

## Revision reverse shoulder arthroplasty in failed shoulder arthroplasties for rotator cuff deficiency

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### Abstract

**Purpose:** the aim of this systematic literature review is to report clinical outcomes of reverse shoulder arthroplasty (RSA) used as a revision surgery following failure of the primary implant due to rotator cuff insufficiency.

**Methods:** a systematic review was performed using the following key words: revision, shoulder, rotator cuff deficiency, outcome assessment, treatment outcome, complications. Studies eligible for inclusion in the review were clinical trials investigating patients in whom a primary shoulder arthroplasty implant with an incompetent rotator cuff was replaced with a reverse shoulder prosthesis.

**Results:** nine articles were identified and further reviewed. The results refer to a total of 226 shoulders that were treated with RSA as revision surgery. The patients in the studies had a mean age ranging from 64 to 72 years and the longest follow-up was 3.8 years. Improvements in function and reduction of pain were shown by many studies, but the mean Constant score ranged from 44.2 to 56. High complication rates (of up to 62%) were recorded, and a mean reoperation rate of 27.5%.

**Conclusions:** RSA as revision surgery for patients with rotator cuff deficiency is a valid option, and often the only solution available, but it should be limited to elderly patients with poor function and severe pain.

**Level of evidence:** level IV, systematic review of level I-IV studies.

**Key Words:** failure, reverse, revision, rotator cuff tear, shoulder arthroplasty.

### Introduction

Reverse shoulder arthroplasty (RSA) is one of the main recent evolutions in shoulder surgery and it has generated a great deal of enthusiasm in a relatively short period of time. The technique was devised to provide a solution to the problem of how to reduce pain and restore mobility with a stable rotational center. Introduced by Paul Grammont in 1985 and initially recommended for patients with cuff tear arthropathy (CTA), surgeons have expanded its application to massive cuff tears without arthritis, fracture care, rheumatoid arthritis, and revision of failed replacements (1, 2). The effectiveness of RSA is related to the two major changes in shoulder morphology that it produces: a large-diameter metallic hemisphere with no neck is implanted into the glenoid cavity, while a polyethylene socket covering less than half of the glenosphere and having a non-anatomical neck-shaft angle is used to replace the humeral head. This reversal of the glenohumeral joint anatomy confers important biomechanical advantages, e.g. increasing the deltoid lever arm due to medialization of the center of rotation and increasing the deltoid force due to its lengthening through the distal positioning of the humerus (3). In this way, the deltoid acts as both stabilizer and motor, allowing an almost normal range of motion in patients with significant rotator cuff deficiency.

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approaches are the ones most widely used by surgeons (4).

Clinical outcomes are influenced by the reason for performing RSA. According to Khan et al. (4), this surgery has a better outcome when it is used for CTA and massive cuff tears than when it is used for revision of a previous arthroplasty. The most frequent causes of failure of previous shoulder arthroplasties are rotator cuff deficiency, infections, aseptic mobilization of prosthesis components and instability (5, 6).

In particular, secondary rotator cuff tear has become increasingly recognized as a late complication after total shoulder arthroplasty (TSA), with rates approaching 45% at 10 years postoperatively (7). The aim of this literature review is to describe the outcomes reported for revision shoulder replacement after failure of the primary implant (hemiarthroplasty or TSA) due to rotator cuff insufficiency, thus underlining the potential for RSA as a procedure for salvage revision surgery.

## Methods

In order to investigate the clinical outcomes of RSA used in revision shoulder replacement, a Medline search of English language papers was performed. The search terms used included: reverse shoulder arthroplasty, revision, shoulder, rotator cuff deficiency, outcome assessment, treatment outcome, and complications. In the case of combined key words, the conjunction “and” was inserted. The criteria for

including studies (level 1-4) in our review were the following: (i) clinical trials investigating patients submitted to RSA for revision of a primary shoulder replacement; (ii) data reported on a failed arthroplasty due to an incompetent rotator cuff.

Studies that were only presented as abstracts and book chapters were not included in the analysis. We also excluded cohorts of patients treated with RSA for a failed arthroplasty in whom it was not possible to distinguish the clinical outcome only of those with an incompetent rotator cuff. For the same reason, articles investigating the clinical outcome following RSA performed for failure of total or partial shoulder arthroplasty due to infections, aseptic mobilization of prosthesis components, fractures and instability were not considered.

The full text of each potentially eligible article was examined, and data were extracted from the papers included.

## Results

Nine articles respecting the inclusion criteria were identified and underwent further review (Tab. 1). Table 2 reports the clinical outcomes of the studies investigating the use of RSA for revision shoulder replacement necessitated by rotator cuff insufficiency that were included in this review.

Boileau et al. (8) evaluated 45 patients with a Grammont prosthesis at a mean follow-up of 40 months. Patients were divided into three groups

**Table 1.** Clinical studies investigating the use of RSA for revision shoulder replacement due to rotator cuff insufficiency.

Authors (Ref.)	Year	Prosthesis	Diagnosis	No. of shoulders	Follow-up (months)
Boileau et al. (8)	2006	Delta III	a,b,c	45	40
Cuff et al. (9)	2008	RSA (Encore Medical, Corporation)	a, c	94	27.5
Kelly et al. (6)	2012	Aequalis	c	30	34
Flury et al. (5)	2011	Delta III	c	21	46
Wall et al. (10)	2007	Delta III Aequalis	a,b,c,d	191	40
Levy et al. (11)	2007	RSA (Encore Medical, Corporation)	c	19	44
Levy et al. (11)	2007	RSA (Encore Medical, Corporation)	c	29	35
Werner et al. (12)	2005	Delta III	a,c	58	38
Budge et al. (13)	2012	Delta III, Aequalis, Trabecular Metal reverse	c	15	34.5
Black et al. (15)	2014	Delta III	a, c	73	54.7

a: rotator cuff tear arthropathy/osteoarthritis with cuff tear; b: fracture and fracture sequelae; c: failed hemiarthroplasty or total shoulder arthroplasty; d: other diagnosis.

**Table 2.** Studies reporting clinical outcomes after RSA for revision shoulder arthroplasty due to rotator cuff insufficiency.

Authors (Ref.)	No. of failed TSA	Mean age (years)	Clinical outcome	Elevation	External rotation	Reoperation/ Revision rate
Boileau et al. (8)	19	67	46	113°	1°	42% (8/19)
Cuff et al. (9)	23	66.7	67.7 (ASES)	90°	16.6°	13% (3/23)
Kelly et al. (6)	30	64	48.9	105.7°	8.2°	23.3% (7/30)
Flury et al. (5)	21	n.a.	56	97°	12°	10% (2/21)
Wall et al. (10)	49	n.a.	52.2	118°	9°	36.7% (18/49)
Levy et al. (11)	19	72	61.2 (ASES)	76°	n.a.	32% (6/19)
Levy et al. (11)	29	69	52.1 (ASES)	72.7°	17.6°	28% (8/29)
Werner et al. (12)	21	n.a.	55% (relative Constant score)	96°	n.a.	38% (8/21)
Budge et al. (13)	15	67	44.2	103.2°	11.9°	13.3% (2/15)
Black et al. (15)	37	59.3	n.a.	115°	31°	18.7% (6/32)

n.a.: not available.

according to etiology: a massive and irreparable cuff tear associated with arthrosis (n=21, CTA group); fracture sequelae with a functionally useless cuff (n=5, FS group); revision prosthesis after failure of a previous arthroplasty in which the cuff was deficient, scarred or retracted or had undergone fatty infiltration (n=19, revision group).

The outcome of no or slight pain at the follow-up was achieved by 82% of the patients in the CTA group, 50% in the FS group and 36% in the revision group. The pain score was significantly better in the CTA group than in the revision group (p=0.01). The mean Constant score increased significantly in all three groups but the increase was significantly greater in the CTA group than in the revision group. The gain in the Constant score was 49 (from 18 to 66) in the CTA group compared to 32 (from 15 to 46) in the revision group (p=0.01). There was a significant gain in active anterior elevation in all three groups. However, active external rotation did not improve.

Reoperation without revision of the prosthesis was required in three patients in the revision group (16%) and one in the CTA group (5%). Prosthesis removal was performed in 1 patient in the FS group (20%) and in 5 patients of the revision group (26%). Overall the reoperation and revision rate was 5% in the CTA group, 20% in the FS group and 42% in the revision group. Three deep infections occurred in the revision group in the months after the reverse prosthesis was implanted. The authors concluded that reverse prosthesis implantation should be considered a salvage

procedure: its use should be limited to elderly patients, arguably those aged over 70 years, with poor function and severe pain related to cuff deficiency.

Cuff et al. (9) prospectively evaluated 96 shoulders in 94 patients with a mean age of 72 years treated with RSA. All the patients included in the study had rotator cuff deficiency of the shoulder. Of the 96 shoulders, 37 had a primary rotator cuff deficiency, 33 had undergone a previous rotator cuff repair, 23 had had a previous arthroplasty, and 3 had proximal humeral nonunion. The patients (n=13) with substantial proximal humeral bone loss were treated with proximal humeral allografting along with RSA and those (n=6) deemed to have a glenoid deficiency had bone-grafting of the defect as well.

Patients who had a failed arthroplasty showed a significant improvement in the mean American Shoulder and Elbow Surgeons (ASES) Shoulder score (from 25 to 67.7, p<0.001) and in range of motion (flexion: from 46.4° to 90°, p<0.001); however their outcome was worse than the outcome of patients with primary rotator cuff deficiency (ASES score: from 30.2 to 85.9; flexion: from 73.8° to 130°) (p<0.001). Furthermore their external rotation had not significantly improved at the last follow-up (from 9.2° to 16.6°; p=0.4). A complication requiring reintervention occurred in three out of 23 patients (13%) available at the last follow-up.

Kelly et al. (6) retrospectively examined 30 shoulders in 28 patients treated with a reverse prosthesis for a failed arthroplasty. All the shoulders had an incompetent rotator cuff and there was concomitant glenoid

bone loss in 16 of them. At a minimum follow-up of 24 months clinical outcome had improved significantly in all categories, except for active external rotation (from 7.3° to 8.2°,  $p=0.8$ ). In 24 (80%) of the 30 cases, the patients were satisfied with the surgical intervention. Complications occurred in 15 shoulders (50%), seven of which required reoperation (23%).

Similarly, Flury et al. (5) found an improvement in clinical outcomes in 21 shoulders in 20 patients who underwent replacement of a primary shoulder arthroplasty using a reverse shoulder prosthesis. The reason for revision in these patients was painful loss of function due to a rotator cuff insufficiency of the primary implant. Although the mean Constant score showed a significant improvement (from 16.6 to 56,  $p=0.005$ ), it was still considerably below the age-related norm (70.2). Furthermore the external rotation decreased significantly from 26° to 12° ( $p=0.01$ ). This can be explained by the severe structural damage to the rotator cuff and postoperative scarring.

There were 11 postoperative complications (38%) including two infections (10%) that required reoperation. Wall et al. (10) evaluated the effects of etiology on the results of RSA. Fifty-four shoulders, in which the rotator cuff was deficient, were treated with the reverse prosthesis for failed arthroplasty. Although the mean Constant score improved significantly in this group of patients (from 19.7 to 52.2,  $p<0.001$ ), their clinical outcome was worse than that of patients who had received a primary implant for cuff tear arthropathy, primary osteoarthritis with rotator cuff tear, or massive rotator cuff tear without arthritis (65.1, 65.1, and 63.4, respectively,  $p=0.006$ ). No significant improvement was seen in external rotation (from 5° to 9°,  $p>0.05$ ). The risk of complications associated with revision surgery (36.7%, 18 of 49 procedures) was significantly higher than that associated with primary surgery (13.3%, 20 of 150 procedures) ( $p<0.001$ ).

Levy et al. (11) used the reverse shoulder prosthesis in the revision of a failed shoulder hemiarthroplasty in 19 shoulders (18 patients) with severe pain and loss of function. The primary procedure was performed because of rotator cuff dysfunction in the presence of glenohumeral arthritis. The mean age of the patients at the time of revision was 73 years. A significant improvement was observed in pain and functional out-

come (ASES score: from 29.1 to 61.2,  $p<0.0001$ ). The overall complication rate was 47%: six shoulders (32%) had prosthesis-related complications and three shoulders (16%) had complications which were not related to the prosthesis. Overall, six shoulders (32%) required reoperation, four of which (21%) required revision. The same authors used the reverse shoulder prosthesis alone or in combination with a proximal humeral allograft to treat failed hemiarthroplasty for proximal humeral fracture associated with glenoid arthritis and rotator cuff deficiency. Twenty-nine patients with a mean age of 69 years were available for the last follow-up (2 years) and were included in the study. At the time of the latest follow-up, the mean ASES score had improved from 22.3 to 52.1 ( $p<0.001$ ). No improvement was seen in external rotation (from 11.2° to 17.6°,  $p=0.2$ ). Twenty-three patients (80%) rated the outcome as good, excellent or satisfactory. Four of the six patients who were dissatisfied had been treated with a reverse shoulder prosthesis alone. Complications occurred in eight cases (28%): three among eight patients (37.5%) treated with allografting plus reverse shoulder prosthesis, and five among 21 patients (24%) managed with a reverse shoulder prosthesis alone.

Werner et al. (12) evaluated the clinical and radiographic outcomes of arthroplasty with the Delta III prosthesis in 58 consecutive patients treated for painful pseudoparalysis of the arm due to irreversible loss of rotator cuff function. Seventeen patients (group 1) with cuff tear arthropathy had not had a previous operation. In 21 patients (group 2) the implantation of the Delta III prosthesis was a revision of another prosthesis (16 were revisions of a failed hemiprosthesis and five were revisions of a failed total shoulder replacement). The other 20 patients (group 3) had undergone a previous shoulder operation other than implantation of a prosthesis.

Similar improvements were found in the patients in whom the implantation of the Delta III prosthesis was the primary procedure and in those who had had previous surgery. The mean relative Constant score increased from 35 to 72% in group 1, from 25 to 55% in group 2, and from 27 to 61% in group 3. In all patients active external rotation did not improve but actually decreased by a mean of 5° ( $p=0.04$ ).

Thirteen complications occurred in the 21 patients

submitted to a revision of a prosthesis (62%). Of these patients, eight (38%) had a reoperation after implantation of the Delta III prosthesis. Four patients (19%) had a failure of implant prosthesis with removal or conversion of the Delta III prosthesis. The rate of reoperations in group 1 (18%) was significantly lower than that in group 2 (38%) ( $p=0.005$ ).

Budge et al. (13) reported the clinical outcomes of 15 patients (mean age: 67 years) with proximal humeral bone loss secondary to failed shoulder arthroplasty. At the time of revision surgery with RSA, all the patients were noted to have an absent or irreparable rotator cuff. The patients showed significant improvement in mean Constant score, from 23.0 to 44.2 ( $p=0.002$ ). External rotation improved from  $-0.5^\circ$  to  $11.9^\circ$ , but this difference was not statistically significant. Overall, seven of the 15 patients (47%) experienced complications related to the surgery. Complications in 2 of the 15 patients (13%) required surgical intervention.

Little literature is available about revision surgery in young active patients, even though an increasing number of procedures is being performed in such patients; indeed, revision rates in younger patients are higher than in older, less active patients (14). An interesting retrospective study performed by Black et al. (15) compared the results of 37 primary implants with those of revision with RSA in 36 patients. The results showed similar complication rates and pain and function scores, with better subjective results for primary implants.

## Discussion

RSA offers a surgical option to patients with pain and loss of function after failure of total or hemi-shoulder arthroplasty used for glenohumeral arthritis in the presence of severe rotator cuff deficiency (Figs. 1, 2). This literature review describes reported clinical outcomes of the use of RSA as revision surgery for failure of the primary implant due to rotator cuff insufficiency. The results refer to a total of 226 shoulders that were treated with RSA. The mean age of the patients ranged from 64 to 72 years and the mean follow-up did not exceed 3.8 years.

Many studies have shown this revision surgery to be

associated with a reduction of pain and improvement of functional outcomes. The mean active elevation was lower than  $90^\circ$  in two studies, close to a value of about  $90^\circ$  in three studies and ranged from  $103^\circ$  to  $118^\circ$  in the remaining four trials. Although there were significant improvements, at best approximately 65% of the normal range of movements was obtained after the revision procedure.

The mean Constant score ranged from 44.2 to 56 after revision arthroplasty. These values are considerably below age-related norms and are significantly lower than those observed after primary RSA (range, 63.4 to 69) (8, 10).

Active external rotation was not related to the etiology that led to the RSA. Results from the literature highlight that external rotation does not improve after RSA. In revision cases it ranged from  $1^\circ$  to  $17.6^\circ$  which corresponds to less than 20% of the normal range of motion. The deficit in external rotation can be attributed to infraspinatus and teres minor deficiency, as well as to the prosthesis design.

The rate of surgical revisions ranged from 13 to 42%, and in all series was higher than the rate of primary surgeries. Despite these findings, a considerable proportion of the patients included in these studies expressed satisfaction with their surgical treatment with RSA. This result could be related to the reduction of pain highlighted by all the studies included in our review, which occurred together with a partial restoration of range of movement and function that made patients able to take care of themselves. Patients with this kind of disability aim to regain a pain-free shoulder that improves their quality of life.

The overall complication rate after revision arthroplasty has been reported to be as high as 62% (2). The reoperation and revision rate ranged from 13 to 42%. Based on pooled data from the trials considered in this review, the overall reoperation and revision rate was 27.5% (62 of 226 procedures). A reintervention rate of approximately 28% is significantly higher than the overall complication rate of 12% (35 of 286 procedures) associated with primary surgery (8, 10, 12).

In the light of the findings of all the articles included in this review, the use of a reverse prosthesis should, in general, be limited to elderly patients, aged over 70 years, with poor function and severe

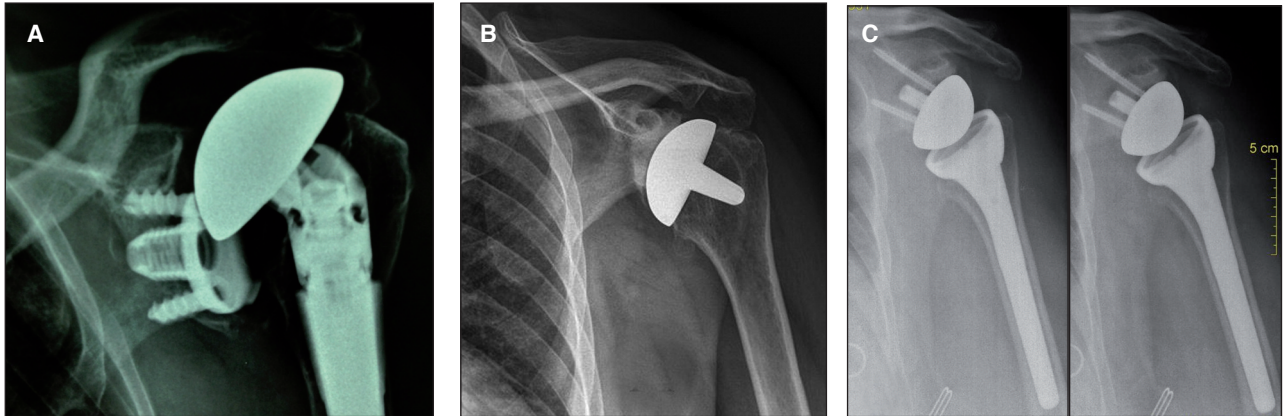


Fig. 1. A: Failure of anatomical shoulder arthroplasty after 10 years. B: A hemiarthroplasty that failed because of pain due to cuff insufficiency. C: Revision with RSA, Delta Extend, Depuy.

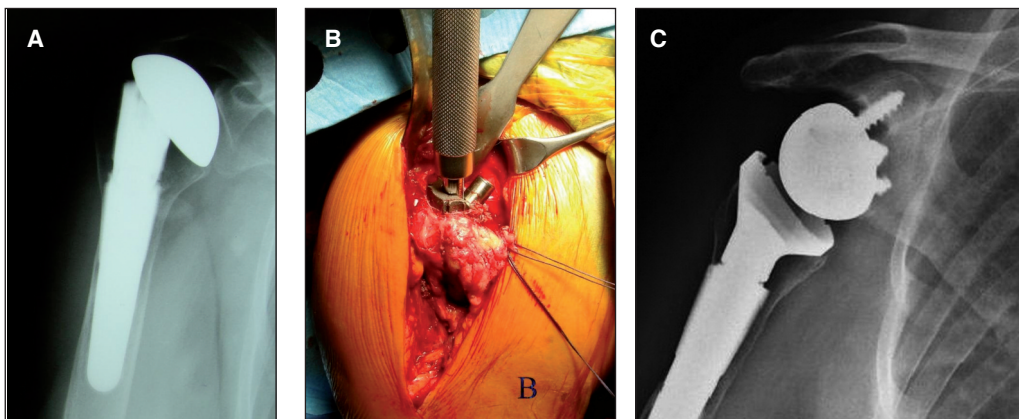


Fig. 2. A: Hemiarthroplasty with stem that failed because of cuff insufficiency, SMR System, LIMA. B: Extraction system to remove only proximal stem component and easily transform the implant to RSA, SMR System, LIMA. C: Final X-ray view. SMR System, LIMA.

pain related to cuff deficiency. Caution is required in younger patients who want to recover normal shoulder function; as indicated in a recent article, revision surgery has a high complication rate also in young patients (14). It should be noted that our review of the literature on this topic failed to reveal factors relating to age, gender, implant, or delayed surgery that might predispose to failure of RSA, as these factors were not clearly analyzed in the selected articles. Another limit of our work is the limited number of articles we found, which is probably due to the fact that this surgery has become relatively frequent only in recent years. Despite these limits, we suggest that these patients should be informed about the high complication rate and possible loss of shoulder motion and function highlighted in all the included

articles. However, to date there are no other satisfactory surgical treatment options available for patients with pain and loss of function after failure of hemi- or total shoulder arthroplasty used for glenohumeral arthritis in the presence of severe rotator cuff deficiency.

In conclusion, RSA is a valid option for a difficult clinical situation and often the only solution available. Its use can reduce pain and improve function, thus positively affecting patients' quality of life. More studies should be performed to understand the factors, such as age, gender and glenoid erosion, that may influence the final results. However, clinical outcomes are clearly less predictable and complications and revision rates are higher in patients undergoing revision RSA than in patients treated with a primary RSA procedure.

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