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ORIGINAL STUDY

Reversed Revised : What to do when it goes wrong ?

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Reversed total shoulder arthroplasty (RTSA) has well known indications and good to excellent results are described in the literature. When the arthroplasty fails however, revision remains a technical challenge with many questions unanswered.
To analyse retrospectively and consecutively the indications and results of primary RTSA-revision.
All patients that underwent revision RTSA between 2004 and 2009 were included. Indications for surgery, surgical details and clinical evaluation with the pre- and postoperative Constant-score (CS) were analyzed. 37 Revisions (37 patients) of RTSA were analysed with an average follow up of 41.2 months (24-84). Indications were infection (23), glenoid loosening (9), instability (2) malpositioning (2) and suprascapular nerve irritation (1). 25 patients obtained a one-stage conversion to a new reversed prosthesis ; 4 patients obtained a two-stage revision ; 8 patients got a mega-head prosthesis. No difference in reinfection rate is seen between one- and two stage techniques. An overall lower CS is seen for the mega-head prosthesis.
Conclusions : **The main indication for revision was infection. Revision of RTSA to a new reversed prosthesis is to prefer even when several procedures are necessary in one patient. When this is impossible, a mega-head prosthesis is to consider and gives reasonable results.**

Keywords : Reversed ; total shoulder prosthesis ; revision ; complications ; infection ; dislocation ; malpositioning.

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INTRODUCTION

Reverse total shoulder arthroplasty (RTSA) is primarily indicated for patients with rotator cuff arthropathy for which conventional total shoulder arthroplasty is not suitable. Industry reports have demonstrated a dramatically increasing trend in reverse shoulder device sales. An implant market analysis revealed that approximately 2000 reverse total shoulder arthroplasties were performed in the U.S. in 2004, compared with nearly 10,000 in 2007 and a 30,000 reverse total shoulder arthroplasties in 2012 *(9)*.

Knowing these numbers, one can expect that the future shoulder surgeon will deal with a lot of revision type surgeries for RTSA. As described by Zumstein *et al*, primary RTSA comes with problems, complications, reoperations, and revisions in up to 44%, 24%, 3.5%, and 10%, respectively *(13)*. It is already published that patients, requiring an additional intervention for a complication of RTSA, profit significantly as long as the prosthesis remains

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in place (*5*). When however this is not possible, and a revision of humeral and/or glenoid component is necessary, the shoulder surgeon is left with a technical challenge for which many questions remain unanswered.

The aim of this study is to analyse retrospectively and consecutively the preliminary experience of one single surgeon with the indications, surgical techniques and the results of primary total RTSA-revision.

SUBJECTS AND METHODS

This study was set up at the University Hospital of Ghent. A consecutive series of all patients with failed reversed total shoulder arthroplasty treated with total revision between 2004 and 2009 were analysed. Revision was defined as being the replacement of all prosthetic elements. Only the patients with a minimum follow up of 2 years were included. All patients were operated on by the senior author.

In each case a superior extended deltopectoral approach with clavicle osteotomy was used where the osseous fragment hinges in the ac-joint (*1*). This approach is used to rely on bony elements as guidance instead of scarred soft tissues that are inevitable in revision surgery. Opening the joint from above permits the surgeon to use the superior glenoid and the lateral coracoid as bony guiding elements. By doing so, an extended view into the joint can be obtained in a safe manner avoiding damage to the neurovascular structures. Once a good view at the joint is obtained, the polyethylene inlay is disengaged, after which the glenosphere is disconnected from its baseplate, creating more space and allowing adequate movement of the upper arm. The entire humeral epiphysis is then dissected until fresh bleeding bone is seen all around the prosthesis. The humeral prosthesis is then removed using the standard extractor. If necessary, a proximal humeral longitudinal osteotomy is performed to allow extraction. Bearing in mind that this action can induce fractures of the often thinned humeral cortex. The next step depended on the indication and the glenoid bone stock after removal of the prosthesis.

Concerning the type of prosthesis : When enough glenoid bone stock was available a new metaglene was inserted. During the first years of this study, megahead prostheses were used when perioperative not enough native glenoid bone stock was left to fix a stable metaglene with two angular stable screws. After obtaining more experience a metaglene was placed in slight varus if the center of rotation is still at the coracoid level. If the center of rotation is medial to the coracoid base, the glenoid was reconstructed with an auto- or allograft and a new reversed prosthesis was placed. At the time of this study no long pegged baseplates were available. Nowadays we prefer this long pegged baseplate because it reaches into the native bone. A glenosphere of 42 mm was used in all revisions to a new reversed. Concerning infection : During the first years of this study, revisions were done in two stages. Later one-stage revisions were performed. During both types of procedures a thorough synovectomy was performed. At the end of the procedure, the clavicle osteotomy is closed with three non-absorbable sutures, with each thread going twice around the clavicle to allow immediate active movement.

Data

We grouped our patients according to their indication and for each group we described the surgical technique : from reversed to a new reversed prosthesis (one or two staged revision) or from reversed to a megahead prosthesis ; the post-revision complications and re-interventions (reoperations and revisions) according to the definitions of Zumstein *et al* (*13*) ; the clinical outcome using the Constant-score (4) (pre-operative ; post-operative at 3 months, 6 months, 1 year and further on annually) and at each contact moment we also described radiological parameters : notching (*11,12*) ; resorption of the tuberosity's (none, partial, complete) ; humeral loosening (*7*) and peri-articular ossification (*2,10*).

After having read about the importance of measuring both upper arms in the preoperative planning to obtain stability during surgery (*3*), we called back all our revised patients who dislocated postoperatively and were treated with closed reduction, open reduction and poly-exchange or open reduction and augmentation with a lengthener. We measured their upper arms using a simple tool to measure the distance between the acromion and the tip of the olecranon with a flexed elbow (Fig. 1). We than compared with the contralateral side.

Statistical analysis

Dividing the patients according to their indication and treatment, created small groups on which statistical analyses seemed not representative.

To determine the reliability of the humeral length measurement, we measured 10 normal humeri twice and determined the IntraClass Correlation Coefficient using SPSS statistical software.

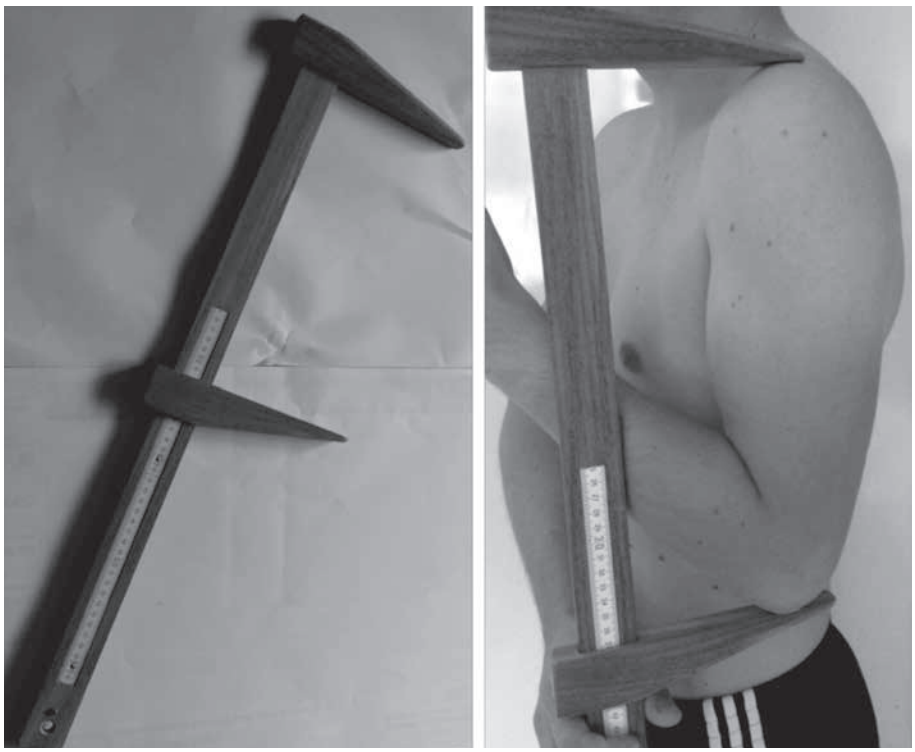

Fig. 1. — Tool to measure the distance between the acromion and the tip of the olecranon with a flexed elbow.

RESULTS

Population

We included 37 patients (21 male – 16 female) with a mean age of 71 years and with an average follow up of 41.2 months. No patients were lost in follow up.

The indications for revision were chronic infection (23 patients), glenoid loosening (9 patients), chronic dislocation (2 patients), malpositioning (2 patients) and 1 painful shoulder as the result of a suprascapular nerve irritation by one of the screws (Table I). In 29 patients a new reversed prosthesis was placed, in 8 cases we used a megahead prosthesis.

The mean time between primary and revision surgery of the RTSA was 42 months.

Surgical details

In all patients who obtained a new reversed prosthesis a 42 mm glenosphere was used. In 12 patients only 2 angular stable screws were necessary to obtain a stable construct. In all other cases 3 or 4 screws were used. No long-peg baseplates were used because at that time not commercially available yet.

To remove the humeral component, a humeral osteotomy was needed in 6 patients. The new humeral stem was a cemented monobloc in all but 3 cases.

Complications ; Reoperations ; revisions

We observed complications of the revision procedure in 17 of our patients, being infections

Table I. — Summary of the studied population*

number of patients	revision-indication	revision-procedure	months to revision	preop Constant score	postop Constant score
4	infection	Two-stage rRTSA	14	not available	64
3	infection	Megahead	56	30	42
16	infection	One-stage rRTSA	28	27	52
3	glenoid loosening	Megahead	86	30	36
6	glenoid loosening	One-stage rRTSA	59	31	57
2	diclocation	One-stage rRTSA	24	not available	40
1	malposition	Megahead	82	not available	45
1	malposition	One-stage rRTSA	36	not available	87
1	suprascapular nerve irritation	Megahead	108	6	27

*displayed numbers are average values ; rRTSA : revision to a new reversed total shoulder prosthesis ; postop Constant-score : score at latest follow up.

(4 patients), dislocations (6 patients), glenoid loosening (1 patient), humeral loosening (1 patient), periprosthetic fractures (3 patients), scapular (stress-)fractures (2 patients), clavicular fracture (1 patient), nerve irritation (1 patient) and sometimes combinations of these (3 patients). 9 patients had to be reoperated on for hematoma-debridement (3 patients), open reduction (4 patients), nerve release (1 patient) or humeral fracture-osteosynthesis (1 patient). 5 of our patients needed a total revision of which 3 obtained more than one revision (2, 2 and 4 times were these patients revised) (Table II).

Radiographic follow up

Analyzing the most recent radiography revealed notching (*11,12*) grade 0,1,2 in 21 patients and grade 3,4 in 7 patients. The greater tuberosity was normal in 5 cases, partially resorbed in 4 cases and completely resorbed in 27 patients. The lesser tuberosity was normal in 1 case, partially resorbed in 8 cases and completely resorbed in 27 patients. Periarticular ossification (*2,10*) was graded 0 or 1 in 22 cases and graded 2 or 3 in 14 patients. One patient refused the second procedure of a 2-stage revision and also refused postoperative radiographs.

Humeral loosening (*7*) was seen in zone 1 and 7 in 17 cases. Loosening in more than these two zones was described in 10 patients. The remaining patients did not present loosening.

Clinical follow up

Patients' Constant-score went from an average 27 (lowest :6 – highest :68) preoperative to 51 (6-93) postoperative.

Groups

Chronic infections (n = 23)

One and two-stage procedures were carried out. 3 patients got a two-stage revision to a new reversed prosthesis using an intermediate spacer, 16 patients were revised in one-stage to a new reversed prosthesis. 3 patients were revised in one-stage to a megahead prosthesis. One patient was satisfied with only the spacer and refused the second stage revision. Pre-operatively five patients presented with a sinus tract infection. In this case, the fistula was excised completely as previously described by the senior author (*1*). In each case a new reversed prosthesis was put in, an antibiotic-impregnated (Gentamicin) implant was used to fill the void between baseplate and glenosphere.

On microbiological cultures we found : Propionibacterium acnes (5 patients), P. acnes associated with others (7 patients), coagulase-negative Staphylococcus (5 patients), CNS associated with others (5 patients), Staphylococcus aureus (2 patients) and Staphylococcus aureus associated with others

Table II. — Summary of the complications, reoperations, revisions

patient	complications			reoperation	total revision
	infection	dislocation	others		
1	X	X	periprosthetic fracture	open reduction	2X
2			periprosthetic fracture	humeral osteosynthesis	
3			suprascapular nerve irritation	nerve release	
4			hematoma	hematoma-debridement	
5		X		open reduction	
6			hematoma	hematoma-debridement	
7	X	X	clavicular fracture; periprosthetic fracture	clavicle osteosynthesis; open reduction	4X
8		X			
9			scapular (stress-)fracture		
10	X		humeral loosening		2X
11		X		open reduction	
12			hematoma	hematoma-debridement	
13			scapular (stress-)fracture		
14	X				
15			glenoid loosening		1X
16		X			
17			(pain)		1X

(3 patients). After surgery antibiotics were prescribed for a minimum of 6 weeks and were only stopped after normalization of the inflammatory parameters (sedimentation and crp). The antibiotic agens was chosen according to the antibiogram. Postoperative we noticed 2 reinfections in the 1stage group (2/19 patients) and 1 reinfection in our 2stage revision group (1/4 patients). One of them was treated with debridement alone and the other two needed another revision.

Complications were seen in 11 patients (dislocation, infection, humeral fracture, clavicle fracture, hematoma, fracture of scapular spine and humeral loosening) of whom 10 needed a re-intervention. Three of them needed total revision. These last 3 patients were reoperated on for 2, 5 and even 16 times. This last patient ended with the sad clinical result of a joint-resection.

Clinically these patients went from 27 (4-68) to 53 (6-93) in general Constant-score (lowest-highest) ; those with a new reversed prosthesis did better on average than the ones with a mega head (54 vs. 42).

Patients with a preoperative sinus tract infection were clinically better before (36 vs. 21) and after the surgery (68 vs. 47).

Glenoid loosening (n = 9)

Most of these patients suffer from bone loss due to the glenoid loosening. For those whose glenoid could still hold a baseplate (6 patients), a new reversed prosthesis was put in place. When medialisation beyond the coracoid base is seen, we believe grafting is necessary. This was the case in five of these patients. We used crista allografts (4 patients) or caput femoris allografts (1 patient). A standard baseplate with normal peg was sufficient in all these cases. If the glenoid bone loss was too excessive and reconstruction was impossible, a megahead prosthesis was used (3 patients) with the coracoid as superomedial stabilizing element to obtain a stable fulcrum.

Of these nine patients only one needed a re-intervention. We performed a total revision on this patient for a new aseptic loosening of the glenoid.

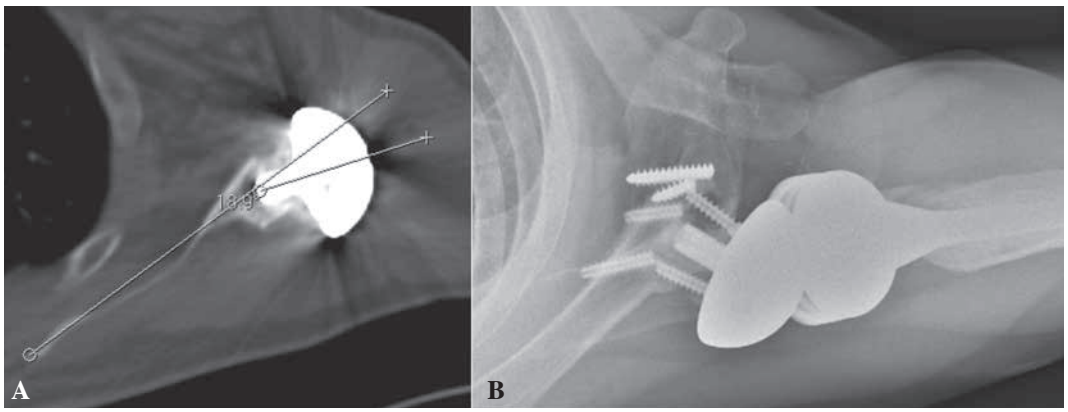

Fig. 2. — A. Glenoid not being placed in line with the scapular plane ; B. glenoid failure

Overseeing the imaging studies of this patient, we believe the failure was due to the glenoid not being placed in line with the scapular plane (Fig. 2).

The patients with a new reversed prosthesis went from a preoperative Constant-score of 31 (8-62) to a postoperative score of 57 (12-93).

The one patient without a graft obtained a Constant-score of 27 postoperative being far worse than the 64 Constant-score on average in the grafted cases.

The patients with a new reversed prosthesis did clinically better on average than those with a mega-head prosthesis (57 vs. 36).

Chronic dislocation (n = 2)

Two patients with chronic dislocation were converted to a new reversed prosthesis. After revision one of them re-dislocated, within the first postoperative week, which could be treated successfully with closed reduction and an abduction pillow for 5 weeks.

A main Constant-score of 40 (29-52) was obtained postoperative. This rather low score can mainly be explained due to stiffness.

Malpositioning (n = 2)

The first of our malpositioning group patients was revised to a new reversed prosthesis with correction of excessive anteversion of the glenoid. In the other patient, the glenosphere was positioned in too much valgus and was revised with a megahead prosthesis due to excessive bone loss after base-plate-removal.

The patient with a new reversed prosthesis did better clinically than the one with a mega head (87 vs. 45).

Suprascapular nerve irritation (n = 1)

This patient was converted to a megahead-prosthesis and obtained a Constant-score of 27 which is unsatisfactory for the patient and she has a conversion to a reversed type prosthesis planned for the future.

Humeral length measurement

Postoperative we observed 6 dislocations. 3 Of them were willing to come back for measuring their upper arms. We measured one patient with a lengthening of 5 cm (dislocation was treated with closed reduction) and one of 2.5 cm (dislocation was treated with open reduction). The third patient had a shortening of 1.5 cm (dislocation was treated with open reduction and poly-exchange).

The two lengthened patients obtained a final Constant score of 74 and 81 respectively. The shortened patient obtained a lesser 60 in Constant score due to stiffness.

An IntraClass Correlation Coefficient of 0.946 was obtained after measuring only 10 normal humeri twice with this simple device (Fig. 1).

DISCUSSION

Revision type surgery is mostly a challenge for each orthopedic surgeon and there is no exception for the shoulder surgeon dealing with the revision of a reversed total shoulder prosthesis. One should be well prepared preoperatively when doing this type of surgery and have more than one backup plan before initiating the procedure. The surgeon should bear in mind that the revision of a RTSA comes with a high complication, reoperation and revision rate. Fortunately even with more than one intervention in the same patient, the end result is still acceptable. In our studied population the Constant-scores went from an average 27 (lowest : 6 – highest : 68) preoperative to a better 51 (6-93) postoperative.

This is a retrospective study about a rather small population (37 patients). This will be the main weakness. Also the lack of statistics, due to the small patient-groups, is a downside. A bigger population is needed to create more accurate guidelines. This study can only give recommendations based on the personal experience with this limited population. On the other hand we had no dropouts during the follow up period of 41.2 months on average and were also able to obtain consecutive data. In this manner we present our good results but also the worst cases we experienced. All patients were operated on by the same surgeon. These are strong points for which we believe this paper holds good value. When more of these experiences with this type of revision surgery become accessible (*3,5,8*), review articles will hopefully give us the bigger idea concerning this topic. More and more revisions will be necessary in the future and by documenting the experiences with this type of surgery, it hopefully will become possible, to create usable and proven guidelines for this difficult task.

In this studied population the most common indication was infection. This is in contrast to the findings of Farshad *et al* (*5*) and Boileau *et al* (*3*) who presented instability as main indication for their population.

For the revision of an infected RTSA, the surgeon can choose for a one- or two-stage procedure. This study clearly showed no difference in outcome between those two groups. Either way the surgeon should be aware of a significant reinfection rate (3/23) and be suspicious for it (*1*). In our 'infection-group', the best clinical results were observed whenever a fistula is present. In these cases the sinus tract needs complete resection. In our centre local antibiotics are used in all revision cases. Antibiogram-guided Antibiotics were administered for a minimum of 6 weeks until normalization of inflammatory parameters.

When revising a RTSA for a loose baseplate, one should be prepared to find significant bone-loss. To overcome this loss of bone, we suggest the use of a crista-allograft to fill the defect because of the cortical support. To decide for grafting, we use the coracoid process as a reference mark. When the center of rotation would become medial to the coracoid base, we believe grafting is necessary. We prefer to have the center of rotation lateral to the coracoid base to obtain sufficient deltoid tensioning and force (*3*). We observed far better results in patients with a graft put in place paying attention to the position of the graft. As a result of the one failure in this group, we believe the graft and peg should be in line with the scapular body as shown in fig. 3.

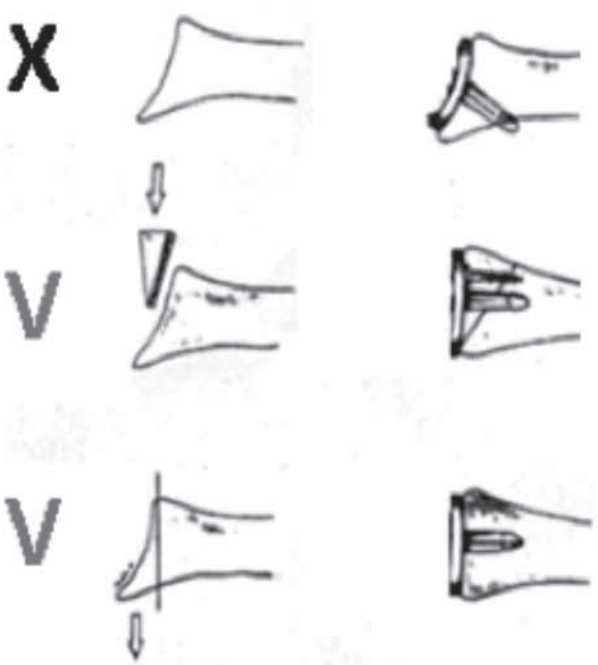

Fig. 3. — Graft and peg placed in line with the scapular body

If however the glenoid cannot be reconstructed, a megahead prosthesis is still an option, accepting the somewhat lesser clinical outcome.

When dealing with dislocation we try to find a positioning error on the preoperative CT-scan as an explanation. If this is impossible we believe the tension will be the problem. During the revision, tension can be gained by lateralizing the glenosphere (using grafts or prosthetic lateralization) or lengthening the humerus. Stability can also be obtained using a 42 mm glenosphere instead of a 36 mm (*3*). Preoperative planning and templating to address excessive medialization or humeral shortening can be done using a standard radiography of the shoulder (*3*) associated with the comparison of both upper arm lengths using a simple measuring-tool (Fig. 1) which is easy to use, fast, cheap and very reliable.

In this study, the clinical outcome was related to the indication, with infection (especially in the presence of a fistula) and malpositioning doing best on average. Also the outcome was technique-dependent with generally better results for a revision to a new reversed prosthesis using a bone graft in case of a glenoid-defect. In this studied group the patients with a sinus tract infections had the best clinical outcome before and after the one-stage revision. Overall we noticed that patients obtaining a new reversed prostheses did clinically better in general than those with megahead prostheses. This was already described by Gamradt *et al* (*6*).

Synthesis

– If there is no glenoid bone loss, a new reversed prosthesis seems preferable
– If there is reconstructable bone loss one should try grafting the defect and revise to a new reversed prosthesis with the central peg of the baseplate in line with the scapular plane
– If the glenoid is impossible to reconstruct, a Megahead prosthesis is an acceptable alternative

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