MUSCULOSKELETAL SURGERY (2022) 106:43–48
https://doi.org/10.1007/s12306-020-00669-5

ORIGINAL ARTICLE

Angular stable plate versus reverse shoulder arthroplasty for proximal humeral fractures in elderly patient

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Received: 9 July 2019 / Accepted: 26 May 2020 / Published online: 5 June 2020

Abstract

Background Treatment of complex proximal humeral fractures in the elderly is a challenge and reverse shoulder arthroplasty (RTSA) is now an important alternative to open reduction internal fixation (ORIF) with angular stable plate. The purpose of this study is to compare clinical and radiological outcomes of RTSA and ORIF in the elderly.

Methods We retrospectively analyzed patients treated for three- or four-part displaced fractures of the proximal humerus. Range of motion, disabilities of the arm, shoulder and hand (DASH) and Constant scores were recorded. X-ray exam in three projections completed the clinical observation at follow-up.

Results Forty-eight patients were enrolled after a mean follow-up of 37 months: 22 RTSA and 26 ORIF. Mean age at trauma was 74 years. Compared with RTSA patients, ORIF patients had significantly higher mean external rotation (28° vs. 14°) and better results in modal internal rotation (hand at D7 vs. hand at L5-S1). No significant differences were seen in DASH and Constant scores. Avascular necrosis and loss of reduction with varus dislocation of the humeral head were the most frequent causes of revision surgery in ORIF (34.6%) while the revision rate of the RTSA was 9.1%.

Conclusion In this study, both treatments showed good clinical outcomes, but RTSA resulted in lower revision rate than ORIF. Even if external and internal rotation in RTSA patients were worse than ORIF, they did not affect the patient's quality of life. So, the reverse arthroplasty seems to be a more reliable treatment.

Keywords Proximal humeral fractures · Reverse shoulder arthroplasty · Angular stable plate · Revision surgery · Elderly patient · Complications

Introduction

Proximal humeral fractures represent 6–8% of all fractures [1]. The incidence is steadily increasing due to an ever older population and changes in lifestyle [2, 3].

In elderly patient, these fractures represent a big problem because of pain, loss of function, and high mortality rate [4, 5].

The treatment is still under doubt, especially for 3- and 4-part fractures [6]: complexity of proximal humeral anatomy, surgery complications, and lack of scientific evidences, lead surgeons to make a choice relying on their experience and confidence with a surgical technique.

Three- and four-part fractures usually require a surgical approach, even though some studies suggest that conservative treatment should be considered in ultra-elderly people and in patients with a lot of comorbidities [7].

RTSA was initially recommended in elderly patients with rotator cuff pathology [8]. Subsequently, the use of RTSA has increased a lot during the last decade [9], and it is an optimal alternative to locking plates for the treatment of 3- and 4-part displaced fractures [10].

ORIF offers a reconstruction that respects the shoulder anatomy, but it presents several complications like avascular necrosis of the humeral head, screws cutout, loss of reduction, nonunion, and impingement syndrome [11].

RTSA is less dependent on rotator cuff status and synthesis of tuberosities than hemiarthroplasty, and it is characterized by a faster recovery after surgery [12]. Nevertheless, RTSA may presents complications like scapular notching, instability of the shoulder and the abolition of rotation [13]. Preservation of the tuberosities in anatomic position

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improves active forward elevation and external rotation as well as patient satisfaction with less complications [14].

We designed this retrospective study in order to compare clinical and radiological outcomes in patients older than 65, who were treated with ORIF or RTSA for 3- or 4-part proximal humeral fractures.

Materials and methods

We selected patients between 65 and 85 years old that were treated with a surgical approach (ORIF or RTSA) between January 2009 and June 2017 for 3- or 4-part proximal humeral fracture (AO-OTA type 11-B2 or 11-C2).

Fracture patterns were evaluated by two independent operators using X-rays (true AP view and Y-view) that were performed when the patient arrived at the hospital after trauma.

A CT-scan exam with 3D reconstruction was performed before surgery to characterize fracture patterns.

We excluded patients that presented a follow-up shorter than 12 months, cases of bifocal humeral fractures, patients with neurologic diseases or systemic comorbidities that could compromise clinical results. We also excluded patients who previously underwent surgery to the same shoulder in the past, and the ones who were treated after 10 days from their trauma.

We selected 63 patients operated at Clinical Orthopedics, University Politecnica delle Marche (AN).

Out of these 63 patients, 10 dropped out of the study due to death, together with 5 more patients who did not accept the clinical-radiological follow-up.

In the end, our retrospective comparative study was based on 48 patients.

We filled in a demographic form for each patient, in which we reported: date of birth, gender, weight, height, date of trauma, age at surgery time, total months of follow-up, and injured side.

Functional results were assessed using the Constant–Murley score (0–100 points). Overall subjective patient's satisfaction was evaluated using the disabilities of the arm, shoulder and hand (DASH) score (100–0 points).

Besides, we took X-rays in three projections (true AP view, Y-view and axillary-view) just before the clinical evaluation.

An expert orthopedic evaluated each patient and two independent observers evaluated the X-rays exams during the follow-up.

Scapular notching was graded according to Sirveaux et al. [12] classification.

The 48 patients were divided into two groups depending on the kind of treatment.

The first group was composed of patients who were treated with PHILOS plate (Synthes, Paoli, PA, USA).

The second group was composed of patients who were treated with reverse total shoulder arthroplasty (Lima Corporate, San Daniele Del Friuli, Italy).

The choice of the treatment depended on the type of fracture, the presence of head splitting, bone stock quality, the presence of rotator cuff tear arthropathy, glenohumeral osteoarthritis, and function of the deltoid muscle.

An upper-limb specialist operated all patients. The patient, after regional anesthesia, was placed in beach chair position. A deltoid-pectoral approach was used for reducing the fracture and positioning the plate. The upper part of the plate was positioned at least 1 cm far from the great tuberosity apex and lateral from the bicipital groove in order to avoid interferences with the anterior branch of the anterior circumflex humeral artery. We were also really careful about positioning inferior screws in order to give a medial support to the surgical humeral neck [15].

Humeral tuberosities, when possible, were fixed in their anatomical position using an intraosseous suture with non-absorbable wires (2/0 Ethibond Suture, Ethicon Inc., USA).

We employed a deltoid-pectoral approach in patients treated by RTSA and then, after removing humeral head fragments, we passed non-absorbable wires (2/0 Ethibond Suture, Ethicon Inc., USA) between tendon-bone junctions of the great and less tuberosity.

The glenoid component (36 or 40 mm of diameter) was implanted with an inferior tilt of 10°, and it was fixated to the scapula using two screws. Humeral component was positioned with a version of 0°, and we adjusted the height after taking some articular stability tests. The humeral component was never cemented.

Humeral tuberosities were sutured one to the other and then to the prothesis neck, respecting their anatomical position. It was impossible to fix tuberosities in 5 cases due to the poor bone stock or to the excessive bone fragmentation.

The rehabilitation program, in patient treated with plate, required a sling immobilization of the limb for 4 weeks. Passive shoulder exercises without gravity and active elbow movements were allowed on the very first postoperative day. After 4 weeks, progression to active assisted motion was started avoiding internal and external rotation until 40 days after surgery.

The rehabilitation program in patient treated with RTSA required a sling immobilization for 2 weeks, allowing passive movements of the shoulders and active elbow movements from the first postoperative day. After 2 weeks, progression to active assisted shoulder movements were allowed avoiding internal and external rotation until 40 days after surgery.

Data were collected and organized using Excel (Microsoft, Redmond, WA, USA).

Table 1 Patient demographic data

Group	No. patients	Age at surgery (years)	% Female	Follow-up (months)	% Affecting dominant limb
ORIF	26	73 ± 7.1	96	40 ± 25.4	73
RTSA	22	75.5 ± 5.6	91	33.4 ± 10.4	73

RTSA reverse total shoulder arthroplasty, *ORIF* open reduction and internal fixation. When appropriate, data are reported as arithmetic means ± standard deviation

Categorical variabilities were expressed in numbers and percentages. Continuous variabilities were expressed by averages and standard deviation (DS).

Data from two groups were compared using Mann–Whitney test, *t* test, and Fisher exact test when appropriate.

Statistical analyses were made using SPSS (version 21.0; IBM, Armonk, NY, USA). A $p < 0.05$ was considered as significant.

Table 2 Clinical results in both groups

Variable	ORIF	RTSA	*P Value*
Active abduction	105.5° ± 21.02°	109.75° ± 20.09°	0.48
Active forward flexion	125.75° ± 33.13°	124.5° ± 20.45°	0.99
Active external rotation	28° ± 14.18°	14.25° ± 13.69°	**0.0059**
Active internal rotation	D7 (52%)	L5-S1 (68%)	
Constant score	65.85° ± 15.73°	63.65° ± 12.14°	0.34
DASH score	18.99° ± 14.13°	25.1° ± 11.66°	0.19

RTSA reverse total shoulder arthroplasty, *ORIF* open reduction and internal fixation, *DASH* disabilities of the arm, shoulder and hand

When appropriate, data are reported as arithmetic means ± standard deviation

Bold value indicates statistical significance of $P < 0.05$

Results

The patient demographics are reviewed in Table 1. The mean ages of patients and the follow-up periods were similar with no significant difference between groups ($p > 0.05$).

In the group treated with locking plate, 3-part fractures were present in 9 patients, 15 patients had a 4-part fracture, and the remaining 2 patients had fracture with dislocation.

In the group treated with RTSA, 5 patients had a 3-part fracture, 14 patients had 4-part fracture, and the rest 3 cases had fracture with dislocation.

The mean DASH score in patients treated with ORIF was 18.99 ± 14.13, and the mean Constant–Murley score was 65.85 ± 15.73. The ORIF group average values were: abduction 105.5° ± 21.02°, forward flexion 125.75° ± 33.13°, external rotation 28° ± 14.18°, and modal internal rotation was D7.

The patients treated with RTSA had a mean DASH score of 25.1 ± 11.66 and a mean Constant–Murley score of 63.65 ± 12.14. The average values were: abduction 109.75° ± 20.09°, forward flexion 124.5° ± 20.45°, external rotation 14.25° ± 13.69°, and modal internal rotation was L5-S1.

We did not find any statistically significant difference between groups about Constant–Murley score and DASH score and neither about abduction and forward flexion ($p > 0.05$).

We found a statistically significant difference between two groups for external rotation ($p = 0.0059$) that was better in patients treated with ORIF. Also, it offered better results for internal rotation (Table 2).

The group treated with plate was characterized by 5 cases of avascular necrosis of the humeral head (19.2%), in particular, 4 cases were complete necrosis and 1 case was partial necrosis.

We observed 3 cases (11.5%) of loss of reduction with varus displaced humeral head (1 of those had a screw cutout) and 1 case (3.8%) of deep infection. Also, we registered 2 cases (7.6%) of great tuberosity malunion and 2 cases (7.6%) of subacromial plate impingement.

The group treated with RTSA was characterized by 1 case (4.5%) of instability, 1 case (4.5) of deep infection and 7 cases (31.8%) of inferior scapular notching (grade 1 or 2). We also registered 5 cases (22.7%) of great tuberosity malunion.

In the ORIF group, 3 out of 5 patients with necrosis required a surgical revision with reverse arthroplasty because of the persistent pain and poor ROM. In 2 cases of varus dislocation, a second reduction and fixation with plate was needed. In the patient with screw cutout, the removal of internal devices after fracture healing was sufficient. In the patient with deep infection, a two-step surgery was necessary, and in patients with impingement, the plates were removed after fracture healing (Table 3). The revision rate was 34.6% in the ORIF group.

In the RTSA group, the patient with instability of the arthroplasty required implant revision. In the patient with deep infection, a two-step revision surgery was needed (Table 4). The revision rate was 9.1% in the RTSA group.

At the end, we concluded that the revision rate was significantly higher in the group treated with ORIF than the group treated with RTSA ($p = 0.045$).

Table 3 Complications and their treatments (ORIF group)

Complication	Number (%)	Treatment
AVN complete	4 (15.4%)	3 Patients: RTSA 1 patient: observation
AVN Partial	1 (3.8%)	Observation
Loss of reduction	3 (11.5%)	2 Patients: replacing plate 1 patient: removal of the implant
Deep infection	1 (3.8%)	Two-step operative revision
Subacromial impingement	2 (7.6%)	Removal of the implant
Tuberosities Malunion	2 (7.6%)	Observation

AVN avascular necrosis, *RTSA* reverse total shoulder arthroplasty, *ORIF* open reduction and internal fixation

Table 4 Complications and their treatments (RTSA group)

Complication	Number (%)	Treatment
Instability	1 (4.5%)	Replacing components
Deep infection	1 (4.5%)	Two-step operative revision
Scapular notching	5 Nerot-1 (22.7%) 2 Nerot-2 (9%)	Observation
Tuberosities Malunion	5 (22.7%)	Observation

RTSA reverse total shoulder arthroplasty

Discussion

The best treatment for 3- and 4-part dislocated fractures in elderly patients remains under doubt. The most frequent operative treatments are the open reduction and internal fixation, and the reverse shoulder arthroplasty.

However, in the literature, we found only two works that compared these two techniques in patient over 65.

Giardella et al. [16] obtained a better Constant–Murley score and forward flexion with RTSA; while they achieved a better external rotation in patients with angular stable plate. The authors concluded that RTSA is one of the best treatments in elderly patients, in which rotator cuff is frequently poor and degenerated.

Chalmers et al. [11] found that RTSA offers better results in forward flexion, but they did not find any difference in quality life scores neither in other evaluated ROMs.

In our study, we reached great DASH and Constant–Murley scores with both the techniques. We did not find any significant difference in abduction and forward flexion among the groups, but ORIF offers better results in external and internal rotation. In fact, it achieved $28° \pm 14.18°$ during external rotation, while RTSA only obtained $14.25° \pm 13.69°$. The patients treated with plate usually have an internal rotation that reached D7, and patients treated with RTSA achieved L5-S1.

There are a lot of factors that could influence rotations in patient with reverse arthroplasty [12, 17–21]. In particular, in our study, the high index of great tuberosity malunion (22.7%) played an important role. We have also to consider that the synthesis of the tuberosities sometimes was not possible due to the poor bone stock or to the excessive fracture comminution.

However, osteosynthesis with plate remains a challenge even for superior limb expert orthopedics. In fact, even though new implants and materials are developed, complications and revision rate remain very high [21–23].

Du et al. meta-analysis [23] compared various types of treatment including RTSA and ORIF. In this metanalysis, RTSA has higher Constant–Murley score, and it also has lower revision rates in comparison with plate, hemiarthroplasty, and conservative approach. In the same metanalysis, the plate is characterized by the worst results.

AVN incidence rate is between 3 and 68% [24, 25], and it depends a lot on the fracture pattern, metaphyseal extension, and calcar integrity [26]. We have also to consider the important damage that the surgeon can do to the vascular system during the reduction with ORIF [21].

We registered several AVN cases (19.2%) in our study, and it was the most frequent cause leading to an implant revision.

The second most frequent complication in patients treated with plate was the loss of reduction with varus dislocation of the humeral head (11.5%), and in one case among those, we observed a screw cutout. In order to avoid this complication, we suggest to follow tips and strategies that the literature gives us: supporting the medial hinge, restoring the cervical-diaphyseal angle, putting screws on calcar, using cement augmentation [21, 27]. Even if the surgeon follows all these tips, the loss of reduction incidence rate is still elevated.

About the RTSA procedure, there was a single case of dislocation (4.5%) that was in line with the literature [11]. The difficulty in preventing dislocation lies in the fact of having to establish the correct height of the humeral stem in the presence of a subverted anatomy, and therefore, the risk of an unstable or a rigid shoulder is high.

The group treated with ORIF was characterized by high revision rate (34.6%) and that confirms what we knew [21, 28–33].

Reverse shoulder arthroplasty was more reliable, with a revision rate of 9.1%.

Many plate revisions (33%) required a conversion to reverse prosthesis. However, RTSA, as a revision treatment, is described as definitely worse if compared with a case in which it is used as first implant [34].

Summarizing the present study could represent a valid guide for the choise of the treatment of complex proximal humeral fractures. Indeed, RTSA represents a safe and effective option in elderly with a lower complication rate than ORIF. However, this study has several limitations: (1) small sample size for each group; (2) it is a retrospective and non-randomized study; (3) only medium-term follow-up was obtained; (4) we lost some patients during the follow-up.

Further prospective studies with a higher sample size and a longer follow-up are needed in order to more properly define the role of reverse shoulder arthroplasty in this kind of fractures.

Conclusions

We confirm good clinical results in patients treated both with open reduction and internal fixation using an angular stable plate and with the reverse shoulder arthroplasty for 3- and 4-part proximal humeral fractures in patients older than 65 years. Even if external and internal rotation in RTSA patients were worse than the ORIF group, they did not affect the patient's quality of life.

However, osteosynthesis with locking plate is characterized by a higher revision rate than the group treated with RTSA. Therefore, the reverse shoulder arthroplasty seems to be a more reliable treatment.

Acknowledgements None

Author contributions All authors contributed to the study conception and design. Pierfrancesco Luciani and Francesco Pettinari collected the patient data. Roberto Procaccini performed the surgeries. Marco Rotini and Pierfrancesco Luciani analyzed the patient data. Antonio Gigante supported Pierfrancesco Luciani and Marco Rotini with analyzing and interpreting the data. Francesco Pettinari wrote the manuscript. All authors helped write the manuscript and have read and approved the final version.

Funding This manuscript was not supported financially by any funding agency.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was approved by the institutional review board and performed in accordance with 1964 Helsinki Declaration.

Informed consent Informed consent was obtained from all individual participants included in the study.

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