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ORIGINAL ARTICLE

The use of the Lima reverse shoulder arthroplasty for the treatment of fracture sequelae of the proximal humerus

Angel Antonio Martinez · Angel Calvo · Carlos Bejarano · Ignacio Carbonel · Antonio Herrera

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Abstract
Background Experience treating proximal humerus fracture sequelae with reverse total shoulder arthroplasty is limited. We report our results.
Patients Forty-four patients with sequelae of a proximal humeral fracture were treated with a reverse total shoulder prosthesis. There were 26 women and 18 men, with a mean age of 77 years (range, 74–84 years). The mean follow-up after reverse arthroplasty was 48 months (range, 40–84 months).
Results The mean Constant score increased from 28 preoperatively to 58 postoperatively ($p < 0.0001$). The average anterior elevation increased from 40° to 100° ($p < 0.0001$), abduction from 41° to 95° ($p < 0.0001$), external rotation from 15° to 35° ($p < 0.0001$) and internal rotation from 25° to 60° ($p < 0.0001$). The average subjective shoulder score increased from 13% preoperatively to 56% postoperatively ($p < 0.0001$). All but six patients would undergo the same procedure again if faced with the same problem. Twenty-four patients were very satisfied, 14 satisfied and 6 unhappy with the operation. Six prosthetic dislocations occurred (13.6%). Two of them were successfully treated by adding an extension to the humeral neck component to increase the offset and tension. In the other four dislocations this procedure failed, and the prosthesis was revised and converted to a hemiarthroplasty. There was one case of glenoid component loosening that was converted to a hemiarthroplasty.
Conclusions The reverse total shoulder arthroplasty improves function and motion in patients with proximal humeral fracture sequelae. However, the dislocation rate is high.

A. A. Martinez (✉) · A. Calvo · C. Bejarano · I. Carbonel · A. Herrera
Department of Orthopaedic and Trauma Surgery, Miguel Servet University Hospital, C/Calamita s/n, Avda. Juan Pablo II, 48, 9°G, 50009 Zaragoza, Spain
e-mail: anmarti67@yahoo.es

Introduction

Fractures of the proximal humerus may result in pain and disability of the shoulder. Malunions of the tuberosities with preserved humeral heads can be successfully treated by osteotomy of the tuberosity and fixation in the correct position [1, 2], but some cases of avascular necrosis, locked dislocations, nonunions of the surgical neck in osteoporotic patients and malunions of the tuberosities with incongruity of the humeral articular surface may be indications for a shoulder prosthesis [1–7].

Several studies have analyzed the results of late non-constrained arthroplasty for failed primary treatment of proximal humerus fractures. The results have been good in terms of pain, but some problems have been reported, such as instability, loosening, glenoid erosion, heterotopic ossifications, impingement syndrome and rotator cuff tear [8].

Poor results have been reported in 33–50% of patients with sequelae of the proximal humerus treated by hemiarthroplasty or total shoulder arthroplasty [3–7]. Greater tuberosity osteotomy was the most important reason for poor and unpredictable results because of the high incidence of tuberosity nonunion or resorption.

Reverse total shoulder arthroplasty has been used to treat cuff tear arthritis [9–13], fracture sequelae [11, 12], acute proximal humeral fractures [14, 15] and failed

hemiarthroplasty [16, 17]. However, experience with treating proximal humerus fracture sequelae with reverse total shoulder arthroplasty is limited [11, 12] and its benefit has not yet been clearly established.

The purpose of this study is to evaluate the results achieved using the Lima reverse total shoulder arthroplasty for treating the sequelae of proximal humerus fractures.

Materials and methods

Patients

Between 2003 and February 2007, 44 patients with sequelae of a proximal humeral fracture were treated with the Lima reverse shoulder prosthesis. We obtained Institutional Review Board authorization agreement for the study design and publication of the study. All patients gave written consent to undergo the surgical procedure and have their data published. There were 26 women and 18 men, with a mean age of 77 years (range, 74–84 years). The failed initial treatment was percutaneous pinning in 6 cases, fixation with the Philos plate in 14 cases and conservative treatment in 24 cases.

The mean time interval from the initial fracture treatment to surgery for sequelae was 12 months (range, 10–14 months). The mean follow-up after the reverse arthroplasty was 48 months (range, 40–84 months). According to the classification of proximal humeral fracture sequelae described by Boileau et al. [4, 18], there were 16 type 1 sequelae (valgus impacted malunion), 8 type 2 (locked dislocation or fracture dislocation with cephalic collapse or necrosis), 14 type 3 (surgical neck nonunion) and 6 type 4 (severe tuberosity malunion).

Radiological preoperative assessment included anteroposterior, scapular lateral and axillary radiographs, and a magnetic resonance scan to evaluate the preoperative cuff status, bone morphology of the fracture and bone loss of the glenoid or proximal humerus.

The subscapularis was intact in 40 cases and partially torn in 4. The supraspinatus was intact in 31 cases, partially torn in 10 and completely torn in 3. The infraspinatus was intact in all patients. Fatty infiltration was greater than 50% in 10 cases of the subscapularis and in 28 cases of the supraspinatus.

Erosion of the glenoid was graded as central, peripheral or combined, and its severity was classified as mild, moderate or severe. There was one case of moderate anterior erosion, three cases of mild posterior erosion and four cases of mild central erosion. A proximal humeral bone loss was found intraoperatively in eight cases. This bone loss was always moderate, not extensive, and located in the greater tuberosity area.

Operative technique

All patients were operated on in a beach-chair position. A deltopectoral approach was used. We released the adherences between the proximal humerus and the deltoid. The subscapularis was released from the lesser tuberosity. The axillary nerve was exposed and protected. The plate was removed if present. The rotator cuff was resected if present, trying to partially preserve the infraspinatus. The tuberosities were removed if there were a nonunion, but we tried to preserve the area of bone that was not included in the cut if the tuberosities were united. We resected the areas of severely malunited bone that could produce an impingement with the glenoid or acromion. The humeral resection guide was placed to achieve 20° humeral retroversion. With the arm flexed at 90°, we inserted an alignment rod into the prosthesis introducer, and the desired retroversion was calculated placing the rod parallel to the reference to the forearm axis.

After exposure of the glenoid, the soft tissues and capsule were released. The axis of the glenoid was determined, and the insertion point for the guide pin was chosen approximately 2 mm inferior to the middle of the glenoid and approximately centered anteroposteriorly. To obtain good bone seating, the metaglene has to be positioned on the lower circular area of the glenoid. The metaglene central peg should to be positioned in the center of the inferior circle of the glenoid. The guide pin was inserted perpendicularly with respect to the glenoid face. The direction was also chosen by palpating the anterior and posterior aspects of the scapula as well as examining the X-rays and magnetic resonance preoperative images. The glenoid was reamed until a flat uniform surface was achieved. The glenoid was replaced with a small uncemented glenoid component placed anatomically and fixed with two 6.5-mm screws. The superior screw was directed toward the scapular spine to obtain strong fixation. The inferior screw was directed towards the inferior cortical area of the glenoid. In the eight cases where proximal bone loss was found, an allograft and a long humeral stem were used. A femoral head was used for allograft. An oscillating saw was used to create a cut of the femoral head that fit into the defect of the proximal humerus, which was always located in the greater tuberosity area. The allograft was placed around the proximal body of the prosthesis in the greater tuberosity area and fixed with cable wires around the graft and the inner humerus.

The humeral component was implanted with gentamicin-impregnated bone cement in 20 cases and without cement in 24. A concentrical glenosphere was used in the first 23 cases and an eccentric glenosphere in the following 21. We changed our indication and started to use an eccentric glenosphere in order to avoid scapular notching.

The subscapularis tendon was reinserted with transosseous sutures. A biceps tenodesis was performed. Postoperatively, the patient was allowed to perform pendulum exercises. After 3 weeks, rehabilitation was started, and passive and active mobilization was allowed.

Clinical analysis

Range of motion, Constant score and subjective shoulder value (the estimated value as a percentage of an entirely normal shoulder) were recorded pre- and postoperatively. In addition, we asked the patients their subjective satisfaction and willingness to undergo the operation again.

Radiographic analysis

Anteroposterior, axillary lateral and scapular lateral radiographs with a minimum 28-month follow-up were available in all patients. The radiographs were examined to assess component position, radiolucent lines, osteolysis, heterotopic ossification and infrascapular notching. Inferior scapular notching was classified according to Nérot's system [19].

Statistical analysis

Statistical analysis of the results was performed with a paired *t* test for comparison of specific preoperative and postoperative values.

Results

Clinical results

- *Constant score*: the mean Constant score increased from 28 preoperatively to 58 postoperatively ($p < 0.0001$) (Table 1; Fig. 1a, b).
- *Range of motion* (Table 2): the average anterior elevation increased from 40° preoperatively to 100° postoperatively ($p < 0.0001$). The average abduction increased from 41° preoperatively to 95° postoperatively ($p < 0.0001$). The average external rotation increased from 15° preoperatively to 35° postoperatively ($p < 0.0001$). The average internal rotation increased from 25° preoperatively to 60° postoperatively ($p < 0.0001$).
- *Subjective shoulder value*: the average subjective shoulder score increased from 13% preoperatively to 56% postoperatively ($p < 0.0001$).
- *Patient satisfaction*: all but six patients (the patients that had a dislocation of the prosthesis) would undergo the same procedure again if faced with the same problem. Twenty-four patients were very satisfied, 14 satisfied and 6 unhappy with the operation (the patients that had a dislocation of the prosthesis).

Table 1 Constant score

	Preoperatively	Postoperatively
Pain	4.5/15	10.2/15
Mobility	10.6/40	20.8/40
Activity	6/20	14/20
Strength	6.9/25	13/25
Total	28	58

Radiological results

There was one case of glenoid loosening, five cases of humeral radiolucency without signs of loosening and 18 cases of glenoid notching (15 grade 1 and 3 grade 2). Scapular notching was observed in ten cases of concentric glenosphere and in eight cases of eccentric glenosphere. This difference was not statistically significant. The allograft incorporated around the prosthesis in four cases (Fig. 2d), and a graft reabsorption was observed in other four.

Complications

A complication occurred in 12 patients (27%). The complication had an effect on the final outcome in five patients, as it led to removal of the prosthesis and to conversion to a hemiarthroplasty with a head with a larger cover (CTA head).

We had one case of superficial infection treated by antibiotics and one case of transitory axillary nerve palsy.

Six prosthetic dislocations occurred (13.6%), all of them within 6 weeks after the operation. Two of them were successfully treated by adding an extension to the humeral neck component to increase the offset and tension. In the other four dislocations this procedure failed, and the prosthesis was revised and converted to a hemiarthroplasty. The glenoid was removed, a reverse body adaptor screwed to the humeral body of the prosthesis and a head with a larger cover (CTA head) placed on the adaptor (Fig. 2a–c). The six dislocations occurred in one case of moderate anterior glenoid erosion, in three cases of proximal humeral bone loss that had needed an allograft and in two cases without bone loss. The cases without bone loss were the ones solved by adding an extension to the humeral component.

There was one case of glenoid component loosening that was converted to a hemiarthroplasty with a CTA head.

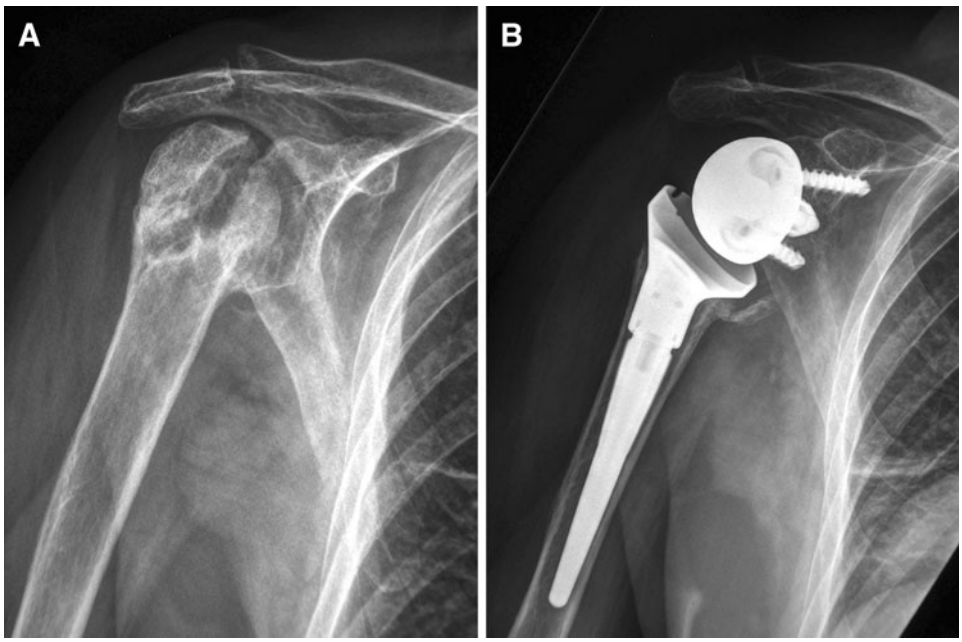

Fig. 1 A locked fracture dislocation (**a**) treated successfully by reverse arthroplasty (**b**)

Table 2 Range of motion

	Preoperatively	Postoperatively
Anterior elevation (°)	40	100
Abduction (°)	41	95
External rotation (°)	15	35
Internal rotation (°)	25	60

The five cases treated by a CTA head had poor functional results. The average anterior elevation was 60°, the average abduction 60°, the average external rotation 25° and the average internal rotation 50°. All of the patients had pain during activities of daily living.

There were two cases of intraoperative minor split of the proximal humerus resulting from final implantation of the stem that were treated by cerclage wire around the proximal humerus. There was one case of periprosthetic humeral fracture type C 12 months after the operation. It was treated by open reduction and internal fixation with a compression plate fixed with wires and screws.

Discussion

The reported that the short-term functional results of reverse total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff have been good [9–11, 13, 19–24], but the reported survival rate at 10 years is 58%. Scapular notching is a main concern for the long-term survival of the implant. This is why this arthroplasty has been recommended for patients over 70 years old [25]. Future studies will be necessary to determine the longevity of the implant and whether it will provide continued improvement in function.

The reported results of reverse total shoulder arthroplasty for the treatment of posttraumatic arthritis have been worse than for cuff tear arthropathy [11, 12], mainly because of the high rate of complications, reoperations or revisions. However, the experience of the use of reverse total shoulder arthroplasty for the treatment of fracture sequelae is limited. In the study of Boileau et al. [11], only 5 cases of posttraumatic arthritis were included, and in the study of Wall et al. [12], 33 cases of this etiology were included. In those studies, patients with primary rotator cuff arthropathy had better clinical results and fewer complications than patients with posttraumatic arthritis and revision arthroplasty. The most common complications were dislocation and infection. Patients who received reverse total shoulder arthroplasty at the time of a revision had the highest complication rates.

We think that in cases of cuff tear arthroplasty, the bone anatomy of the proximal humerus and glenoid used to be preserved, but it is technically easier to calculate the height and position of the humeral component.

The reverse total shoulder arthroplasty has been used in the revision of failed shoulder hemiarthroplasty for glenohumeral arthritis associated with rotator cuff deficiency and for proximal humeral fracture. The prothesis provided improvement in pain and function. However, high rates of complications were associated with glenoid and proximal humeral bone loss [16, 17]. In cases of severe proximal humeral bone loss, augmentation of the reverse total shoulder arthroplasty with a proximal humeral allograft improved patient satisfaction.

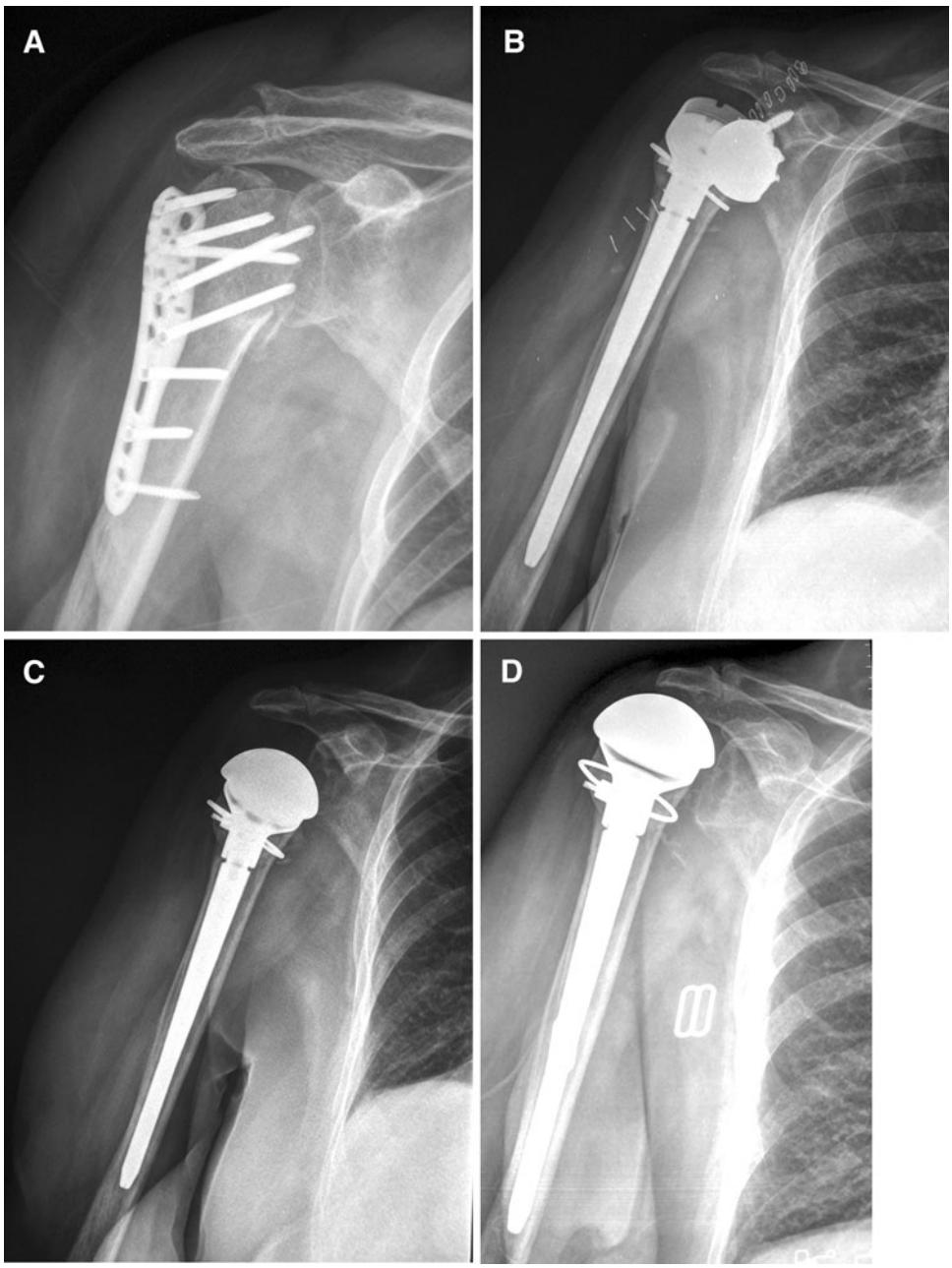

Fig. 2 A four-part fracture of the proximal humerus was treated initially by plate fixation. The reduction was incorrect, and a severe tuberosity and humeral head malunion occurred (**a**). It was treated by reverse arthroplasty, and as a proximal humeral bone loss was found intraoperatively, an allograft and a long humeral stem were used. The allograft was placed around the proximal body of the prosthesis in the greater tuberosity area and fixed with a cable wire around the graft and the inner humerus. The prosthesis dislocated and was not stable upon adding an extension to the humeral neck component (**b**). Therefore, it had to be revised and converted to a hemiarthroplasty with a larger head cover (**c**). We could observe the allograft incorporated into the prosthesis 2 years later (**d**)

Several studies have reported the results of anatomical prosthesis for the treatment of proximal humeral fractures sequelae. Boileau et al. [4] obtained poor or fair results in 58% of cases. The most significant factor affecting functional outcome was greater tuberosity osteotomy. Dines et al. [5] reported fair and poor results in 30% of patients. One patient had nonunion of a tuberosity repair with superior instability and secondary impingement, and another patient had a postoperative posterior subluxation. These authors advised to avoid tuberosity osteotomy if possible. Antuña et al. [3] had unsatisfactory results in 50% of patients because of lack of postoperative motion or pain. Of the 24 shoulders that underwent tuberosity osteotomy, 10 had nonunion or resorption. All of them had an unsatisfactory result. Norris et al. [7] reported that prosthetic arthroplasty reduced the shoulder pain in 95% of cases, but activities at or above shoulder level were possible only in 53% of the patients. Mansat et al. [6] found satisfactory results in only 64% of patients.

We used reverse total shoulder arthroplasty for the treatment of fracture sequelae because we thought that in the cases of incongruent glenohumeral joints of long evolution in elderly people, the rotator cuff is functionally useless. There are adherences between the rotator cuff and the deltoid and capsule, and the fatty infiltration of the muscles makes the cuff functionally very weak.

Our rate of dislocation has been high. We think that in the cases of reverse total shoulder arthroplasty for the treatment of sequelae, there are several factors that increase the risk for postoperative dislocation. The amount of soft tissues release needed to implant the prosthesis is very important. In some cases there are deficiencies of tendons such as the subscapularis or infraspinatus, and bone loss of the glenoid or proximal humerus. This makes the procedure more complicated because in these cases, an allograft is needed, and the correct position and appropriate height of the prosthesis is difficult of calculate. This can result in poor muscular control and instability of the prosthesis.

We started to use eccentric the glenosphere to avoid scapular notching. We noticed a lower incidence of scapular notching with this eccentric component, although the difference was not statistically significant. It is necessary to study a larger series of patients to reach a conclusion about whether this eccentric component can decrease the incidence of scapular notching.

Conclusions

In summary, reverse total shoulder arthroplasty improves function and motion in patients with proximal humeral fracture sequelae. However, the rate of dislocation is high. Therefore, it has to be used judiciously, and, because of concerns about the longevity of the implant, its use should be limited to elderly patients with poor function and severe pain.

Conflict of interest None.

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