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Reverse total shoulder arthroplasty with a humeral inclination of 135° for treatment of 3- and 4-part proximal humeral fractures: Clinical analysis with minimum follow-up of 2 years

Abstract

Background: The reverse shoulder arthroplasty (RSA) is indicated for the treatment of proximal humerus fractures (PUF). To present day, there are limited data regarding the difference in functional outcomes of the RSA with a humeral inclination of 135º or 155º, in fracture context. The purpose of this study is to retrospectively analyze the functional outcomes of complex PUF treated with RSA with a humeral inclination of 135º.

Materials and Methods: We carried out a retrospective study in which we analyzed 22 patients with PUF, who underwent RSA with a humeral inclination of 135º, between January 2017 and June 2019. Functional outcomes were measured through the Q-DASH and ASES scores. The Constant-Murley score (CS), active elevation (AA), abduction (ABD), internal rotation (IR), external rotation (ER), and abduction strength were obtained in both arms, using the contralateral shoulder as an estimative of preinjury function.

Results: The patients were followed for a mean of 39.5 months. Seven patients were pain-free while performing their daily activities. Thirteen referred minor pain in their usual activities and 2 reported moderate to very severe pain. The mean ASES and Quick-DASH scores were 80% and 18.1 points, respectively. The CS was 59 points, 13 points less than the nonoperated side. The average AA was 128º, ABD 123º, ER 27º, and IR 36º. We found no correlation between the age and ASES score or Q-DASH score and between ER and ASES or Q-DASH score, but we found a positive correlation between ASES score or Q-DASH score and AA, ABD and IR.

Conclusion: RSA is a valid and reliable option in selected elderly patients with complex PUF. The choice of the RSA humeral inclination (135º Vs 155º) does not currently have defined criteria, and there are no studies with sufficient statistical power to validate one of these options.

Keywords: proximal humerus fractures, reverse shoulder arthroplasty, humeral inclination of 135º, Q-DASH, ASES, constant-murley score

Volume 13 Issue 6 - 2021

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Received: October 30, 2021 | **Published:** November 12, 2021

Introduction

Proximal humerus fractures are frequent, accounting for approximately 5% of all fractures in adults[1–3] and more than 10% in the elderly. The number of proximal humerus fractures will rise due to the growing of the elderly population (with accompanying osteoporosis, resulting in an even higher healthcare resource utilization).[1]

When a fall occurs, the arm is normally held in flexion, abduction, and internal rotation in order to absorb the impact. Thus, the head of the humerus collides with the glenoid, which normally has a stronger bone structure, causing finally a proximal humerus fracture.[2]

Most of these fractures can be treated conservatively, however, in displaced fractures, surgical treatment is recommended. Several surgical options are described in the literature: osteosynthesis, when possible;[3] Hemiarthroplasty, used in the cases not amenable to osteosynthesis, with good results in pain relief but with unpredictable functional results (less used currently);[4,5] Reverse Shoulder Arthroplasty (RSA), preferable in the elderly population.[3]

Historically, the RSA was used for the treatment of rotator cuff arthropathy, as it optimized the lever arm of the deltoid muscle, especially in anterior flexion.[6–8] In fact, RSA has revolutionized the treatment of these several conditions. The initial Grammont design used a neutral glenosphere and a humeral prosthesis with an inclination of 155º. However, this nonanatomic humeral inclination leads to scapular notching in 50% to 96% of cases.[9,10] In order to reduce scapular notching, some authors advocate the use of more anatomic or vertical humeral inclination prosthesis.[9] In the literature, some studies are described, such as the one by Cuff *et al.* who report only 9% of scapular notching with the use of prosthesis with a humeral inclination of 135º, in the treatment of rotator cuff arthropathy.[9,11]

As mentioned before, the RSA is currently indicated for the treatment of proximal humerus fractures that are not susceptible to osteosynthesis, with predictable functional results and excellent pain relief.[6–8] Nonetheless, to present day, there are limited data regarding the difference in functional outcomes of the RSA with a humeral inclination of 135º or 155º, in fracture context.

Some published studies suggest that RSA with humeral inclination of 135º are associated with increased external limb rotation with decreased abduction, compared to RSA with humeral inclination of 155º.[12] The purpose of this study is to retrospectively analyze the

functional outcomes of complex proximal humeral fractures treated with RSA with a humeral inclination of 135º and to understand what variables may influence them.

Material and methods

From 2017 to June 2019, we operated on 25 shoulders of 25 patients with complex proximal humeral fracture. In all patients, an RSA was performed by 2 surgeons from our institution. Two patients were lost to follow-up before 18 months. One died a few days postoperatively for reasons unrelated to surgery and was also excluded.

Hence, 22 patients (22 fractures), 8 men and 14 women, with the mean age of 78.19 (67-89) years, were included in this study. All patient had computed tomography scan preoperatively that showed severe comminution of the tuberosities and poor bone stock, predicting poor results with osteosynthesis. The fracture pattern, as described by Neer[13,14] was a 3-part fracture in 6 cases and a 4-part in 16. Regarding laterality, 11 fractures were on the right and 11 fractures on the left.

Functional outcomes were measured through the Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) and American Shoulder and Elbow Surgeons (ASES) scores.[15,16] The Constant-Murley score,[17] flexion, abduction, internal rotation, external rotation, and abduction strength were obtained in both arms, using the contralateral shoulder as an estimative of preinjury function.

Strength of abduction was measured with the arm abducted at 90º pulling upward (isometric contraction) against the resistance of a spring balance.[18] External and internal rotation were measured with a goniometer with the patient supine and the arm at 90º of abduction, the elbow was stabilized by the observer, and the patient was asked to rotate the arm inward and outward.

Surgical technique

The patients were placed in a beach chair position and operated under a combination of general anesthesia and interscalenic block. A deltopectoral approach was used in all cases. The tuberosities were identified and retracted - isolated with suture passage for better exposure (and latter reattachment). If the long portion of the biceps was present, it was detached and a tenodesis to pectoralis major tendon was performed. If the lesser tuberosity (LT) was attached to humeral head, an osteotomy of the LT was done. The glenoid baseplate was fixed in the center of the glenoid using 2 locked screw and 2 lag screws. For optimal glenosphere position, an lateralizad or a standard glenosphere diameter was chosen for best fit. The same principle was applied when choosing the diameter size. The length of the humeral component was measured with a trial and the definitive cementeless Monobloc Implant was fixed (humeral inclination of 135º) at the appropriate height with 0º of retroversion. The polyethylene inserted height was also tested for optimal tension and stability. Lastly, the tuberosities were reattached around the prosthesis using high- resistance sutures. In the cases with severe metaphyseal destruction, bone graft or bone substitute was used to fill in the space between the metaphysis and the tuberosities. The wound was closed in a standard fashion, and before skin closure, the articular space was infiltrated with gentamycin.[19] A drain was left in place, opened after 2 hours, and maintained for 24 hours.

Postoperative care

After surgery, the patients were placed in a sling for 2 weeks for pain management. They started physiotherapy the day after surgery with passive ROM (Range Of Motion) of the shoulder. Hospital discharge occurred after three days and physiotherapy was encouraged. Patients were allowed to start active ROM at 6 weeks postoperatively and weight lifting at 12 weeks.

Statistical analysis

Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 26. Nominal data were evaluated using x^2 test. Pearson correlation test was also used to correlate mobility with outcome scores.

Results

The patients were followed for a mean of 39.5 months (24-50). Seven patients were pain-free while performing their daily activities. The majority (13 patients) referred minor pain in their usual activities. Only 2 patients reported moderate to very severe pain during daily activities.

The mean ASES and Quick-DASH scores were 80% (range: 23%-100%) and 18.1 points (range: 0-78), respectively. The mean Constant score (CS) was 59 points (22-79 points), 13 points (18,1%) less than the nonoperated side. The average active elevation was 128º (range: 30º-165º), abduction 123º (range: 30º-165º), external rotation 27º (range: 0º-50º), and internal rotation 36º (range: 5º-60º). The differences between the operated and the contralateral side are summarized in Table 1.

Table 1 Difference Between Sides of Constant Score, Shoulder Mobility and Abduction Strength

Measurement	Operated shoulder (Mean / Range)	Contralateral shoulder (Mean / Range)	Difference (value / %)
Constant Score (Points)	59 / 22 - 79	72 / 36 – 81	13 / 18,06%
Active Anterior Elevation (°)	128 / 30 - 165	161 / 100 – 180	33 / 20,5%
Active Abduction (°)	123 / 30 - 165	158 / 95 – 170	35 / 22,15%
External Rotation (°)	27 / 0 - 50	30 / 0 - 60	3 / 10%
Internal Rotation (°)	30 / 5 - 60	40 / 20 – 90	10 / 25%
Abduction Strength (kg)	4.13 / 0 - 10	5,02 / 1 - 10	0,89 / 17,73%

Citation: Brito FD, Pires L, Rego P, et al. Reverse total shoulder arthroplasty with a humeral inclination of 135° for treatment of 3- and 4-part proximal humeral fractures: Clinical analysis with minimum follow-up of 2 years. *MOJ Orthop Rheumatol.* 2021;13(6):131–135. DOI: 10.15406/mojor.2021.13.00563

We found no correlation between the age of the patient and ASES score (P = 0.55) or Q-DASH score (P = 0.87). We found a positive correlation between:

- Active abduction and the ASES score (P = 0,000003);
- Active abduction and the Q-DASH score (P = 0,003);
- Active anterior elevation and the ASES score (P = 0,0087);
- Active anterior elevation and the Q-DASH score (P = 0,00024);
- Active internal rotation and the ASES score (P = 0,009);
- Active internal rotation and the Q-DASH score (P = 0,0014).

There was no correlation between active external rotation and ASES or Q-DASH score.

Complications

From the total of 22 shoulders operated, we had no infections. We report three cases of brachial plexus injury, not identified in the pre-surgical period. These cases were confirmed at 6 weeks postoperatively by electromyography. The suspicion started with the slow evolution of the postoperative ROM. The injury prevented adequate recovery with important repercussions on ROM and PROMs (patient reported outcome measures) - Table 2 & 3. Hence, we consider that in our series there were no cases of complications related to surgery, despite the cases described above, being the global complication rate 0%.

Table 2 Characterization of cases of brachial plexus injury (2 years after surgery)

Genre / Age (years)	Neer	AAE (°) / AA (°)	IR (°) / ER (°)	AS (kg)	CS	ASES score	Q-DASH score	VAS score
Male / 80	3	45 / 45	40 / 0	2,25	36	55	29,50	3
Male / 82	4	45 / 30	20 / 0	1	27	45	56,80	4
Male / 67	4	30 / 30	5 / 0	0	25	67	56,80	0

Neer, neer classification; AAE, active anterior elevation; AA, active abduction; IR, internal rotation; ER, external rotation; AS, abduction strength; CS, constant score

Table 3 Characterization of case of hemorrhagic stroke (2 years after surgery)

Genre / Age (years)	Side	Neer	AAE (°) / AA (°)	IR (°) / ER (°)	AS (kg)	CS	ASES score	Q-DASH score	VAS score
Female / 82	Op	4	110 / 90	20 / 0	2	51	92	13,60%	0
	CL	NA	115 / 100	20 / 0	2	57			

Op, operated; CL, contralateral; Neer, neer classification; NA, not applied; AAE, active anterior elevation; A, active abduction; IR, internal rotation; ER, external rotation; AS, abduction strength; CS, constant score

Discussion

The problem of treating proximal humerus fractures has generated numerous articles and studies for decades. These fractures are truly a challenge, both in the area of osteosynthesis and arthroplasty. The therapeutic decision involves measuring the patient's own parameters (age, functional reserve and ability to carry out activities of daily living), as well as the fracture's own parameters (bone stock and Neer's classification). The doubtful results of the osteosynthesis quality often lead the orthopedic surgeon into choosing arthroplasty. Latest evidence supports that RSA yields better outcomes than hemiarthroplasty in these patients.[6–8,20] While clinical results appear promising, it is important to remember that most proximal humerus fractures may be treated successfully with conservative management.[21]

The paradigm of using RSA with a humeral inclination of 135º or 155º started at the end of the last decade and has been the subject of some publications. Gobezie et al., in 2018, carried out a randomized clinical trial with the objective of evaluating the functional results of patients with rotator cuff arthropathy, submitted to primary ARS with humeral inclination of 135º or 155º, concluding that there were no differences in postoperative anterior flexion or external rotation after an RSA with a humeral inclination of 135º compared to 155º.[22] After an exhaustive literature search, we did not find similar studies comparing the two types of prostheses in the treatment of proximal humerus fractures.

In 2015, Erickson et al. published a systematic review in which they reported the number of dislocations, number of patients with scapular notching, and postoperative range of motion after RSA.[23] Table 4 compares the results (ROM) obtained by Erickson et al. with the results obtained in our study.

Lädermann et al. in 2019, carried out an experimental biomechanical study (3D computer models), concluding that a lower humeral inclination of the RSA is associated to a lower angle of active abduction (average of 90º - not comparable to the results in our study because it is related to of a study with 3D computer models).[12] Comparing this with the results obtained by Erickson et al., we conclude that what was postulated by Lädermann et al. was not found in our study, as the abduction mean was higher in our patients.

Regarding Functional outcomes, we found in the literature only two studies that reported the same scores as our study:

- Lenarz et al. in 2011, carried out a retrospective descriptive study, in which they described an average ASES score of 78 in patients undergoing RSA due to fracture of the proximal humerus; These results are in line with the ones obtained in our study (average ASES Score of 80), however, Lenarz does not specify the humeral inclination of the RSA used, which does not allow us to make a reliable comparison with this study;[24]

- Klein et al., in 2008, carried out a prospective study, in which

they described a mean ASES score of 68 and a mean Constant Score of 53 in patients undergoing RSA due to fracture of the proximal humerus; This result is lower than that obtained in our study (average ASES Score of 80 and Constant Score of 59), however, in this article, Klein also did not specify which RSA humeral inclination was used.[25]

Table 4 ROM - Erickson et al.Vs Brito et al.

	Erickson et al.		Brito et al.
Humeral Inclination RSA (°)	155	135	135
Active Anterior Elevation (°)	125,5	119	128
Active Abduction (°)	105,7	115	123
External Rotation (°)	23	32,9	27°

A curious fact from our study was that no statistically significant correlation was found between active external rotation and the ASES or Q-DASH score. This allows us to hypothesize that the degree of active abduction, active previous elevation and active internal rotation influences the ability of patients to carry out their daily activities more preponderantly than the degree of external rotation. In this regard, we argue that the degree of external rotation may not be a preponderant factor for choosing the inclination of the RSA.

Limitations

This study had several limitations. On the other hand, the limited number of patients (n = 22) does not allow us to relate our results to populations with similar diagnoses and treatments. On the other hand, both time of initiation and duration of physiotherapy may influence functional outcomes. In this study, due to local logistic restraints, patients may had different physiotherapy protocols and some did not even do any physiotherapy after hospital discharge.

Conclusion

According to the most recent evidence and the functional results and scores calculated in our study, we can state that RSA is a valid and reliable option in selected elderly patients with complex fractures of the proximal humerus. Despite good results in functional scores, internal and external rotation are always inevitably reduced.

The choice of the RSA humeral inclination (135º Vs 155º) does not currently have defined criteria, and there are no studies with sufficient statistical power to validate one of these options. This should be the focus of future research in an attempt to overcome this limitation.

Acknowledgments

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 manuscript has been read and approved by all authors. Each author believes that the manuscript represents honest work.

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflicts of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Dauwe J, Walters G, Holzer LA, et al. Failure after proximal humeral fracture osteosynthesis: a one year analysis of hospital–related healthcare cost. *Int Orthop*. 2020;44(6):1217–1221.
2. Schmalzl J, Jessen M, Gilbert F, et al. Proximal humeral fracture morphology in patients with advanced osteoarthritis: An observational study in a surgically treated cohort. *J Orthop Surg (Hong Kong)*. 2020;28(3):2309499020944114.
3. Dauwe J, Danker C, Herteleer M, et al. Proximal humeral fracture osteosynthesis in Belgium: a retrospective population–based epidemiologic study [published online ahead of print, 2020 Aug 20]. *Eur J Trauma Emerg Surg*. 2020.
4. Antuña SA, Sperling JW, Cofield RH. Shoulder hemiarthroplasty for acute fractures of the proximal humerus: a minimum five–year follow–up. *J Shoulder Elbow Surg*. 2008;17(2):202–209.
5. Robinson CM, Page RS, Hill RMF, et al. Primary hemiarthroplasty for treatment of proximal humeral fractures. *J Bone Joint Surg Am*. 2003;85– A(7):1215–1223.
6. Ryan P, Dachs RP, du Plessis JP, et al. Reverse total shoulder arthroplasty for complex proximal humeral fractures in the elderly: how to improve outcomes and avoid complications. *SA Orthop J*. 2015;14(1):25–33.
7. Ferrel JR, Trinh TQ, Fischer RA. Reverse total shoulder arthro– plasty versus hemiarthroplasty for proximal humeral fractures: a systematic review. *J Orthop Trauma*. 2015;29(1):60–68.
8. Forcada ES, Gomez RC, Utrilla AL, et al. Reverse shoulder arthroplasty versus hemiarthroplasty for acute proximal humeral fractures. A blinded, randomized, controlled, prospec– tive study. *J Shoulder Elbow Surg*. 2014;23(10):1419–1426.
9. Gobezie R, Shishani Y, Lederman E, et al. Can a functional difference be detected in reverse arthroplasty with 135° versus 155° prosthesis for the treatment of rotator cuff arthropathy: a prospective randomized study. *J Shoulder Elbow Surg*. 2019;28(5):813–818.
10. Boileau P, Moineau G, Roussanne Y, et al. Bony increased–offset reversed shoulder arthroplasty: minimizing scapular impingement while maximizing glenoid fixation. *Clin Orthop*. 2011;469:2558–2567.
11. Cuff D, Clark R, Pupello D, et al. Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency: a concise follow–up, at a minimum of five years, of a previous report. *J Bone Joint Surg Am*. 2012;94:1996–2000.
12. Lädermann A, Tay E, Collin P, et al. Effect of critical shoulder angle, glenoid lateralization, and humeral inclination on range of movement in reverse shoulder arthroplasty. *Bone Joint Res*. 2019;8(8):378–386.
13. Neer CS. Displaced proximal humeral fractures. II. Treatment of three–part and four–part displacement. *J Bone Joint Surg Am*. 1970;52(6):1090–1103.
14. Beaton DE, Wright JG, Katz JN. Upper Extremity Collaborative Group. Development of the QuickDASH: comparison of three item–reduction approaches. *J Bone Joint Surg Am*. 2005;87(5):1038–1046.
15. Richards RR, An KN, Bigliani LU, et al. A standardized method for the assessment of shoulder function. *J Shoulder Elbow Surg*. 1994;3(6):347–352.
16. Constant CR, Murley AH. A clinical method of functional assess– ment of the shoulder. *Clin Orthop Relat Res*. 1987;(214):160–164.
17. Bankes MJ, Crossman JE, Emery RJ. A standard method of shoulder strength measurement for the Constant score with a spring balance. *J Shoulder Elbow Surg*. 1998;7(2):116–121.

18. Lovallo J, Helming J, Jafari SM, et al. Intraoperative intra–articular injection of gentamicin: will it decrease the risk of infection in total shoulder arthroplasty?. *J Shoulder Elbow Surg*. 2014;23(9):1272–1276.

19. Gallinet D, Clappaz P, Garbuio P, et al. Three or four parts complex proximal humerus fractures: hemiarthroplasty versus reverse prosthesis: a comparative study of 40 cases. *Orthop Traumatol Surg Res*. 2009;95(1):48–55.

20. Schairer WW, Nwachukwu BU, Lyman S, et al. Arthroplasty treatment of proximal humerus fractures: 14–year trends in the United States. *Phys Sportsmed*. 2017;45(2):92–96.

21. Gobezie R, Shishani Y, Lederman E, et al. Can a functional difference be detected in reverse arthroplasty with 135° versus 155° prosthesis for the treatment of rotator cuff arthropathy: a prospective randomized study. *J Shoulder Elbow Surg.* 2019;28(5):813–818.

22. Erickson BJ, Frank RM, Harris JD, et al. The influence of humeral head inclination in reverse total shoulder arthroplasty: a systematic review. *J Shoulder Elbow Surg*. 2015;24(6):988–993.

23. Lenarz C, Shishani Y, McCrum C, et al. Is reverse shoulder arthroplasty appropriate for the treatment of fractures in the older patient? Early observations. *Clin Orthop Relat Res*. 2011;469(12):3324–3331.

24. Klein M, Juschka M, Hinkenjann B, et al. Treatment of comminuted fractures of the proximal humerus in elderly patients with the delta III reverse shoulder prosthesis. *J Orthop Trauma.* 2008;22(10):698–704.

Citation: Brito FD, Pires L, Rego P, et al. Reverse total shoulder arthroplasty with a humeral inclination of 135° for treatment of 3- and 4-part proximal humeral fractures: Clinical analysis with minimum follow-up of 2 years. *MOJ Orthop Rheumatol.* 2021;13(6):131–135. DOI: 10.15406/mojor.2021.13.00563