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Original Research Article

Clinical outcomes of reverse total shoulder arthroplasty (RTSA)

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ABSTRACT

Patients who have been diagnosed with glenohumeral arthritis due to inflammatory, degenerative and traumatic causes usually have a progressive course of disease and is very often not controlled with medication and conservative treatment. Most patients eventually end up with disabling pain, dysfunction and limited mobility requiring surgical intervention. Few treatment options are available when it comes to surgical intervention. These primarily include anatomical shoulder arthroplasty hemiarthroplasty and the more recent reverse total shoulder arthroplasty. Although approved by the United States Food and Drug Administration (FDA) in 2004, reverse total shoulder arthroplasty (RSA) has recently become popular worldwide as a treatment of choice for glenohumeral arthritis with promising outcomes and minimal complications.

Background: Reverse Total Shoulder Arthroplasty (RTSA) is indicated for variety of shoulder conditions that involve a loss of rotator cuff function or massive tears, inflammatory pathology, gleno humeral arthritis complex proximal humerus trauma and other pathologies that cannot be effectively treated with traditional shoulder arthroplasty. RTSA can restore shoulder function and alleviate pain in these individuals. The goal of this study confirms previously reported improvements in pain, function scores, and range of motion, in patients treated with RTSA and to record clinical outcomes in Asian population.

Aim: To evaluate the clinical outcomes of patients undergoing reverse total shoulder arthroplasty (RTSA).

Materials and Methods: The present study was undertaken as a prospective, observational study among 30 Patients undergoing RTSA for various indications and attending the study hospital for medical care. The deltopectoral surgical approach was used on all participant placed in the beach chair position. Patients were followed up for 1 year postoperatively to asses outcome of RTSA.

Results: Study showed participants were elderly(>60yrs) and female predominance. Mean body weight of participants was 57.37 ±4.25 kg, (95%CI 55.78-58.96 kg). Among 19 (63.3%) participants affected hand was right, 10 (33.3%) had left hand and 1 (3.3%) had bilateral limb affected. Study demonstrated significant improvements in all clinical outcomes measured using Constant Murley, ASES, SANE, SST scores and pain relief following shoulder surgery ($p<0.05$).

Conclusion: The study demonstrated significant improvements in functional outcomes and pain relief following shoulder surgery. The Constant Murley, ASES, SANE, and SST scores all showed consistent and substantial enhancement from preoperative to multiple postoperative time points, up to 1 year. Pain reduction was evident with a decrease in the VAS score.

1. Introduction

The shoulder girdle consists of the clavicle and scapula, which connect to the proximal humerus of the upper limb.

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There are four joints in the shoulder: the sternoclavicular (SC), acromioclavicular (AC), scapulothoracic, and glenohumeral joints. The glenohumeral joint is a highly mobile ball-and-socket synovial joint. It connects the humeral head to the glenoid fossa of the scapula. The stability of this joint is provided by the rotator cuff muscles, which attach to the joint capsule, as well as the tendons of the biceps and triceps brachii. The glenoid fossa is relatively shallow, covering less than one-third of the humeral head, but it is deepened by the labrum, a fibrocartilaginous ring that attaches to the outer rim of the glenoid fossa. Several fluid-filled sacs called bursae are present around the joint, including the subacromial, subdeltoid, subscapular, and subcoracoid bursae, which aid in movement and reduce friction.[1]

Over the years, there have been significant advancements in RTSA implant design and surgical techniques. Manufacturers have introduced various prosthesis designs, including modular components, improved fixation methods, and more refined instrumentation. These advancements aim to enhance implant stability, function, and patient outcomes. With the growing utilization of RTSA, numerous studies have been conducted to evaluate its outcomes and efficacy. Clinical evidence has shown that RTSA can provide pain relief, functional improvement, and better range of motion in patients with rotator cuff deficiency or other complex shoulder conditions.[2]

By shifting the center of shoulder rotation medially and inferiorly, RTSA extends the moment arm of the deltoid muscle. This allows the deltoid muscle to compensate for the loss of rotator cuff function, enabling active forward flexion and abduction movements of the shoulder.[3]

RTSA is commonly used to treat patients with massive rotator cuff tear arthropathy, it has also demonstrated effectiveness in cases of failed shoulder arthroplasty or internal fixation revisions, rheumatological diseases affecting the shoulder, tumor reconstruction, and multi-fragmentary proximal humerus fractures.[4]

Reverse Total Shoulder Arthroplasty (RTSA) is indicated for specific shoulder conditions that involve a loss of rotator cuff function or other complex pathologies that cannot be effectively treated with traditional shoulder arthroplasty. RTSA is commonly used for patients with massive rotator cuff tears and associated arthritis, a condition known as cuff tear arthropathy. In these cases, the rotator cuff muscles are no longer functional, and traditional shoulder arthroplasty may not provide satisfactory results. RTSA can restore shoulder function and alleviate pain in these individuals. The purpose of this study was to compare the clinical outcomes after RTSA according to the primary diagnosis.

2. Objectives

1. To assess the clinical outcomes in terms of Constant-Murley Scores, American Shoulder and Elbow Surgeons (ASES) score, Single Assessment Numeric Evaluation (SANE) score, Simple Shoulder Test (SST) scores and, Visual Analogue Score (VAS) Range of motion (ROM), Strength, of patients undergoing RTSA for various indications postoperatively.
2. To identify potential complications like Scapular notching, humeral component loosening, glenoid component loosening and dislocation.

3. Materials and Methods

The present study was undertaken as a prospective, observational study in the Department of Orthopaedics, of a tertiary care teaching institute in North India. Patients undergoing RTSA for various indications and attending the study hospital for medical care was the study population. A total of 30 patients who underwent RTSA in Artemis hospital comprised the study sample.

3.1. Inclusion criteria

All patients willing to participate in the study who have one or more indications for RTSA were included in the study as listed below:

1. Cuff tear arthropathy.
2. Osteoarthritis of shoulder with severe pain and functional impairment.
3. Completely torn rotator cuff that cannot be repaired.
4. Rheumatoid arthritis with cuff deficiency.
5. Comminuted 3- or 4-part proximal humerus fracture.
6. Malunited proximal humerus fracture.
7. Failed hemiarthroplasty or total shoulder replacement with cuff deficiency.
8. Any other indication.

3.2. Exclusion criteria-patients having any of the following

1. Active infection
2. Non-functioning deltoid
3. Neurological Conditions (Parkinson's disease, multiple sclerosis, or a previous stroke)
4. Mental condition that might interfere with the ability to give informed consent and follow the postoperative protocol
5. Known metal allergy (Titanium / Tantalum)

3.3. Brief procedure

Study participants were informed in detail about the study procedure, intervention, and required follow-up. Patients who satisfied eligibility criteria and were willing to participate were included in the study after providing their informed written consent. Basic demographic and clinical information, including preoperative workup, detailed

examination of the involved shoulder, and comorbidities, were documented in a pre-structured questionnaire.

Preoperative radiographs were examined and reported for Hamada shoulder classification, glenoid erosion, and glenoid subluxations. The deltopectoral surgical approach was used on all participant placed in the beach chair position. A cemented or uncemented humeral component was used along with a base plate fixed with screws on the glenoid, followed by glenosphere insertion. Patients were kept in a shoulder sling for one month, with only passive range of motion (ROM) exercises allowed. Passive external rotation was avoided initially to protect the repair of the subscapularis tendon. Patients were allowed to use the arm in the sling for activities of daily living. At one month, the sling was discontinued, and closed-chain deltoid and teres minor exercises at home were initiated. No concomitant procedures were performed.

Patients were instructed not to lift anything heavier during the recovery period.

Postoperatively, patients were evaluated clinically and radiographically after three months. The postoperative radiographs were assessed for evidence of humeral component loosening, glenoid component loosening, scapular notching, and dislocation. All clinical measurements and radiographic assessments were performed by an independent observe.

3.4. Outcome measures

Constant-Murley Score (Evaluates level of pain, activities of daily living, range of motion like forward flexion internal and external rotation and ability to lift objects) American Shoulder and Elbow Surgeons (ASES) score (Evaluates difficulty in carrying out normal and sports activities, need for medication for pain relief, sleep disturbance due to pain).

Single Assessment Numeric Evaluation (SANE) score (Rates affected and normal side on scale of 1 to 100 in percentage).

Simple Shoulder Test (SST) scores (12-point questionnaire that evaluates shoulder function in yes or no format).

Visual Analog scores for pain (VAS-pain) (Patient reported intensity of pain on scale of 0-10 with 0 being no pain 10 being the worst pain).

Patient satisfaction (Subjective Likert scale) (Evaluates satisfaction of patient whether patient is not satisfied, somewhat satisfied, or fully satisfied with outcomes post-surgery).

3.5. Ethical considerations

Institute ethical committee clearance certificate was sought and obtained before the study was begun. Informed written consent was obtained from all the study participants before including them in the study.

3.6. Statistical analysis

Data entry was done in MS Excel 2013 and data analysis was carried out using SPSS version 22.0. Continuous and categorical variables were expressed as means and proportions respectively. Difference in means of outcome measures; pre and post-operatively at serial interval were tested for statistical significance using repeated ANOVA test. A p value <0.05 was considered statistically significant.

4. Results

Out of 30 participants 14 (46.7%) each were in the age group 60-69yrs and 70-79yrs respectively, 1 (3.3%) each were in the age group 80-89 years and 90-99 yrs. Majority (70%) study participants were female; F: M 2.3:1. Mean body weight of participants was 57.37 ±4.25 kg, (95% CI 55.78-58.96 kg). Among 19 (63.3%) participants affected hand was right, 10 (33.3%) had left hand and 1 (3.3%) had bilateral limb affected.

The mean varus present in study participants was 14.37±5.82 (95% CI 12.19-16.54). Mean functional score was 17.24±3.148 (95% CI 19.56-32.44); mean of range of movement was 88.23±24.20 (95% CI 79.20-97.27); mean FFD 9.77±7.40, (95% CI 7.0-12.53).

The mean Constant Murley score in pre-operative period was 38.03±6.667, which increase to 47.20±5.97 immediately pre-operatively, 64.37±6.24 at 1 month, 85.23±9.02 at 3 months, 91.97±7.14 at 6 months and 96.8±5.34 at 1 year post-operatively. There was statistically significant improvement in mean Constant Murley score after procedure ($p<0.05$) similarly, in pre operative period mean ASES score was 43.33±13.19, which increase to 55.73±8.47 immediately pre-operatively, 69.10±4.80 at 1 month, 79.87±4.66 at 3 month, 93.40±4.01 at 6 months and 95.6±3.23 at 1year post-operatively. There was statistically significant improvement in mean ASES after procedure ($p<0.05$).

Preoperatively the mean SANE score was 38.57±6.51, which increase to 53.37±3.77 immediately post-operatively, 64.87±5.50 at 1 month 81.53±7.16 at 3-month, 92.27±6.49 at 6 months and 94.47±4.5 at 1 year post-operatively. There was statistically significant improvement in mean SANE after procedure ($p<0.05$).

5. Discussion

RTSA (Reverse Total Shoulder Arthroplasty) emerged as an alternative to existing shoulder prostheses in the 1970s. However, early designs suffered from issues like improper shoulder joint rotation center alignment, leading to increased glenoid stress and premature loosening.

In 1987, Paul Grammont introduced a novel prosthesis concept. His biomechanical studies demonstrated that shifting the rotation center 10 mm medially increased deltoid abduction force by 20%, while a 10 mm inferior shift

enhanced it by 30%. Initially intended for severe rotator cuff tear arthropathy, the reverse shoulder prosthesis's applications expanded over time. It's now used for various conditions, including failed shoulder arthroplasty, revisions of internal fixation, rheumatological shoulder problems, tumor reconstructions, and complex proximal humerus fractures of varied geographical region of world.

In the present study 46.7% study subjects each were in the age group 60-69 yrs and 70-79 yrs respectively, 3.3% study subjects each were in the age group 80-89 years and 90-99 yrs. This aligns with the common clinical scenario where RTSA is often recommended for older individuals who are more prone to rotator cuff tears, arthritis, and other degenerative shoulder conditions. The high percentage in this age group suggests that the study might be investigating the effectiveness and outcomes of RTSA specifically in the elderly population. In a study by Emre Bilgin et al[5] the mean age of the patients was 54.8 ± 15.8 years (range, 30–77 years) when the first stage of the procedure was performed. Study by Robert Z. Tashjian et al[6] shows 70±10 years, these findings were almost in accordance with our present study. Study by Max J Kaab et al[7] shows Patients had a mean age of 75.8±6.6 years (range 41.9–91.6 years) at the time of surgery.

In our study, the average range of motion was determined to be 88.23±24.20. Research conducted by Max J. Kaab and colleagues[7] revealed noteworthy improvements in abduction range of motion postoperatively in relation to patient pain and satisfaction. These improvements were consistent across different time points within each group, specifically at both the 24-month mark and the final follow-up assessment. Furthermore, there was no significant difference observed between the groups throughout the entire duration of observation (with a p-value exceeding 0.05). Similarly, findings from a study by Aaron J. Bois et al.[8] highlighted that all the studied groups demonstrated enhanced range of motion after surgery across various motion parameters, except for external rotation in the RSA group. The improvements were statistically significant solely within the Humeral Articular (HA) fracture group, with flexion-extension (FE) and abduction displaying notable enhancements. Additionally, it was noted that the range of motion for external rotation was superior in anatomical Total Shoulder Arthroplasty (ATSA) compared to RTSA, attributed to differences in their underlying mechanisms. A prior investigation also reported on functional outcomes and survival rates during the short- to medium term follow-up period.

In our current study, we found that the average Forward Flexion Deficit (FFD) was 9.77±7.40 (95% confidence interval 7.0 to 12.53). In a study conducted by Jung Youn Kim and colleagues,[9] significant improvements were observed in active forward flexion, increasing from 51.5° before surgery to 121.8° at the 2-year follow-up. However, no substantial differences were noted in external rotation at the side (37.9° preoperatively to 35.5° at the 2-year follow-up) and internal rotation motion (L2.8 preoperatively to L3.4 at the 2-year follow-up). In a separate investigation by Michael-Alexander Malahias et al[10] the study reported a range of preoperative and postoperative active motion values. Preoperatively, forward flexion/elevation, external rotation (ER), and abduction ranged from 35 to 77 degrees, 10 to 29 degrees, and 35 to 102 degrees, respectively. Postoperatively, these values ranged from 121 to 143 degrees for forward elevation, 17.1 to 45 degrees for external rotation, and 112 to 142 degrees for abduction. Sirveaux et al.[11] reported that 96% of patients experienced little to no pain postoperatively and observed a notable increase in mean active forward flexion, going from 73° to 138°. In another study by Morris et al.,[12] their patients displayed higher postoperative mean forward elevation and abduction (143.3° and 135°, respectively), but slightly lower mean external rotation (20°) compared to the subjects in our study.

Table 1: Demographic details of study participants

Variables	Freq (%)/ mean+ sd
60-69 yr (%)	14 (46.7)
70-79 yr (%)	14 (46.7)
80-89 yr (%)	1(3.3)
90-99yr (%)	1(3.3)
Female (%)	21(70)
Male (%)	9 (30)
Bilateral (%)	1(3.3)
Left (%)	10 (33.3)
Right (%)	19 (63.3)
Weight (mean+sd)	57.37± 4.25
Varus (mean+sd)	14.37 ±5.82
Functional outcome (mean+sd)	26.00 ±17.24
ROM (mean+sd)	88.23 ±24.20
FFD (mean+sd)	9.77 ±7.40
VAS Score (mean+sd)	7.20±1.40
Liker scale (mean+sd)	3.67±0.92

5.1. Functional outcome

In our present study, we initially observed a mean Constant Murley Score of 38.03±6.667 before the operation. This score increased to 47.20±5.97 immediately before surgery, 64.37±6.24 at 1 month postoperatively, 85.23±9.02 at 3 months postoperatively, 91.97±7.14 at 6 months and 96.8±5.34 at 1 year postoperatively. Similarly, the mean SANE score before surgery was 38.57±6.51, which rose to 53.37±3.77 immediately after the operation, 64.87±5.50 at 1 month postoperatively, 81.53±7.16 at 3 months postoperatively, 92.27±6.49 at 6 months and 94.47±4.5 at 1 year postoperatively. Furthermore, the mean SST score before the operation was 43.33±13.19, which increased to 55.73±8.48 immediately postoperatively,

Table 2: Mean clinical and functional outcome score comparison in pre and post-op time

Outcome scores	Pre-op	Post-op immediately	Post -op 1 month	Post-op 3 months	Post-op 6 months	Post -op 1year	P value
Constant Murley score	38.03±6.66	47.20±5.97	64.37±6.24	85.23±9.02	91.97±7.14	96.8±5.34	0.0001
ASES score	43.33±13.19	55.73±8.47	69.10±4.80	79.87±4.66	93.40±4.01	95.6±3.23	0.0001
SANE score	38.57±6.51	53.37±3.77	64.87±5.50	81.53±7.16	92.27±6.49	94.47±4.5	0.0001
SST score	43.33±13.19	55.73±8.48	69.10±4.80	79.77±4.51	93.40±4.01	95.70±5.01	0.0001

69.10±4.80 at 1 month postoperatively, 79.77±4.51 at 3 months postoperatively, and 93.40±4.01 at 6 months and 95.70±5.01 at 1 year postoperatively. Additionally, the mean ASES score before surgery was 43.33±13.19, which improved to 55.73±8.47 immediately before surgery, 69.10±4.80 at 1 month postoperatively, 79.87±4.66 at 3 months postoperatively, 93.40±4.01 at 6 months and 95.6±3.23 at 1year postoperatively. Various authors have reported encouraging short-term clinical and functional outcomes for RTSA. For instance, Sirveaux et al.[11] noted a substantial increase in the mean Constant score from 22.6 points prior to surgery to 65.6 points after surgery. They found that 96% of patients experienced minimal or no pain, accompanied by a notable enhancement in mean active forward flexion from 73° to 138°. On the other hand, Bryan et al[13] observed that patients treated with RTSA for different shoulder conditions had varying degrees of improvement and complication rates, with certain conditions showing better outcomes than others. In the RTSA procedure, the deltoid muscle takes on a crucial role in powering and positioning the arm, in contrast to the rotator cuff. A study by Morris et al.[12] displayed comparable results to our study, reporting a postoperative mean ASES score of 78.4 (compared to our 77.8), while the mean Constant score was slightly lower at 56.7 (compared to our 70). However, it's important to note that their evaluation of postoperative outcomes was conducted telephonically for a subset of patients, limiting the objective assessment of scores and range of motion for only a small number of subjects during their final follow-up. In the study conducted by Max J Kaab et al,[7] the average Constant score and ASES score exhibited enhancement from their respective preoperative values in each participant group. These scores, however, remained fairly consistent within the same groups both at the 24-month mark and during the final followup evaluation ($P > 0.05$). Moreover, the clinical scores did not show substantial differences between the two distinct groups throughout the entire observation period ($P > 0.05$). Research led by Taylor A. VanHelmond et al[14] demonstrated mean outcome scores of 9.11, 77.79, and 74.12 for the SST, ASES, and PSS, respectively. Similarly, Chun et al[15] determined an average ASES score of 74.3 among individuals with healed tuberosities and 70.7 among those with tuberosity malunion, with no statistically significant disparity. Interestingly, our study cohort displayed ASES results resembling those of Chun et al's[15] tuberosity repair group. In another investigation involving patients under 60 years old (with an average age of 54), the mean SST and ASES scores were 6.2 and 65.8, respectively. Our participants, despite their advanced age and tuberosity excision, achieved higher SST and ASES scores. It's worth noting that the surgical indications for the younger patients in the latter study were not exclusively confined to proximal humerus fractures. Shields et al. found an average ASES score of 81 at the two-year postoperative mark, encompassing various indications for RTSA. When juxtaposed with the final ASES measurements in our study and considering the minimal clinically important difference of 6.2 points, it's likely that the disparities between our studies would not be statistically significant. Another study, led by Aaron M. Chamberlain et al[16] revealed that among 66 participants who completed the ASES questionnaire preoperatively, the mean ASES score was 27.3 (SD 17.4). After surgery, 90 subjects completed the ASES, VAS pain, and WOOS surveys. The average postoperative ASES score was 74.1 (SD 18.9), and the mean postoperative WOOS score was 70.9 (SD 23.5). Notably, significant improvements were observed after surgery based on both ASES and VAS pain surveys for those who completed both preoperative and postoperative assessments ($P < .0001$).

5.2. *VAS score*

In our current study, the average Visual Analog Scale (VAS) score was determined to be 7.20±1.40, (95% confidence interval 6.68 to 7.72). In a study by Choi et al[17] the mean VAS score showed improvement, decreasing from 4.0 points prior to surgery to 2.8 points at the follow-up assessment ($p = 0.013$). Similarly, Jung Youn Kim and colleagues[9] reported a decline in the mean subjective pain score (VAS) during motion, reducing from 5.2 (range: 0–10) before surgery to 1.8 (range: 0–5) at the 2-year follow-up ($p < 0.001$). Furthermore, Aaron M. Chamberlain et al[16] study revealed a preoperative mean VAS pain score of 7.1 (SD 2.1), which significantly improved to a mean postoperative VAS pain score of 1.4 (SD 2.1). Our study findings are consistent with existing literature.[9,16,17]

5.3. Likert scale score

In our current study, the average Likert scale score was found to be 3.67±0.92 (95% confidence interval 3.32-4.01). In a study led by Max J. Kaab et al[7] improvements in range of motion (ROM) for abduction were observed postoperatively, contributing to enhanced patient satisfaction and reduced pain. These improvements were consistent within each group at both the 24-month mark and the final follow-up assessment, with no significant differences detected between the groups throughout the entire observation period (P>0.05). Furthermore, a study conducted by Aaron M. Chamberlain et al[17] revealed that 95% of the subjects expressed satisfaction with the overall outcome of the procedure.

6. Conclusion

Our study demonstrated significant improvements in functional outcomes and pain relief following shoulder surgery. The Constant Murley, ASES, SANE, and SST scores all showed consistent and substantial enhancement from preoperative to multiple postoperative time points, up to 1year. Pain reduction was evident with a decrease in the VAS score. Additionally, patients reported improved well-being on the Likert scale. These findings underscore the positive impact of the surgical intervention on patients' shoulder function, pain, and overall quality of life.

7. Recommendation

With good functional outcome and relatively lesser complications RTSA becoming popular and recommended as a treatment method, for extensively studying the outcomes of the procedure, large multi centric studies with longer follow up periods are required.

8. Sources of Funding

None.

9. Conflict of Interest

None.

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