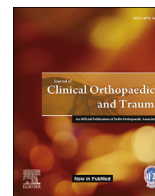




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Short term results of reverse total shoulder arthroplasty

Aditya K. Agrawal^{a,*}, Carlos Wigderowitz^b, Bruno Ribeiro^c, Amar Malhas^b,
Abhishek Vaish^d, Rami Abboud^b^a Dept of Orthopaedics, Dhiraj Hospital, Sumandeep Vidyapeeth University, Waghodia, Vadodara, 391760, Gujarat, India^b Dept of Orthopaedic and Trauma Surgery, College of Medicine, Dentistry and Nursing, Tayside Orthopaedic and Rehabilitation Technology (TORT) Centre, Ninewells Hospital and Medical School, Dundee, DD1 9SY, Scotland, United Kingdom^c College of Medicine, Dentistry and Nursing, Tayside Orthopaedic and Rehabilitation Technology (TORT) Centre, Ninewells Hospital and Medical School, Dundee, DD1 9SY, Scotland, United Kingdom^d Indraprastha Apollo Hospitals, New Delhi, India

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1. Introduction

Shoulder arthroplasty audit is the evidence based process of reviewing the delivery of care, to monitor the short term and long term measures of shoulder replacements. It has been used to evaluate the patient reported functional and objective outcomes, surgeon related experience and implant related radiological outcomes and survivorship. An audit is used to improve the quality of care and to give impetus for future research. Arthroplasty of the shoulder offers pain relief and improved function when the native gleno-humeral articulation is affected by arthritis, trauma and cuff arthropathy. Surgeons have acknowledged the stabilizing role of the rotator cuff and noted that the loss of these stabilizers may lead to additional force on the implant.¹ It was also noted that the patients with a deficient rotator cuff, had problems with shoulder

replacement as the prime movers of the shoulder were unable to act in the absence of a stabilizing force of the rotator cuff. Reverse total shoulder arthroplasty (RTSA) initially gained popularity in the treatment of the patients with insufficient rotator cuffs and arthritis, nowadays the indications have expanded and surgeons are including this technique to treat proximal humeral fractures, massive rotator cuff tears without glenohumeral arthritis, revision arthroplasty, and glenohumeral osteoarthritis in the setting of irreparable rotator cuff tears.² Many new models of reverse shoulder arthroplasty have been introduced in the hope to improve implant survivorship, to reduce the rates of complication and to increase post-operative function, but still only limited follow up has been reported.^{3,4} At present, there are a plethora of different reverse designs from companies such as Tornier, Zimmer, DJO Surgical (formerly Encore Medical), Exactech, Biomet and Lima LTO. Each one has its benefits and drawbacks, but they all are based on the same principle of reversing normal shoulder anatomy. The aim of this study was to review the results of the patients who underwent an operation and received a reverse shoulder replacement between 2010 and 2015. The objectives of this study were to retrieve the information from the database regarding the patients' demographics, pre-operative diagnosis, range of motion, x rays and indications for surgery, to recall the post-operative patients for clinical and objective evaluation, to invite all those patients to complete validated questionnaires both retrospectively for pre-operative function and prospectively for their post-operative function, to obtain survivorship data and post-operative function at a mean follow-up period, to obtain and compare the functional outcomes between the patients who underwent reverse shoulder arthroplasty for glenohumeral arthritis with cuff tear arthropathy and proximal humerus fractures and to discuss the complications regarding the mechanism of failure in patients operated with reverse total shoulder arthroplasty.

2. Materials and methods

The first part of the study was to perform a retrospective case

* Corresponding author.

E-mail addresses: adityagrawal83@gmail.com (A.K. Agrawal), c.a.wigderowitz@dundee.ac.uk (C. Wigderowitz), b.ribeiro@dundee.ac.uk (B. Ribeiro), a.m.malhas@dundee.ac.uk (A. Malhas), drabhishekvaish@gmail.com (A. Vaish), r.j.abboud@dundee.ac.uk (R. Abboud).

review of all patients in the last 5 years undergoing a reverse shoulder replacement by examining the medical case notes and radiographic records. Medical history of the patients were analysed in terms of demographics, diagnoses and surgery indications. The second part of the study was to invite all those patients to complete validated questionnaires, to discuss patient related outcome measures and clinical scores. Post-operative clinical outcomes were evaluated in terms of objective questionnaires, strength, pain and functional assessment using published classifications and scores. Ethical approval was obtained prior to any patient contact. In the first phase 29 patients were included, the files were analysed to collect data such as age at surgery, gender, the diagnosis which led to the operation, amount of pain before surgery, presence of previous surgeries, details of complications related to the procedure, length of hospitalization and range of movement of the shoulder. Three patients had deceased. Twenty six patients were invited, by letter, for the review clinic. Eleven patients were not able to come to the clinic for clinical and radiological examination. However, they were able to fill in and post the questionnaires mailed to their addresses. So, Oxford Shoulder Score and QuickDash (quick version of the Disabilities of the Arm, Shoulder and Hand Score) were calculated for them.⁸ Fifteen patients confirmed and attended the appointment and the results analysis (Constant-Murley score, Oxford score, QuickDASH score) was performed based on them. During the review clinic the patients were asked to fill three validated questionnaires. The questionnaires used were the Constant-Murley Shoulder Outcome Score (CS), the Oxford Shoulder Score (OSS) and the quick version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH) score. In addition, a functional assessment (range of shoulder movement and a strength test), as part of the Constant-Murley Shoulder Outcome Score, was performed and also the pre and post-operative radiographs were reviewed on PACS X-ray archiving system on the intranet. The statistical analysis was performed using SPSS software (Illinois, Chicago). The Wilcoxon signed rank test was used to compare preoperative and postoperative data for paired groups, and the Mann-Whitney *U* test was used for unpaired groups. The Fisher exact test was used to compare end point frequencies in different patient populations. The level of significance was set at *p* value < .05.

3. Results

3.1. Patient demographics

There were nineteen females and ten males who underwent shoulder replacement surgeries from 2010 to 2015. Six patients underwent hemi arthroplasty (four females and two males) and twenty three patients (fifteen females and eight males) underwent reverse shoulder arthroplasty. The mean age of the patients undergoing shoulder replacement (including both hemi arthroplasty and reverse shoulder arthroplasty) was 69.5 years. The mean age of the female patients undergoing shoulder replacement was 73.5 years and for the male patients, it was found to be 62.5 years. The mean age for reverse shoulder arthroplasty at 72.7 years (Females at mean age of 73.5 years and males at mean age of 72.5 years) and mean age for hemi arthroplasty at 67.5 years (Females at mean age of 72.4 years and males at mean age of 58.5 years). The affected extremity was more of the right side in terms of gender and primary diagnosis. Twenty seven patients had right side as their dominant working hand. Twenty patients had fracture proximal humerus (sixteen females and four males), eight patients had cuff tear arthropathy with glenohumeral arthritis (three females and five males), and one male patient had avascular necrosis of head of humerus due to posterior dislocation of his shoulder during seizure from alcohol withdrawal. Seventeen patients were of ASA grade 2,

one was of ASA grade 1 and remaining eleven patients were of ASA grade 3. The average BMI (body mass index) was of 24 kg/m². All the twenty nine patients were operated under general anaesthesia with additional supplementation of inter scalene block and local injection of ropivacaine.

3.2. Surgical approach

Six patients underwent deltopectoral approach, out of which five patients were with fracture proximal humerus and one patient was having avascular necrosis of head of humerus secondary to posterior dislocation. Remaining twenty three patients underwent Mackenzie approach, out of which eight were having cuff arthropathy and fifteen with fracture proximal humerus. Sixteen patients had uncemented humeral stem implantation and the remaining thirteen patients had cemented humeral stem implantation. Commonly used humeral stem were size 10 & 12 and that for glenosphere were size 42 mm diameter (Figs. 3 and 4). The cortical screws used for the fixation of the glenosphere to the scapula were of 25,30,35,40 × 3.5 mm size. Average blood loss was 350 mL. Average duration of surgery was 90 min. PDS™ was used for repairing the cuff muscles. None of the patients had drains kept in the wound postop. Intraoperative findings include that more than half of the patients with cuff arthropathy had superior humeral head migration, severe osteoarthritic changes of the glenohumeral joint (none were glenoid deficient shoulders) and massive rotator cuff tears with supraspinatus and infraspinatus tendons retraction of more than 1 cm. The average hospitalization was 3 days (2–7 days).

3.2.1. Subscapularis management during shoulder arthroplasty

Subscapularis muscle is an important rotator cuff muscles which stabilizes the humeral head to prevent anterior dislocation. It arises from almost the entire costal and anterior surface of the scapula and inserts on the lesser tuberosity of the humerus. In cuff arthropathy patients, the subscapularis was found thin with fatty infiltration while it was found avulsed with lesser tuberosity in the group with three and four part proximal humerus fractures. The subscapularis was repaired only in cases which underwent deltopectoral approach. In cuff arthropathy patient, thin wafer flake osteotomy of the lesser tuberosity was carried out while preserving the insertion of subscapularis tendon onto it. It was secured using non absorbable sutures and kept in the medial axillary pouch during the operation. After the insertion of the stem, the sutures attached with the subscapularis tendon were tied on the holes of the stem. The greater and lesser tuberosities were also tightly secured around the prosthesis using non absorbable sutures. Thus a

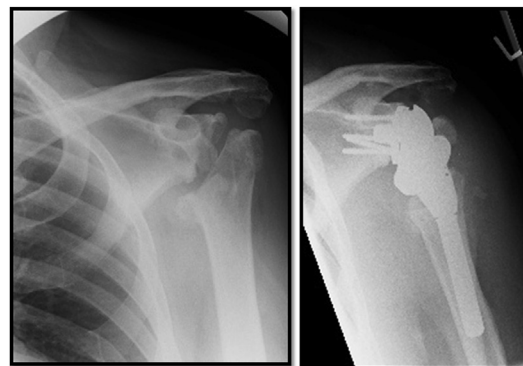


Fig. 1. Pre-operative and Post-operative radiographs of the patient operated with reverse total shoulder arthroplasty.

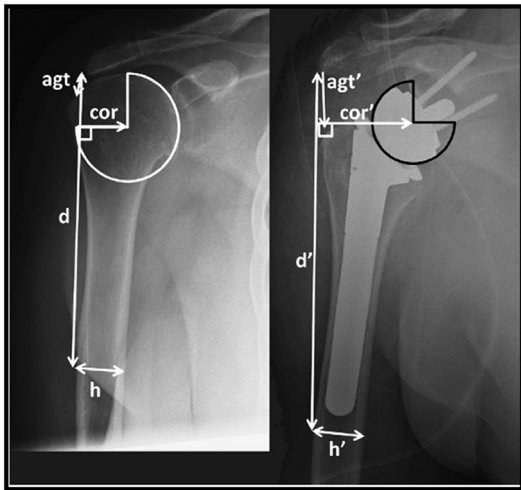


Fig. 2. Centre of Rotation (COR) is from the centre of the humeral head. It gets medial and inferior (COR) after reverse total shoulder arthroplasty. Thereby the lateral lever arm gets effective by the pull of the deltoid. ($agt > agt'$) ($d > d'$) (h and h' are width of the diaphysis of the humerus at the level of deltoid insertion).

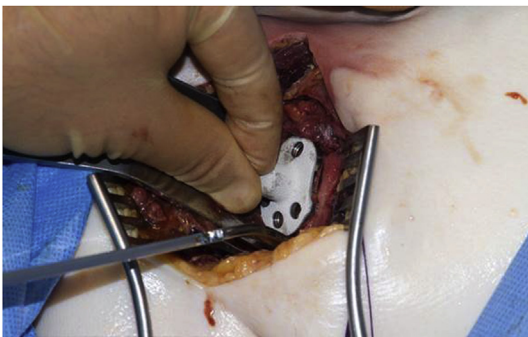


Fig. 3. Preparation of the glenoid for base plate fixation in deltopectoral approach.

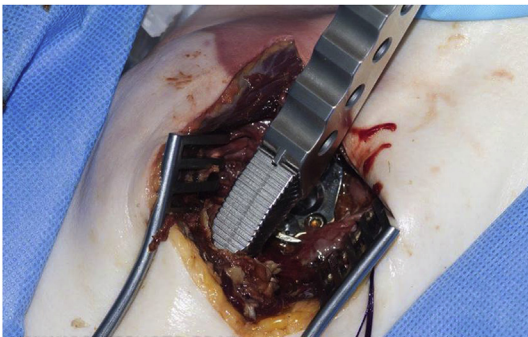


Fig. 4. Preparation of the shaft of right humerus for insertion of the prosthesis.

bony cuff with maximum soft tissue attachment was formed around the prosthesis for early and better functional outcomes.

3.3. post-operative rehabilitation programme

Patients were started with gentle phase 1 scapula retraction and elbow pendulum exercises from day one and phase 2 cuff substitution exercises after six weeks of postoperative follow ups. The

patients were regularly called to be seen in the clinic at six weeks, two months, six months, one year and then on yearly basis unless any complications arise. The post-operative functional scores at the final follow up for both the groups are shown in Table 1.

4. Discussion

Themistocles Gluck was an early pioneer of the shoulder joint arthroplasty. He was the first amongst the few who tried to design the shoulder prosthesis in the late 1800s, although he never published his work on it. The first prosthetic shoulder joint replacement performed has been ascribed to the French surgeon Jules Emile Pe'an in 1893.^{5,6} Charles Neer et al. described shoulder arthroplasty for the proximal humerus fractures in 1955 and afterwards, in 1974, reported its use for glenohumeral osteoarthritis. Superior humeral head migration was often seen postoperatively in patients who had lost the stabilizing function of the rotator cuff. Marmor et al., in 1977 reported shoulder arthroplasty on five patients in his series with rotator cuff tears, all exhibiting superior migration. They reported that substantial forces act across the shoulder joint above 90° of elevation, which can be more than ten times the weight of the extremity.⁷ Reverse shoulder replacement is a relatively new implant which has cuff tear arthropathy – massive cuff tear, superior migration of the humeral head with glenohumeral arthritis – as its original indication.^{9,10} However, over time the indications and designs have been expanding and even though the medium term results so far appear to be promising with high levels of patient satisfaction and function, bigger studies with long term follow-up are lacking.

We have been using the reverse shoulder design released in 2010 with scarce information in the literature up to now. Twenty nine patients who received this prosthesis so far could be included in this study. This study analysed their short and medium term outcomes with a mean follow up of 15.83 months. The authors are aware of the small sample of patients for this study, that it is part retrospective that just 55% of the patients attended the review clinic appointment and that statistical significance could not be reached. However it is still important to describe and publish the outcomes of the patients in a way to share the experience with the reverse shoulder arthroplasty so far as shown in Fig. 1.

A multicentre study conducted by Sirveaux et al. (JBJS 2004), involving 80 shoulders in 77 patients with a mean follow-up of 3.6 years, the largest study so far on the use of the reverse shoulder prosthesis in cuff tear arthropathy, published that in 96% of the shoulders there was no or minimal pain at follow-up.¹¹ In addition, Favard et al. (CORR 2011) retrospectively reviewed 527 arthroplasties and at a minimum follow-up of 5 years in 148 arthroplasties, Constant scores as well as forward elevation and external rotation improvements were noted.¹² The range of motion before and after the replacement procedure was not possible to be compared because there was lack of precise information in the patient files regarding previous shoulder motion. High complication rates have been reported by Zumstein MA et al. (JSES 2011) and it differs for primary and revision reverse shoulder arthroplasty. Two out of the eleven patients had complications (18.2%) regarding the procedure: one peri-prosthetic humeral fracture (9.1%) and one infection (9.1%).¹³ Infection rates of 1–15% have been reported in the literature, they are four times that of total shoulder arthroplasty and are thought to be related to the design of implant.¹⁴ No scapular notching or failures were related until now. Additionally, reverse shoulder replacement results depend on the aetiology.^{15,16} That is why in this study it was decided to divide the patients in two groups according to this characteristic and compare them. The twenty three patients have two different diagnosis, cuff tear arthropathy with eight patients (group 1) and proximal humeral

Table 1

Post-operative Constant score, Oxford score and QuickDash Score for Group 1 (Patients with cuff arthropathy) and Group 2 (Patients with proximal humerus fractures).

Post operative Scores	Cuff tear arthropathy (n = 8)	Fracture proximal humerus (n = 15)
Constant Score (0–100)	54.6	34.9
Oxford Score (0–48)	37.7	31.7
Quick Dash Score (0–100)	80.9	44.8

fracture in fifteen patients (group 2). When comparing both the groups, some findings are important to highlight. The average age is higher and improvement in pain is considerably better among the patients from group 1. In Table 1 it is indicated that in the three scores (OOS, CS and QuickDASH) group 1, with cuff tear arthropathy, had higher and better results. Moreover in the objective part of the Constant-Murley Shoulder Score, that measures strength and range of movement, patients from group 1 obtained higher improvement (Table 1). Similar findings were determined by Cazeneuve et al., evaluating the results of 27 three and four part fractures at a mean follow-up of 72 months, it found good results for pain, mediocre for strength and disappointing results for mobility,¹⁷ as shown in Table 2. It is possible to explain those results based on the patients expectations. Cuff tear arthropathy is the original indication for a reverse shoulder replacement and has been studied for some time now with promising results.¹⁸ In the other hand, a complex three or four part fracture in elderly patients with poor bone quality are a treatment challenge and a new indication for reverse shoulder arthroplasty.¹⁹ Patients with osteoarthritis, a chronic disease, could have lived years with pain and a shoulder with limited range of movement, so are more appreciative of improvement. Patients with fractures had a normal shoulder and were submitted to a replacement with limitations.^{20,21} The humeral stem has uniform hydroxyapatite coating throughout which helps in better bone integration, glenosphere has basal flange to prevent scapular inferior notching, glenoid base plate is more anatomical to the normal glenoid and not just spherical, the screws of the glenoid base plate are more in number at the inferior part to get better purchase inferiorly instead of four screws around the sphere and the armamentarium is more versatile/modular to change from hemi to anatomical to reverse total shoulder. The change in Centre of Rotation (COR) is from the centre of the humeral head. It gets medial and inferior (COR) after reverse total shoulder arthroplasty. Thereby the lateral lever arm gets effective by the pull of the deltoid. (agt > agt are the distance between acromion process and the greater tuberosity where agt > agt), (d & d are the distance of deltoid tuberosity from acromion process where d > d), (h and h are width of the diaphysis of the humerus at the level of deltoid insertion) (Fig. 2).

5. Complications

5.1. Case report 1

Sixty four years lady, right hand dominant, no known drug

allergies, house wife, social drinker, and co morbidities of hypothyroidism, depression, acute renal failure and post-traumatic stress disorder fell from steps at home and had proximal humerus fracture of the right side 4 years back. She was initially treated conservatively with shoulder sling as she refused for the operation. Later she got operated as she had painful and minimally functional shoulder showing changes of non-union of the proximal humerus fracture on the x rays. So, after six months of the initial injury, she underwent open reduction and internal fixation using plate and bone grafting through delto-pectoral approach. Post-operatively, she still had pain and limited range of motion with flexion and abduction of approximately 45°. So, she was consented for reverse shoulder arthroplasty. She underwent RTSA 6 months after the first operation, through the previous incision. 8 mm cemented humeral stem with 42 mm diameter size uncemented glenosphere were implanted. However, she developed post-operative radial nerve palsy, which recovered partially. Post-operative range of motion increased to 80° of flexion and abduction. After 2 years of RTSA operation, there was loosening of the humeral stem noted on the x rays, whereby she underwent removal of the reverse shoulder prosthesis after 2 and half years of the RTSA surgery. The cemented humeral stem was put because previously she had plate being put in which led to severe osteopenia. RTSA can be done immediately in cases of infected plate removal provided shoulder has adequate soft tissue coverage just like hip. Metaglens base plate was kept in-situ. Her bacterial culture came negative. She had no complaint of pain at six months follow up. Radial nerve neuropraxia had recovered with grade 4 power in wrist extensors.

5.2. Case report 2

Seventy years gentleman, right hand dominant, no known drug allergies, retired, does excessive smoking, drinks alcohol, having carcinoma tongue, previously operated for neck of femur fracture with bipolar hemi arthroplasty and total knee replacement for osteoarthritis of the knee, had a fall at home 3 years back. He sustained closed four part proximal humerus fracture of the left side, for which he primarily underwent reverse shoulder arthroplasty though superolateral Mackenzie approach, just one month after the initial trauma. 16 mm uncemented humeral stem and 42 mm diameter glenosphere were implanted. However, he dislocated with reverse shoulder prosthesis the very next day of the operation which was then converted to hemi arthroplasty within 48 h of the initial operation. Then he dislocated his hemi arthroplasty within three weeks of his second operation and within six

Table 2

Comparison of the results of our series with that available in the literature.

Author	Number of patients	Subjective outcome (satisfaction)	Constant Score (0–100)	Follow up (months)
Mol'e and Favard, 2007	484	90%	62	52
Sirveaux et al., 2004	80	96%	65.6	44
Boileau et al., 2006	45	82%	58	40
Wall et al., 2007	240	93%	60	40
Our series 2015	08	75%	55 (Cuff arthropathy)	18
	15	50%	35 (proximal humerus fractures)	14

weeks of the initial trauma. In summary, this patient has dislocated his shoulder prosthesis multiple times. At present, he does not want any operation and is satisfied with his function having no pain.

5.3. Case report 3

Sixty six years gentleman, right hand dominant, no known drug allergies, retired, with previously operated left hip replacement, common femoral and left external iliac thrombosis on anti-platelets, had a fall at home two years back. He sustained left sided proximal humerus fracture for his he underwent open reduction and internal fixation with plate and bone grafting. He also had to undergo stent placement in his left axillary artery. However, he developed infection of his plate after four weeks of the initial operation and CRPS (Complex Regional Pain Syndrome). So, he underwent removal of the previous implants and reverse shoulder arthroplasty was done one year after the removal of the plate. Subsequently, he developed peri-prosthetic fracture within one year of the RTSA operation, which healed with conservative treatment. His post op ROM at two years of RTSA operation is 90° abduction and flexion which are moderately painful. His Constant Murley score is 16, Oxford score 8 and Quick Dash score of 13.6.

6. Limitations of the study

This study is a both retrospective and prospective audit. The sample size is less than thirty. So the statistical significance of various parameters cannot be validated. Three patients had deceased. Among the remaining twenty six patients, eleven patients in the sample refused to come for the follow up appointment in the clinic due to personal reasons for example moved out of the city, missed appointment dates and satisfactory functional outcomes. The questionnaires were also posted to all the patients in the study group. Also, five patients were asked about the outcome (Oxford and Quick Dash Scores) based on telephonic conversations with the Audit Manager. The maximum follow up of the patients have been four years with 6 months as minimum follow up. So, this study has to be carried out further in future to include more patients and to have longer and regular follow ups.

7. Conclusion

The study aims to review the results of the patients who underwent areverse shoulder arthroplasty at the institute. The findings, however, show that the reverse shoulder arthroplasty gives better functional outcomes in cases of cuff tear arthropathy as compared to use for proximal humerus fractures. The shoulder replacement has satisfactory functional scores at short and medium term and its outcomes are comparable to that of the literature for rotator cuff arthropathy. It can be considered as an acceptable treatment option. Patients treated for fractured proximal humerus have clinically poorer results than those treated for rotator cuff arthropathy and this statistical difference in the functional outcomes of the two groups cannot be validated because of the small number of patients in each group. So, further studies are needed having higher number of patients in each group.

Conflicts of interest

None.

Source of funding

None.

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