosity malunions (type 4).[7]

Fracture sequelae in patients initially treated surgically for the proximal humeral fracture were also classified based on the causes for revision (screw protrusion, mal-union, non-union, or avascular necrosis).

Fracture sequelae treated with ORIF included 11 patients treated with locked plates, 6 patients treated with a modified Ender and osteosutures and 1 patient treated with osteosutures and Kirschner wires.

Among the fracture sequelae conservatively treated, there were two of type I, two of type 2, three of type 3 and two of type 4 as defined in the Boileau et al classification system. Among the fracture sequelae treated with ORIF, there were seven of type 1, two of type 2, four of type 3 and five of type 4.

Among the patients included in the ORIF group, there were 8 pseudoarthrosis, 5 malunions, 5 cases of cephalic avascular necrosis and 6 screw cut-outs, with some patients presenting more than one complication.

All surgeries were performed by the same surgeon (CT) through the deltopectoral approach. In the conservatively treated group, a greater tuberosity osteotomy was not required in any case. Reattachment of the greater tuberosity was attempted in all the cases in the surgically treated group. The infraspinatus was repaired or reattached whenever torn. Whenever possible, the largest-sized glenosphere was implanted (size 42 in 18 cases and size 38 in 7 cases). If present, the subscapularis was repaired at the end of procedure. In all the cases, a Delta Xtend (DePuy, Warsaw, IN, USA) RSA was implanted.

The outcomes for this study included: functional scores (Constant Score), radiographic evaluation, and complications. The Constant score includes the evaluation of pain, daily living activities, range of motion and strength.[25] The Constant Score was obtained preoperatively and at the latest follow-up (minimum of two years). All the patients included underwent an imaging study that included plain X-Rays and a CT scan prior to surgery and plain X-Rays after surgery. All complications and reoperations during the follow-up were also recorded.

Statistical analysis

Descriptive statistics were used to summarize the demographic and sample characteristics, and the outcomes. A paired t test was

employed to assess pre- and postoperative differences in the whole sample. An unpaired t test was employed to compare quantitative variables, and a Fisher's exact test for qualitative variables, between both groups. All statistical analyses were conducted with the SPSS (SPSS Inc., Chicago, IL). The alpha level was set at 0.05.

Results

The mean follow-up of the entire series was 54.7 months (range, 24–108) with a minimum of 2 years. The average time between the initial fracture and the need for replacement with RSA was 19 months (range, 4–49 months).

The preoperative Constant Score for the conservative group was 17.21 while it was 16.16 in the ORIF group. Again, there were no significant differences between them ($p = 0.781$).

Both groups had significantly increased Constant Scores after surgery ($p < 0.000$) but the patients in the conservative group had significantly better outcomes for the total Constant Score ($p = 0.024$), for forward elevation ($p = 0.026$) and for external rotation ($p = 0.004$). The mean (SD) postoperative forward elevation was 95 (32.5) degrees in the conservative treatment group, and 77 (40.1) degrees in the ORIF group ($p = 0.02$). The mean (SD) postoperative abduction was 74 (28.7) degrees in the conservative treatment group, and 68 (36.3) degrees in the ORIF group ($p = 0.09$). See the detailed data for outcome results in Table I.

A total of 4 complications (14,8%) were present during the follow-up period. In the conservative group, 1 patient developed an infection and there were 2 dislocations and 1 infection in the ORIF group. The infections were treated with revision surgery in two-stages with the final implantation of another RSA. The dislocations were managed with open surgery and the exchange of the polyethylene component for one that was wider.

Table 1
Age and Constant Score values (preoperative and postoperative) according to Conservative and ORIF group.

	Mean	Std Deviation	p value
Age			
Conservative	79,11	7,04	,54
ORIF	76,83	9,78	
Constant Preoperative			
Conservative	17,21	8,03	,78
ORIF	16,16	7,68	
Constant Postoperative			
Conservative	44,15	11,67	,03
ORIF	32,25	12,06	
Pain Postoperative[a]			
Conservative	11,28	2,69	,27
ORIF	9,5	3,88	
DLA Postoperative[a]			
Conservative	13,99	1,95	,06
ORIF	10,18	2,3	
Forward Elevation[a]			
Conservative	6,00	2,58	,02
ORIF	3,44	2,35	
Abduction[a]			
Conservative	5,42	1,9	,09
ORIF	3,55	2,52	
External Rotation[a]			
Conservative	2,28	1,38	,004
ORIF	0,55	1,14	
Internal Rotation[a]			
Conservative	4,57	1,51	,88
ORIF	5,11	9,48	

DLA, daily-living activities; ORIF, open reduction and internal fixation.
[a] Constant score values.

Discussion

The treatment of PHFS is challenging and usually ends with less than optimal results and a high complication rate. Recently, RSA has successfully been used in the treatment of complex fracture sequelae and has slightly better results and an acceptable complication rate.[5,9–12,14–16,19–23]

The use of RSA in the treatment of PHFS results in a limited outcome improvement but with an acceptable complication rate. Importantly, PHFS without a previous surgery will benefit more from it than those had undergone a previous surgery in terms of an improvement in range of motion. They also show a trend towards a lower complication rate.

There has been an increase in the trend to surgically treat acute proximal humeral fractures, especially with the use of ORIF.[26] Locking plate designs may bring on several complications such as malreduction, screw cutout, malunion, nonunion, avascular necrosis and infection. Most of them come about when ORIF is used in elderly patients.[1–4] Many of these complications require revision surgery. Jost et al, in a series of 121 patients who had been referred due to complications after treatment of a proximal humeral fracture with a locking plate, reported a mean 1.5 surgeries per patient needed to address such complications.[2] The final surgery was an RSA in many cases.

Boileau et al analyzed a series of 71 PHFS treated with an anatomical shoulder.[7] Types 3 and 4 had the poorest results with limited improvement relative to forward elevation (50° preoperative to 63° postoperative in type 3, 58° preoperative to 91° postoperative in type 4). The need for a greater tuberosity osteotomy was the main reason for the poor outcomes. While anatomic shoulder arthroplasty does well in type I proximal humeral fractures as long as there is no varus deformation or fatty infiltration of the cuff muscles,[19] there is agreement that the need for a greater tuberosity osteotomy worsens outcomes.[6,7,13,14] In a series of 95 patients treated with anatomical shoulder arthroplasty because of proximal humerus malunions, Jacobson et al reported an unsatisfactory result in 36 out of those 95 patients.[14]

Alentorn-Geli et al managed to compare outcomes and the complications of hemiarthroplasty and RSA in the treatment of PHFS in a prospective study with 32 patients.[5] A slight improvement in outcomes for the RSA group was reported even though it did not reach significance. The complication and revision rates were significantly lower in the RSA group. Boileau et al also reported better results from RSA when compared to anatomical shoulder arthroplasty in type IV PHFS.[6]

A number of studies report favorable outcomes from RSA when used in PHFS, with a significant improvement in pain relief and range of motion.[9–12,15–17,19–24,27,28] However, complications such as dislocation, intraoperative fractures, component loosening and infection have been reported to be present in some 20%–41% of the patients. Furthermore, revision surgery may be needed in some 9%–28% of the patients.[9–12,15–17,19–24,27,28] Greiner et al, in a series of 49 patients treated with RSA because of PHFS, reported a 10.2% complication rate and all those complications occurred in patients previously treated with ORIF.[10] In the present study, the use of RSA in the treatment of PHFS resulted in a limited outcome improvement but with an acceptable complication rate. However, patients coming from conservative treatment of the index proximal humeral fracture did significantly better in the Constant Score in terms of absolute forward elevation and external rotation when compared to patients coming from ORIF. The complication rate observed was similar to what has been reported (14,8%).[8,11–13,15–18,20–24] Although it did not reach significance, there was a trend towards a higher complication rate in the ORIF group when compared to the conservative group. Few studies compare the results obtained in the treatment of PHFS in patients previously treated by ORIF versus those treated conservatively. While Boileau et al and Greiner et al found better results in the conservatively treated patients, Hattrup et al failed to find any

difference between the two groups.[6,10,12] The present study provides more evidence in favor of better outcomes after RSA in patients treated conservatively as opposed to those treated with ORIF.

The recent trend towards surgical treatment of acute proximal humeral fractures should be questioned, especially if ORIF is planned in elderly patients. This is not only due to the expected high complication rate but also for the inferior results that would be obtained later on if RSA is needed to treat the complications of ORIF as has been shown in this study. On the other hand, conservative treatment of acute proximal humeral fractures should be more frequently considered because, despite RSA offers limited outcomes in patients with PHFS, the complications of RSA after failed conservative treatments are low. Therefore, indication for ORIF in acute proximal humeral fracture should be limited to those cases where a good outcome is very likely, being especially cautious when indicating ORIF in elderly individuals.

The present study has the inherent limitation of its retrospective nature with limited sample size. On the other hand, the study provides useful information with clear clinical application for shoulder surgeons.

Conclusions

The use of RSA in the treatment of PHFS results in a limited outcome improvement but with an acceptable complication rate. Patients developing PHFS after conservative treatment may expect better outcomes and fewer complications than those developing PHFS after ORIF.

Compliance with ethical standarts

None.

Conflicts of interest

Santana F, Alentorn-Geli E, Guirro P, Torrens C declare that they have no conflict of interest.

Ethical approval

"All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

The study was approved by the Ethical Committee of Comité Etico de Investigación Clínica del Parc de Salut Mar with the number 2012/4818/I. All the patients included signed informed consent.

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References

1. Gerber C, Werner CM, Vienne P. Internal fixation of complex fractures of the proximal humerus. *J Bone Joint Surg Br Vol*. 2004;86:848–855. https://doi.org/10.1302/0301-620X.86B6.14577.
2. Jost B, Spross C, Grehn H, et al. Locking plate fixation of fractures of the proximal humerus: analysis of complications, revision strategies and outcome. *J Shoulder Elbow Surg*. 2013;22:542–549. https://doi.org/10.1016/j.jse.2012.06.008.
3. Owsley KC, Gorczyca JT. Fracture displacement and screw cutout after open reduction and locked plate fixation of proximal humeral fractures [corrected]. *J Bone Joint Surg Am*. 2008;90:233–240. https://doi.org/10.2106/JBJS.F.01351.
4. Sudkamp N, Bayer J, Hepp P, et al. Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Results of a prospective, multicenter, observational study. *J Bone Joint Surg Am*. 2009;91:1320–1328. https://doi.org/10.2106/JBJS.H.00006.
5. Alentorn-Geli E, Guirro P, Santana F, et al. Treatment of fracture sequelae of the proximal humerus: comparison of hemiarthroplasty and reverse total shoulder arthroplasty. *Arch Orthopaedic Trauma Surg*. 2014;134:1545–1550. https://doi.org/10.1007/s00402-014-2074-9.
6. Boileau P, Chuinard C, Le Huec JC, et al. Proximal humerus fracture sequelae. Impact of a new radiographic classification on arthroplasty. *Clin Orthop Relat Res*. 2006;442:121–130. https://doi.org/10.1097/01.blo.0000195679.87258.6e.
7. Boileau P, Trojani C, Walch G, et al. Shoulder arthroplasty for the treatment of the sequelae of fractures of the proximal humerus. *J Shoulder Elbow Surg*. 2001;10:299–308. https://doi.org/10.1067/mse.2001.115985.
8. Dezfuli B, King JJ, Farmer KW, et al. Outcomes of reverse total shoulder arthroplasty as primary versus revision procedure for proximal humerus fractures. *J Shoulder Elbow Surg*. 2016;25:1133–1137. https://doi.org/10.1016/j.jse.2015.12.002.
9. Dines DM, Klarren RF, Altchek DW, et al. Posttraumatic changes of the proximal humerus: malunion, nonunion, and osteonecrosis. Treatment with modular hemiarthroplasty or total shoulder arthroplasty. *J Shoulder Elbow Surg*. 1993;2:11–21. https://doi.org/10.1016/s1058-2746(09)80132-8.
10. Greiner S, Uschok S, Herrmann S, et al. The metaphyseal bone defect predicts outcome in reverse shoulder arthroplasty for proximal humerus fracture sequelae. *Arch Orthopaedic Trauma Surg*. 2014;134:755–764. https://doi.org/10.1007/s00402-014-1980-1.
11. Grubhofer F, Wieser K, Meyer DC, et al. Reverse total shoulder arthroplasty for failed open reduction and internal fixation of fractures of the proximal humerus. *J Shoulder Elbow Surg*. 2017;26:92–100. https://doi.org/10.1016/j.jse.2016.05.020.
12. Hattrup SJ, Waldrop R, Sanchez-Sotelo J. Reverse total shoulder arthroplasty for posttraumatic sequelae. *J Orthop Trauma*. 2016;30:e41–e47. https://doi.org/10.1097/BOT.0000000000000416.
13. Hussey MM, Hussey SE, Mighell MA. Reverse shoulder arthroplasty as a salvage procedure after failed internal fixation of fractures of the proximal humerus: outcomes and complications. *Bone Joint J*. 2015;97-B:967–972. https://doi.org/10.1302/0301-620X.97B7.35713.
14. Jacobson JA, Duquin TR, Sanchez-Sotelo J, et al. Anatomic shoulder arthroplasty for treatment of proximal humerus malunions. *J Shoulder Elbow Surg*. 2014;23:1232–1239. https://doi.org/10.1016/j.jse.2013.11.015.
15. Mansat P, Guity MR, Bellumore Y, et al. Shoulder arthroplasty for late sequeale of proximal humeral fractures. *J Shoulder Elbow Surg*. 2004;13:305–312. https://doi.org/10.1016/j.jse.2004.01.020.
16. Martinez AA, Bejarano C, Carbonel I, et al. The treatment of proximal humerus nonunions in older patients with the reverse shoulder arthroplasty. *Injury*. 2012;43:S3–S6. https://doi.org/10.1016/j.injury.2011.12.015.
17. Martinez AA, Calvo A, Bejarano C, et al. The use of the Lima reverse shoulder arthroplasty for the treatment of fracture sequelae of the proximal humerus. *J Orthop Sci*. 2012;17:141–147. https://doi.org/10.1007/s00776-011-0185-5.
18. Merolla G, Tartarone A, Sperling JW, et al. Early clinical and radiological outcomes of reverse shoulder arthroplasty with an eccentric all-polyethylene glenosphere to treat failed hemiarthroplasty and the sequelae of proximal humeral fractures. *Int Orthop*. 2017;41:141–148. https://doi.org/10.1007/s00264-016-3188-1.
19. Moineau G, McClelland WB, Trojani C, et al. Prognostic factors and limitations of anatomic shoulder arthroplasty for the treatment of posttraumatic cephalic collapse or necrosis (Type-1 Proximal humeral fracture sequelae). *J Bone Joint Surg Am*. 2012;94:2186–2194. https://doi.org/10.2106/jbjs.j.00412.
20. Raiss P, Edwards TB, da Silva MR, et al. Reverse shoulder arthroplasty for the treatment of nonunions of the surgical neck of the proximal part of the humerus (type-3 fracture sequelae). *J Bone Joint Surg Am*. 2014;96:2070–2076. https://doi.org/10.2106/JBJS.N.00405.
21. Raiss P, Edwards TB, Collin P, et al. Reverse shoulder arthroplasty for malunions of the proximal part of the humerus (Type-4 fracture sequelae). *J Bone Joint Surg Am*. 2016;98:893–899. https://doi.org/10.2106/JBJS.15.00506.
22. Willis M, Min W, Brooks JP, et al. Proximal humeral malunion treated with reverse shoulder arthroplasty. *J Shoulder Elbow Surg*. 2012;21:507–513. https://doi.org/10.1016/j.jse.2011.01.042.
23. Zafra M, Uceda P, Flores M, et al. Reverse total shoulder replacement for nonunion of a fracture of the proximal humerus. *Bone Joint J*. 2014;96-B:1239–1243. https://doi.org/10.1302/0301-620X.96B9.33157.
24. Shannon SF, Wagner ER, Houdek MT, et al. Reverse shoulder arthroplasty for proximal humeral fractures: outcomes comparing primary reverse arthroplasty for fracture versus reverse arthroplasty after failed osteosynthesis. *J Shoulder Elbow Surg*. 2016;25:1655–1660. https://doi.org/10.1016/j.jse.2016.02.012.
25. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res*. 1987:160–164. https://doi.org/10.1097/00003086-198701000-00023.
26. Bell JE, Leung BC, Spratt KF, et al. Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. *J Bone Joint Surg Am*. 2011;93:121–131. https://doi.org/10.2106/JBJS.I.01505.
27. Raiss P, Alami G, Bruckner T, et al. Reverse shoulder arthroplasty for type 1 sequelae of a fracture of the proximal humerus. *Bone Joint J*. 2018;100-B:318–323. https://doi.org/10.1302/0301-620X.100B3.BJJ-2017-0947.R1.
28. Schliemann B, Theisen C, Kosters C, et al. Reverse total shoulder arthroplasty for type I fracture sequelae after internal fixation of proximal humerus fractures. *Arch Orthopaedic Trauma Surg*. 2017;137:1677–1683. https://doi.org/10.1007/s00402-017-2789-5.