Conversion of shoulder arthroplasty to reverse implants: clinical and radiological results using a modular system

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Abstract

Purpose Revision of a shoulder arthroplasty to a reverse arthroplasty is a highly demanding procedure. The aim of this study is to report the clinical results of hemi and total shoulder prosthesis revisions to reverse implants without removal of the humeral stem, using a modular shoulder replacement system (SMR Lima LTD). We retrospectively reviewed 26 patients who underwent an operation from 2004 to 2009.

Methods The patients were divided into two groups: in Group I, 18 patients underwent a revision of hemiarthroplasty implanted for fracture; in Group II, eight patients underwent a revision of anatomical total prosthesis. All patients were evaluated at a mean follow-up of 32.3 (± 12.7) months using the Constant score rating scale and by range of motion evaluation, EQ-VAS, X-ray and CT scan.

Results The Constant score of each patient was 47.88 (± 5.88) after the revision. The EQ-VAS improved from 40 (± 20) to 70 (± 10). All patients improved in terms of range of motion.

The radiographs and CT scans obtained after revision showed good integration and no signs of loosening of the implant. The mean time of surgery was recorded as 62' ($\pm 8'$), with a maximum blood loss of less than 300 ml in all cases.

Conclusions Our study demonstrates that using a full modular system at the time of the first implant allows avoidance of the step to remove the humeral stem and metal back in cases of shoulder prosthesis revision to a reverse prosthesis, resulting in a short operative time, few intraoperative complications and a satisfactory clinical outcome at medium-term follow-up.

Introduction

In the last two decades, the number of shoulder arthroplasties has increased every year, probably due to the advances in implant design and surgical technique, which have made complicated surgical procedures possible [1, 2]. However, many complications may affect the mid- and long-term results of this type of surgery, leading to loss of function, pain and failure of the implant.

Many studies have reported an incidence of failure of approximately 10 % at ten-years follow-up and have identified several causes for revision surgery after TSA [3–11]. Rotator cuff failure that leads to anteroposterior migration due to the loss of the depressor strength, which is generally granted by the rotator cuff, is one of the most common causes of failure [3–11]. Other causes include glenoid component loosening, instability, infection and component malposition.

The results of the studies involving hemiarthroplasty as a treatment for humeral head fractures are not homogeneous, with many patients reporting pain relief with varying results

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from functional tests. However, the survival rate reported in recent studies rose from 50 % to 80 % at medium-term follow-up [12–18]. Implant failure is frequently due to tuberosity resorption, tuberosity non-union and cuff deficiency [13, 19–22].

Successful management of patients who have had a failure remains a challenge. Revision of the implant to a reverse arthroplasty may be one possible option [23–25].

Generally, a revision surgery is a highly demanding procedure due to the need to remove the humeral stem. The presence of the cement or good ingrowth of a cementless component makes the revision difficult and carries a risk of humerus fracture [24–26].

In fact, a well-fixed humeral implant adds a further difficulty when, in most cases, the reason for the revision is in the glenoid component or is due to a rotator cuff failure.

Different techniques have been proposed to facilitate humeral stem removal and to lower the 24 % rate of fracture, as reported by Wall and Walch [27] in their review of reverse shoulder replacement [28–31]. However, these

techniques appear to be extremely challenging and burdened by many complications.

The use of a modular shoulder system allows revision of an anatomical prosthesis to reverse arthroplasty with a reduced complication rate. In this multicentre study, each institute used a modular shoulder replacement system (SMR Lima LTD). The aim of this study was to report the clinical results of a hemi or total shoulder prosthesis revision to a reverse implant without the removal of the humeral stem. The study demonstrates how this simplified surgical procedure, using a modular system, improves postoperative clinical outcome and enables faster mobilisation with better clinical outcome at longer follow-up times compared to a standard revision.

Methods

In this study, we retrospectively reviewed patients, operated upon from 2004 to 2009 in three different institutes, who underwent revision to a reverse shoulder arthroplasty from

Fig. 1 X-ray analysis of a 68-year-old female patient who underwent a revision to reverse arthroplasty of hemiarthroplasty originally implanted for humeral head fracture failed for non-union of the tuber-

osities. **a** Humeral head fracture. **b** Hemiarthroplasty failed. **c** Reverse arthroplasty

an original implant (hemiarthroplasty or anatomical total prosthesis) of an SMR modular system (Lima LTD).

We identified 26 patients who fulfilled the following inclusion criteria: between 65 and 80 years of age, active forward flexion less than 60°, superior subluxation of the humeral head suggesting a massive cuff tear or severe resorption of the lesser and/or greater tuberosity, pain with loss of function, no clinical or radiological or hematological evidence of active infection and no signs of loosening or instability of the implant. All patients gave their informed consent prior to their inclusion in the study.

We divided the patients into two groups: in group I, we included patients who underwent a revision to reverse (RSA) of an hemiarthroplasty (hemi) (Fig. 1) originally implanted for fracture; in group II, we included patients

who underwent a revision to reverse (RSA) of an anatomical total prosthesis (TSA) (Fig. 2).

Eighteen cases met the criteria for group I (failed hemiarthroplasty for tuberosity resorption or rotator cuff failure) and eight for group II (failed TSA for rotator cuff complication).

The mean patient age was 72.3 for group I and 73.6 for group II at the time of the revision. The dominant shoulder was involved in eight and four cases, respectively, and the male/female ratio was 7/11 in group I and 2/6 in group II.

The patients with hemiarthroplasty began to experience pain, often severe, during shoulder movement; deterioration of shoulder motion was observed, on average, 36 months (range 8–50) from the date of the primary implantation. X-ray (AP, internal and external rotation axillary and outlet view) and CT scans revealed cuff failure in three patients,

Fig. 2 X-ray analysis of a 65-year-old female patient who underwent a revision to reverse arthroplasty of an anatomical total shoulder arthroplasty originally implanted for shoulder arthritis. **a** Gleno-

humeral arthritis. **b** Anatomical total shoulder arthroplasty failed for cuff deficiency. **c** Reverse arthroplasty

tuberosity resorption in 13 patients and tuberosity non-union in two patients.

In group II, the first implant revision was due to cuff failure in seven cases, and a trauma involving a massive cuff tear in the eighth patient. The patients began complaining of pain, on average, at 40 months (range 6–48) after surgery. Based on X-ray and CT scans, no patient had any signs of humeral stem or glenoid loosening.

Using a delto-pectoral approach, when feasible, the humeral insertion of the subscapularis tendon was easily recognised, and the tendon was divided longitudinally. When this approach was not possible, the tendon was sectioned just medial to the prosthetic humeral head and palpated with the fingers.

Two stay sutures were placed in the medial end of the subscapularis tendon when it was present, which was then released medially and inferiorly. The prosthetic head was dislocated and then disconnected with the humeral body

from the stem. For all patients from both groups, the humeral stem was not cemented and had not loosened; thus, a reverse humeral body was implanted on the humeral stem. The instruments allow choices in the version and the height of the implant, using different sizes of the humeral body.

In group I, the glenoid was exposed, and capsular release was performed by sectioning the antero-inferior capsule or the scar tissue that had replaced it, and in a few cases, the posterior capsule as well. In seven patients, the anterior border, posterior border, or the central portion of the glenoid was eroded; however, no bone grafting was necessary. A metal-backed glenoid with a 36-mm glenosphere was implanted in all 18 cases.

In group II patients, following glenoid exposure, the polyethylene insert was removed from the glenoid metal back; the baseplate was stable and well integrated in all patients. Next, 36-mm (in four cases) or 44-mm polyethylene (in the other four cases) glenospheres were implanted on the existing

Fig. 3 Range of motion of a 68-year-old female patient after a revision of hemiarthroplasty to reverse arthroplasty. **a** Forward elevation. **b** Abduction. **c** External rotation. **d** Internal rotation

metal-backed glenoid. The shoulder was then reduced and, when possible, the subscapularis tendon was reattached. The operating time of the revision, in addition to the amount of blood loss and days of hospital stay, were recorded.

All of the patients had a similar rehab program. Group I patients were evaluated at a mean follow-up of 32.3 (± 12.7) months after surgery, and group II was evaluated at 31.6 (± 10.4) months using the Constant score rating scale (CS), range of motion evaluation (ROM) (Figs. 3 and 4), EQ-VAS to evaluate the daily activity, X-ray (AP, internal and external rotation axillary and outlet view) and CT scan. The two groups had a mean follow-up period of 28 months (min 24–max 72).

Postoperative rehabilitation

We applied the same rehabilitation protocol that we used for the first implantation. All patients wore a sling for four weeks, and pendulum exercises were started two weeks after surgery.

Thereafter, over a two-week period, the sling was discontinued and passive-assisted exercises were begun. Active motion was permitted after another four weeks, and resistance exercises were begun at 12 weeks. The rehabilitation program was not delayed in any of the patients.

Statistical analysis

All continuous variables were expressed in terms of mean $\pm$ standard deviation of the mean. The Wilcoxon test was performed to test the significance of continuous data differences between preoperative and follow-up evaluations. The Mann-Whitney test was used to test the significance of continuous data differences between the two treatment groups. For all tests, $P < 0.05$ was considered to be significant. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software version 14.1 (SPSS Inc, Chicago, Illinois).

Fig. 4 Range of motion of a 65-year-old female patient after a revision of anatomical total shoulder arthroplasty to reverse arthroplasty. **a** Forward elevation. **b** Abduction. **c** External rotation. **d** Internal rotation

Fig. 5 Constant score pre-op and at follow-up of group I

Results

Prior to revision, the mean Constant score of all patients was 25.28 points (± 3.24); after revision, it was 47.88 (± 5.88), which was a statistically significant improvement (Wilcoxon test, $P < 0.001$). Group I showed a mean increase of 23.61 points, from 25.16 (± 3.60) to 48.77 (± 4.45) (Wilcoxon test, $P < 0.001$; Fig. 5), while Group II improved from 25.57 (± 2.29) to 45.87 (± 7.52) (Wilcoxon test, $P < 0.001$; Fig. 6). No statistically significant differences were found between the two groups.

The most important gain obtained in all of the patients was in range of motion, with a mean forward flexion of 120° (range, 80 – 140°) and abduction of 95° (range, 80 – 120°) (Tables 1 and 2; Figs. 3 and 4). The strength and internal rotation values did not drastically improve, resulting in a lower final Constant score for all patients. In fact, the mean scores for internal rotation and power did not change significantly. For all patients, the VAS improved from 8 ± 1 to 2 ± 1 , with no statistical differences between the two groups.

The improvements in forward elevation and abduction in addition to decreases in pain had a very positive influence on the patients' daily quality of life, enabling the EQ-VAS to rise from $40 (\pm 20)$ to $70 (\pm 10)$. We did not find any significant differences between the two groups.

Fig. 6 Constant score pre-op and at follow-up of group II

Radiography obtained after revision showed no radiolucency around the humeral stems or glenoid. The CT scan showed good integration and no signs of loosening.

The mean time of surgery was 62' ($\pm 8'$) (51' in group I and 75' in group II), with blood loss always less than 300 ml; no significant differences were found between the two groups. No intraoperative or postoperative complications occurred. Hospital stay continued for two to four days after surgery, with no difference between the two groups.

Discussion

Total shoulder arthroplasty and hemiarthroplasty are well-established operations that are associated with significantly improved function and pain relief in most patients [7, 10, 11, 32]. The survival rate for TSA can exceed 90 % at ten years follow-up and 80 % at 15 years [5, 8–11, 33]. A concern about hemiarthroplasty in the treatment of humeral head fracture is that the survival rate rises from 50 % to 80 % at medium follow-up [12–18].

Longevity of the shoulder prosthesis depends on many factors, and different authors have identified multiple causes of failure [5, 23, 34]. In TSA, the main causes of failure are related to cuff failure or glenoid loosening. In hemiarthroplasty tuberosity non-union, tuberosity resorption and, rarely, glenoid arthritis are the most frequently

Table 1 Range of motion pre-op and at follow-up of group I

Evaluation	FLEX	ABD	RE1	RI
Pre-op	45°±5°	50°±10°	5°±1	S1
Post-op	115°±10°	87±8°	5°±1	L5

indicated causes [13, 19–22]. Less commonly, in both types of implants, the humerus can be afflicted by component malposition, instability, infection, fracture and, atypically, humeral component loosening [35]. The revision procedure can be difficult if the ingrown or cemented humeral stem requires removal. Many authors have suggested different techniques that appear to be challenging and burdened by many complications. Wall and Walch [27] reported humeral fracture in 24.1 % of their patients. Sperling et al. [31] reported a 20 % intraoperative fracture rate. Gohlke and Rolf [29] observed complications in eight patients out of 34 treated by a technique that required two osteotomies with a technically difficult medial osteotomy under the pectoralis insertion. Van Thiel et al. [26] described a vertical humeral osteotomy technique for stem extraction; in their study, they had no perioperative or postoperative fractures upon clinical examination and radiographic review in 23 patients, at an average follow-up of 41 months.

However, despite the promising results, the procedure remains difficult and has to be performed by an expert surgeon. Moreover, the patient needs to be immobilised to allow healing of the humerus osteotomy, which increases the recovery time.

In various studies, despite appropriate surgical management, the reported outcomes of revision arthroplasty are controversial in patients after a painful hemiarthroplasty [10, 28] and after a previous TSA [36–38].

A study conducted by Dines et al. [39] and confirmed by Sajadi et al. [7] proposed that revision operations performed for painful glenoid arthritis or component loosening have better outcomes than those performed for soft tissue problems. These data have recently led to the use of reverse total shoulder arthroplasty for revision procedures to avoid failure due to cuff deficiency [23–25].

Even if satisfactory results have been achieved in treatment of cuff tear arthropathy with RSA [40–42] limited information is available in its use for revision surgery.

Table 2 Range of motion pre-op and at follow up of group II

Evaluation	FLEX	ABD	RE1	RI
Pre-op	60°±10°	45°±8°	20°±5°	S1
Post-op	135°±10°	105±10°	35°±1	L5

Promising results have been reported by Levy et al. [23] at 35 months follow-up in patients treated with RSA for failed hemiarthroplasty. Flury et al. and Ortmaier et al. [24, 25] reported patient satisfaction after revision of primary shoulder arthroplasty using an inverse design in 21 revisions at 46 months follow-up and 50 patients after an average follow-up of 51 months, respectively.

The procedure still remains challenging, and many complications are possible during the revision [23–25]. The complication rate of this procedure is high and generally related to the removal of the humeral stem because the one implanted for a Hemi or a TSA does not allow the use of a reverse humeral body [23–25].

In this study, we report that using a modular implant that allows the conversion to a reverse shoulder arthroplasty without changing the humeral stem and the glenoid metal back avoids the risk of sacrificing bone. We retrospectively reviewed 26 patients operated for revision to an RSA from an original implant (hemiarthroplasty or TSA) with an SMR modular system (Lima LTD). The results achieved are satisfactory, not only in terms of the clinical outcome at 28 months follow-up with an almost-restored ROM, but provide a simplified surgical procedure, the absence of complications and the reduced recovery time.

The clinical results of our study appear to be lower compared to others clinical studies [27, 29, 31]; however, our results are comparable to those of Alta et al. [43] who state that in reverse prosthesis the loss of strength lowers the clinical score.

Although this is a multicentre and retrospective study, we have highlighted that in case of a shoulder prosthesis failure for rotator cuff deficiency, we have used a modular system for the first implant, allowing a revision that would otherwise be too difficult and challenging a procedure for the patient and the surgeon.

Conclusions

Our study results demonstrate that using a full modular system at the time of the first implant allows avoidance of the step to remove the humeral stem and metal back during a revision procedure of a shoulder prosthesis to a reverse type. This approach can result in a short operative time and few intraoperative complications. Adopting this procedure, we observed good clinical results and a lack of radiological signs of loosening or complications.

Conflict of interest All co-authors state that the article is original, that it is not under consideration by another Journal, and that it has not been previously published. We certify that there is no conflict of interest with any financial organisation regarding the material discussed in the manuscript.

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