# Functional and radiologic outcomes of reverse shoulder arthroplasty and greater tuberosity reattachment in proximal humerus fractures

**Juan Martín Patiño, Carlos E. Martínez, Bernardo Andres, Francisco López Bustos, César Ruiz, Hernán Fiminella, Julio Ferro, Alberto Garay**

*Hand and Upper Limb Surgery Unit, Instituto Dupuytren (Buenos Aires, Argentina)*

## ABSTRACT

**Objective:** To report functional and radiologic outcomes of reverse shoulder arthroplasty (RSA) in patients with complex proximal humeral fractures. A second objective was to assess the relation between the greater tuberosity healing and the range of motion (ROM) and the American Shoulder and Elbow Surgeons (ASES) score. **Materials and Methods:** Sixteen patients treated between 2013 and 2017, older than 65 years old, operated before 4 weeks after the trauma, and with a minimum of 2-year follow-up were included. ASES scores and active ROMs were recorded. Greater tuberosity and the prosthesis position and healing were radiologically evaluated, and the complications and treatment were recorded. **Results:** The median age was of 74.5 years (IQR 66-78.5), 11 patients were females (69%). According to Neer classification, 11 cases were four-part fractures and 5 were four-part fracture-dislocations. The average time between trauma and surgery was 9.4 days, and the average follow-up was of 29.5 months. The greater tuberosity was healed in 9 cases (56%). Internal rotation: 5 patients (31.25%) were able to reach up with their thumbs to gluteal level, 4 (25%) to T12, 3 (18.75%) to T7, and 4 (25%) to L3. The medians for external rotation and forward flexion were 30° (IQR 17.5°-40°) and 100° (IQR 87.5°-160°). The average ASES score was of 78.3 (IQR 63.3-87.4). There was no significant statistical relation between greater tuberosity healing and forward flexion or ASES score (P=0.24 and P=0.52, respectively). **Conclusion:** The use of reverse prostheses for complex fractures with greater tuberosity reattachment could lead to good functional outcomes, low complication rates and reoperations. There was no significant statistical relation between ASES score and greater tuberosity healing or failure to heal.

**Key words:** Reverse prosthesis, proximal humerus, fractures, tuberosities, functional outcomes, shoulder arthroplasty.

**Level of Evidence:** IV (case series)

## Resultados funcionales y radiográficos de la prótesis reversa y la reinserción del troquíter en pacientes con fracturas de húmero proximal

## RESUMEN

**Objetivo:** Comunicar los resultados funcionales y radiográficos de pacientes tratados con prótesis reversa por fracturas complejas. El objetivo secundario fue determinar la relación entre rangos de movilidad y puntaje ASES con la evolución radiográfica del troquíter. **Materiales y Métodos:** Se incluyeron 16 pacientes >65 años, tratados con prótesis reversa y reinserción del troquíter, entre 2013 y 2017, operados antes de las 4 semanas del trauma y con un seguimiento mínimo de 2 años Se consignaron el puntaje ASES y el rango de movilidad activa. En las radiografías, se evaluaron la posición y la consolidación del troquíter, y se registraron las complicaciones y su tratamiento. **Resultados:** La media de la edad fue 74.5 años (RIC 66-78.5), 11 (69%) eran mujeres. Once fracturas (69%) eran a 4 fragmentos y 5, luxofracturas a 4 fragmentos. La media entre el trauma y la cirugía fue 9.4 días y el seguimiento, 29.5 meses. En 9 casos (56%), el troquíter presentó consolidación. Rotación interna: 5 pacientes alcanzaron la región glútea con el pulgar; 4, la vértebra T12; 4, la vértebra L3; 3, la T7. Las medianas de rotación externa y flexión anterior fueron 30º (RIC 17,5-40º) y 100º (RIC 87,5-160º). El puntaje ASES promedio fue 78,3 (RIC 63,3-87,4). No hubo una asociación estadísticamente significativa entre la evolución del troquíter y la flexión anterior y el puntaje (p = 0,24 y 0,52, respectivamente). **Conclusión:** La prótesis reversa en fracturas agudas con reinserción de las tuberosidades puede llevar a buenos resultados funcionales. No se encontró relación entre consolidación del troquíter y el puntaje ASES.

**Palabras clave:** Prótesis reversa; húmero proximal; fracturas; tuberosidades; resultados funcionales; reemplazo de hombro.

**Nivel de Evidencia:** IV (Serie de casos)

Received on May 30th, 2019. Accepted after evaluation on October 17th, 2019 • JUAN MARTÍN PATIÑO, MD • drpatinojm@gmail.com

**How to cite this paper:** Patiño JM, Martínez CE, Andres B, López Bustos F, Ruiz C, Fiminella H, Ferro J, Garay A. Functional and radiologic outcomes of reverse shoulder arthroplasty and greater tuberosity reattachment in proximal humerus fractures. *Rev Asoc Argent Ortop Traumatol* 2020;85(2):133-138. http://dx.doi.org/10.15417/issn.1852-7434.2020.85.2.994

## INTRODUCTION

Treatment options for proximal humeral complex displaced fractures and non-displaced fractures are conservative management, internal fixation, anatomic hemiarthroplasty or total arthroplasty, and RSA. Statistical studies[1] report that over the past years the utilization of RSA has increased in patients older than 65 years. Initially, the rationale for RSA was to benefit from its characteristics so as to aim at better outcomes concerning range of motion (ROM) regardless of tuberosity fixation and bone union, and to achieve the expected outcomes concerning the forward elevation determined by the deltoid. However, subsequent studies on case series with tuberosity have reported better outcomes regarding motion, mainly rotation, and fewer complications due to anterior instability.[2,3]

The purpose of our study was to report the functional and radiologic outcomes of RSA and greater tuberosity reattachment in patients with complex proximal humeral fractures (displaced and non-displaced four-part fractures according to Neer classification). A second objective was to assess the relation between the greater tuberosity radiographic evolution (bone union vs. unhealed) and the ROM and ASES score.

## MATERIALS AND METHODS

The inclusion criteria for this retrospective study were as follows: (1) patients that underwent RSA and greater tuberosity reattachment due to complex proximal humeral fractures (displaced and non-displaced) according to Neer classification, (2) treated between 2013 and 2017, (3) older than 65 years old, (4) operated before 4 weeks after the trauma, and (5) with a minimum of 2-year follow-up. Patients with traumatic sequelae such as previous internal fixation complications, non-union, and revision from hemiarthroplasty to RSA were excluded. All patients were operated on by 3 of this study authors (CEM, BA, and JMP), all specialist surgeons, and assessed by the same team.

Nineteen patients were contacted by telephone to arrange an appointment, and 16 patients attended. Functional results were evaluated using the ASES score and active and passive ROM: forward elevation with the back against a wall, external rotation with the arm in adduction and the elbow against the trunk, and internal rotation with the thumb reaching up at the back as high as possible. These values were measured using a manual goniometer. For the last appointment, we ordered lateral and AP X-rays, which we used to assess the greater tuberosity and to classify it into three categories: evident bone union, resorption, or migration. We then divided the cases into 2 study groups: healed and unhealed. We also assessed and documented the type of used prosthesis, the presence of stem or glenoid loosening, the presence of glenoid notching, the complications and their treatment. Complications and their management were also recorded.

In all cases the greater tuberosity and the subscapularis reattachments were performed by using high-resistance sutures with transverse stitches being passed through medially to the humeral component and with vertical stitches sutured to said structures and perforations into the humerus. Cancellous metaphyseal bone autografts (harvested from the humeral head) were also performed.

Continuous variables were described as mean and standard deviation (SD) or median and interquartile range (IQR) according to their distribution and categorical variables were described as absolute values and relative values. In addition, we performed a bivariate association analysis for the ROM and ASES score with the greater tuberosity radiological outcomes (bone union vs. unhealed). According to their distribution, parametric (Student's t-test) and nonparametric (Wilcoxon test) tests were used. Analyses were processed in the Stata 14.0 software.

This study was approved by the Institutional Ethics Committee (2019-01).

## RESULTS

Our study evaluated 16 participants, the median age was of 74.5 years (IQR 66-78.5), and 11 patients were females (69%). According to the Neer classification, 11 (69%) were four-part fractures, and 5 (31%) were four-part fracture-dislocations. The average time between trauma and surgery was of 9.4 days (SD 3), the average follow-up was of 29.5 months (SD 7) (Table 1). The type of prosthesis: cemented stem in 9 cases (56%), glenosphere with two screws in 10 cases (62%) (Arrow, FH Orthopedics) and with four screws and a central peg in the remaining cases (6 Comprehensive® Reverse Shoulder [Zimmer Biomet, Warsaw, IN, USA], 1 Humelock, Fx Solutions, Lyon, France). Designed fracture stems were used in all patients.

**Table 1.** Study patients' demographics and clinical characteristics

| Variable | Value |
|---|---|
| Age, median (IQR) | 74.5 (66-78.5) |
| Sex female, n (%) | 11 (69) |
| Type of fracture*, n (%) | |
| Four-part fracture | 11 (69) |
| Four-part displaced fracture | 5 (31) |
| Time to surgery, mean ± SD | 9.4 ± 3 |

IQR: interquartile range; SD: standard deviation *According to the Neer classification.

The postoperative radiological outcomes were: greater tuberosity adequate healing in 9 cases (56%), bone resorption in 5 cases (31%), migration in 1 case (6%), and 1 case (6%) required spacer implantation due to postoperative infection. Clinical evaluation of the internal rotation showed that 5 patients (31%) were able to reach up with their thumbs to gluteal level, 4 (25%) to T12, 4 (25%) to L3, and 3 (18.75%) to T7. The medians for external rotation and forward flexion were 30° (IQR 17.5°-40°) and 100° (IQR 87.5°-160°). The average ASES score was 78.3 (IQR 63.3-87.4). There were no cases of glenoid loosening no glenoid notching.

Two patients (12.5%) presented complications that required reoperation. One patient suffered a glenosphere disengagement which was resolved surgically two weeks after the RSA and had a favorable course. One case of acute infection was treated with surgical toilet and antibiotic therapy; however, following an 8-month controlled evolution, the infection exacerbated and an antibiotic-cemented spacer had to be implanted. The patient declined revision. To conclude, we performed the association analysis for the ASES score (78.3, IQR: 63.3-87.4) and the ROM with the bone union radiological evaluation. Both analyses yield no statistically significant relation (P=0.24 and P=0.52, respectively) (Table 2, Picture).

**Table 2.** Results

| Result | Value |
|---|---|
| Healing, n (%) | 9 (56) |
| Internal rotation, n (%) | |
| Gluteal level | 5 (31.25) |
| T12 | 4 (25) |
| T7 | 3 (18.75) |
| L3 | 3 (18.75) |
| Lumbar level | 1 (6.25) |
| External rotation, median (IQR) | 30º (17,5-40º) |
| Flexion, median (IQR) | 100º (87,5-160º) |
| ASES score, median (IQR) | 78,3 (63,3-87,4) |

IQR: interquartile range

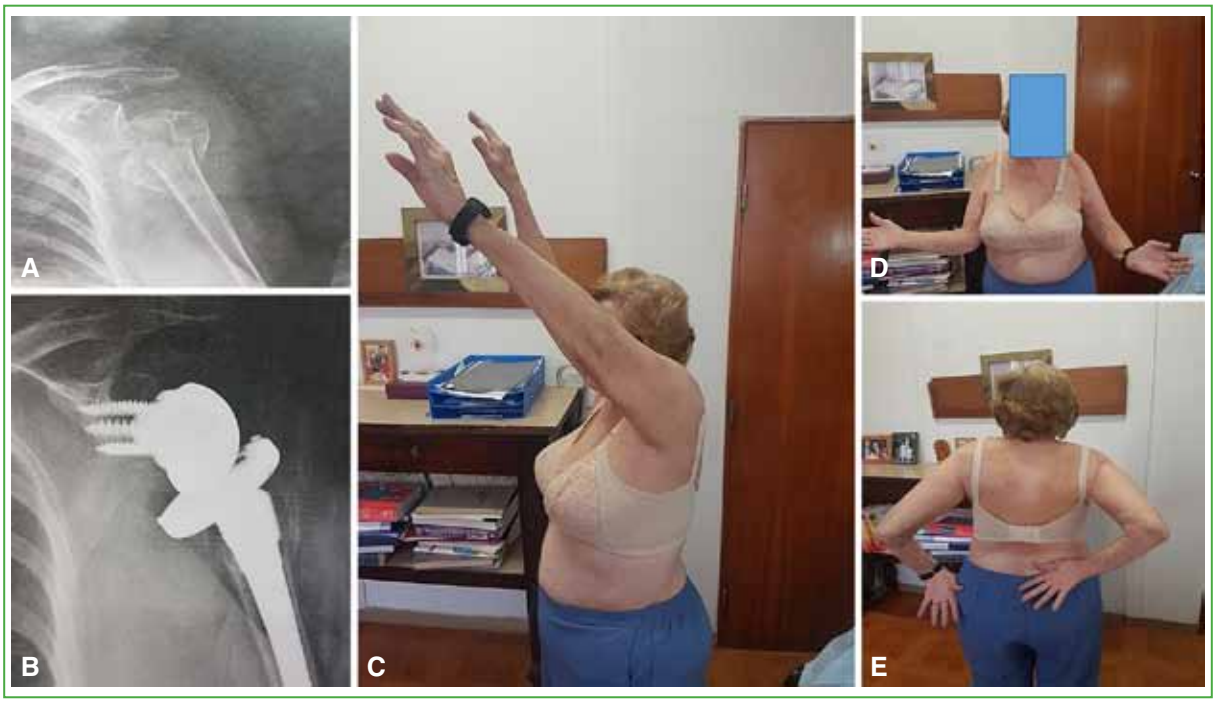


**Figure.** Woman of 79 years of age. **A.** Preoperative anteroposterior X-ray. **B.** Anteroposterior X-ray at 30-month postoperative control. **C-E.** Forward flexion, external rotation and internal rotation at final evaluation.

## DISCUSSION

In this case series, we report the functional and radiologic outcomes of 16 complex fractures which healing cannot be achieved with internal fixation: four-part displaced fractures and non-displaced fractures with fracture line at the anatomic humeral neck level, treated with an RSA and greater tuberosity reattachment. The recommendation and advantages of adequate tuberosity reattachment have not yet been fully elucidated. Data on this subject remain relatively recent and literature on functional and radiologic outcomes is scarce. Our literature review found no relevant reports on this subject.

We studied the evolution of reattached greater tuberosities, concerning shoulder healing and function, in the singular over-65 population.

Our series tuberosity healing rate (56%) was higher than that of some studies, with reports of lower rates in the elderly (40%),[2-6] and was similar to other studies of the same level of evidence, reporting values of approximately 64%,[7,8] and lower than that of other studies that have reported values between 80-100%.[4,9,10]

Designed fracture stems,[4,10] as the ones used in our series, have a low-profile design which allows for better and more anatomic reattachment with more room for the cancellous graft. Both aspects are critical in achieving a better ROM.[4,10-12]

There was no significant statistical relation between the highest ASES score and the greatest forward flexion, both in cases of healed and unhealed greater tuberosity. Literature outcomes for cases of migration, resorption or non-union are associated with lower ROM and more difficulties encountered in their activities of daily living.[13-17] Our reduced population size may account for our failure to corroborate this relation. Additionally, it remains unclear the tendon functional outcome in cases where part of the greater tuberosity presents resorption. We conclude that, although not radiologically apparent, resorption may be partial with insertion remnants.

Our findings included a 56% bone union rate, a 100 degrees average forward flexion, and a 30 degrees external rotation; which are not unlike other series.[5,13,14]

There were no recorded cases of anterior instability. Subscapularis repair may reduce anterior instability rates.[13]

Cases with no greater tuberosity reattachment have reposted higher complication rates, such as instability, loosening, infections, and proximal humeral bone lysis.[15-18] Our series included 1 case of infection and no dislocations. We believe that dislocations are less likely to occur when adequate reconstruction and healing of the greater tuberosity and reattachment of the subscapularis are achieved. The only case of reoperation was due to glenosphere disengagement associated with a technical error, not to instability.

Boileau *et al*.[17] conducted a 38-patient study where the 32 cases of anatomic healing achieved better outcomes regarding mobility, infections, instability and loosening. They suggested 3 advantages: 1) the potential instability risk is reduced as a result of the anterior and posterior restraint as well as the humerus length; 2) infection risk is reduced because the periprosthetic dead space is minimized by the increase of surrounding bone and soft vascularized tissues; and 3) loosening risk may be reduced because the stem is not solely reliant on distal fixation.

Tuberosity healing may be affected by local factors, such as bone fragment vascularization and previous injuries sustained by the rotator muscles of the shoulder, and not only by the performed fixation technique. Studies on these factors and the advance of surgical techniques are warranted to improve the outcomes and to determine the course of each particular case.

The limitations of this study include those derived from the retrospective nature of the analysis and the population size as well as having assessed the greater tuberosity only through plain radiography. The strengths of our study include a thorough follow-up with special attention to function and radiological outcomes in a well-defined population of patients over 65 and a homogeneous type of fracture, a minimal follow-up period of 2 years, and the use of a similar approach regarding reattachment and grafting.

## CONCLUSIONS

This series RSAs and greater tuberosity reattachments in patients with complex acute fractures of the proximal humerus achieved good functional outcomes, with low complications and reoperations rates. There was no significant statistical relation between ASES score and greater tuberosity healing or failure to heal.

Conflict of interests: Authors claim they do not have any conflict of interests.

C. E. Martínez ORCID ID: http://orcid.org/0000-0002-6031-0532
B. Andres ORCID ID: http://orcid.org/0000-0001-7426-5990
F. López Bustos ORCID ID: http://orcid.org/0000-0002-2504-2026
C. Ruiz ORCID ID: http://orcid.org/0000-0002-3300-0141
H. Fiminella ORCID ID: http://orcid.org/0000-0002-7944-2770
J. Ferro ORCID ID: https://orcid.org/0000-0003-3720-7884
A. Garay ORCID ID: http://orcid.org/0000-0001-6371-0884

## REFERENCES

1. Rosas S, Law TY, Kurowicki J, Formaini N, Kalandiak SP, Levy JC. Trends in surgical management of proximal humeral fractures in the Medicare population: a nationwide study of records from 2009 to 2012. *J Shoulder Elbow Surg* 2016;25(4):608-13. https://doi.org/10.1016/j.jse.2015.08.011
2. Bufquin T, Hersan A, Hubert L, Massin P. Reverse shoulder arthroplasty for the treatment of three-and four-part fractures of the proximal humerus in the elderly: a prospective review of 43 cases with a short-term follow-up. *J Bone Joint Surg Br* 2007;89(4):516-20. https://dx.doi.org/10.1302/0301-620X.89B4.18435
3. Chun YM, Kim DS, Lee DH, Shin SJ. Reverse shoulder arthroplasty for four-part proximal humerus fracture in elderly patients: can a healed tuberosity improve the functional outcomes? *J Shoulder Elbow Surg* 2017;26(7): 1216-21. https://dx.doi.org/10.1016/j.jse.2016.11.03410.1302/0301-620X.89B4.18435
4. Garofalo R, Flanagin B, Castagna A, Lo EY, Krishnan SG. Reverse shoulder arthroplasty for proximal humerus fracture using a dedicated stem: radiological outcomes at a minimum 2 years of follow-up—case series. *J Orthop Surg Res* 2015;10:129. https://dx.doi.org/10.1186/s13018-015-0261-1

5. Grubhofer F, Wieser K, Meyer DC, Catanzaro S, Beeler S, Riede U, et al. Reverse total shoulder arthroplasty for acute head-splitting, 3- and 4-part fractures of the proximal humerus in the elderly. *J Shoulder Elbow Surg* 2016;25(10):1690-8. https://dx.doi.org/10.1016/j.jse.2016.02.024
6. Uzer G, Yildiz F, Batar S, Binlaksar R, Elmadag M, Kus G, et al. Does grafting of the tuberosities improve the functional outcomes of proximal humeral fractures treated with reverse shoulder arthroplasty? *J Shoulder Elbow Surg* 2017;26(1):36-41. http://dx.doi.org/10.1016/j.jse.2016.05.005
7. Boileau P, Krishnan SG, Tinsi L,Walch G, Coste JS, Molé D. Tuberosity malposition and migration: reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. *J Shoulder Elbow Surg* 2002;11(5):401-12. https://doi.org/10.1067/mse.2002.124527
8. Sebastiá-Forcada E, Cebrián-Gómez R, Lizaur-Utrilla A, Gil-Guillén V. Reverse shoulder arthroplasty versus hemiarthroplasty for acute proximal humeral fractures. A blinded, randomized, controlled, prospective study. *J Shoulder Elbow Surg* 2014;23(10):1419-26. https://dx.doi.org/10.1016/j.jse.2014.06.035
9. Formaini NT, Everding NG, Levy JC, Rosas S. Tuberosity healing after reverse shoulder arthroplasty for acute proximal humerus fractures: the "black and tan" technique. *J Shoulder Elbow Surg* 2015;24(11):e299-306. https://dx.doi.org/10.1016/j.jse.2015.04.014
10. Levy JC, Badman B. Reverse shoulder prosthesis for acute four-part fracture: tuberosity fixation using a horseshoe graft. *J Orthop Trauma* 2011;25(5):318-24. https://dx.doi.org/10.1097/BOT.0b013e3181f22088
11. Boileau P, Krishnan SG, Tinsi L, Walch G, Coste JS, Molé D. Tuberosity malposition and migration: reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. *J Shoulder Elbow Surg* 2002;11(5):401-12. https://dx.doi.org/10.1067/mse.2002.124527
12. Boileau P, Winter M, Cikes A, Han Y, Carles M, Walch G, et al. Can surgeons predict what makes a good hemiarthroplasty for fracture? *J Shoulder Elbow Surg* 2013;22(11):1495-506. https://dx.doi.org/10.1016/j.jse.2013.04.018
13. Matthewson G, Kooner S, Kwapisz, A, Leiter J, Old J, MacDonald P. The effect of subscapularis repair on dislocation rates in reverse shoulder arthroplasty: a meta-analysis and systematic review. *J Shoulder Elbow Surg* 2019;28(5):989-97. https://dx.doi.org/10.1016/j.jse.2018.11.069
14. Cazeneuve JF, Cristofari DJ, Charalambous CP, Abiddin Z, Mills SP, Rogers S, et al. The reverse shoulder prosthesis in the treatment of fractures of the proximal humerus in the elderly. *J Bone Joint Surg Br* 2010;92(4):535-9. https://dx.doi.org/10.1302/0301-620X.92B4.22450
15. Gallinet D, Adam A, Gasse N, Rochet S, Obert L. Improvement in shoulder rotation in complex shoulder fractures treated by reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2013;228(1):38-44. https://dx.doi.org/10.1016/j.jse.2012.03.011
16. Klein M, Juschka M, Hinkenjann B, Scherger B, Ostermann PA. 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. https://dx.doi.org/10.1097/BOT.0b013e31818afe40
17. Boileau P, Alta TD, Decroocq L, Sirveaux F, Clavert P, Favard L, et al. Reverse shoulder arthroplasty for acute fractures in the elderly: is it worth reattaching the tuberosities? *J Shoulder Elbow Surg* 2019;28(3):437-44. https://dx.doi.org/10.1016/j.jse.2018.08.025
18. Ohl X, Bonnevialle N, Gallinet, D, Ramdane N, Valenti P, Decroocq J, et al. How the greater tuberosity affects clinical outcomes after reverse shoulder arthroplasty for proximal humeral fractures. *J Shoulder Elbow Surg* 2018;27(12):2139-44. https://dx.doi.org/10.1016/j.jse.2018.05.030