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Long-Term Results of Primary Reverse Shoulder Arthroplasty for Massive, Irreparable Rotator Cuff Tears Without Glenohumeral Arthritis with a Mean Follow up of 9.4 Years

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Abstract

Background: The aim of this single-center study was to analyze the long-term clinical results of reverse shoulder arthroplasty in patients with massive, irreparable rotator cuff tears without glenohumeral arthritis.

Methods: A retrospective cohort study of 105 patients (115 shoulders) was conducted. The mean age of the patient group was 76 years (range, 65 to 87 years). The mean clinical follow-up was 9.4 years (range, 5 to 17 years). Pain, range of motion, and complication rates were analyzed pre-operatively and at the last follow-up.

Results: The mean Constant-Murley score increased from 29 points (range, 21 to 34 points) preoperatively to 68.1 points (range, 57 to 81 points) postoperatively (p<0.05). Scapular notching was present in 50 shoulders (43.5%) and it was grade 1 or 2 in 47 of 115 cases (40.9%) and grade 3 or 4 in 3 of 115 cases (2.6%). Complications occurred in 19 patients (17%). Seven patients (6%) underwent revision surgery. The mean satisfaction rate was 94%.

Conclusions: Reverse shoulder arthroplasty is a viable treatment for massive, irreparable rotator cuff tears without glenohumeral arthritis with satisfactory clinical outcomes and low complication and reoperation rates with a mean follow up of 9.4 years after surgery.

Keywords

arthritis, glenoid, humerus, arthroplasty, prosthesis, replacement, outcomes, revision, shoulder, rotator cuff tear

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Introduction

Improved biomechanical design, great expansion of surgical indications and superior clinical outcomes have led to an increase in the use of reverse total shoulder arthroplasty (RTSA) over the past decade.[1–9] The most common indication is rotator cuff tear arthropathy (CTA) followed by massive or irreparable rotator cuff tears (MIRCTs) without glenohumeral arthritis, inflammatory arthropathy, 3- and 4-part fractures and tumors of the proximal humerus, previously failed shoulder arthroplasty and shoulder instability with bone loss.[1,3,6–17] Females older than 75 years have been shown to undergo RTSA more commonly than males whereas the increase in incidence of RTSA is higher in patients aged from 55 to 64 years.[7,9]

MIRCTs without arthritis is a relatively new indication for RTSA.[18] MIRCT is defined as a tear involving 2 or more tendons or a tear size greater than 5 cm.[18] The reparability of massive rotator cuff tears depends on the age of the patient, the chronicity of the tear (acute, chronic or acute on chronic tear), muscle atrophy and fatty infiltration. Surgical options include partial rotator cuff repair, insertion of a subacromial balloon spacer, biologic augmentation of

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partial rotator cuff repair or use of a collagen patch, superior capsular reconstruction, tendon transfers and RTSA.[18–20]

The success of the repair in all cases but RTSA is mostly based on the healing capacity of the rotator cuff. In RTSA, the reverse shoulder design enables the modification of the deltoid moment's arm in relation to medialization or lateralization of the center of rotation (COR) even in absence of a functioning rotator cuff.[4,7,21] Although the reported rates of 7% to 68% of postoperative complications of RTSA make joint preserving options more appealing in patients with MIRCTs younger than 60 years, the good clinical outcomes, the high satisfaction rates and the decreasing revision rates of RTSA create a challenge for optimization of the "reverse ball and socket" method to become the main option in younger patient groups.[2,5,19]

The purpose of this study was to evaluate the long-term clinical outcomes of RTSA in patients older than 65 years with MIRCTs without glenohumeral osteoarthritis. We hypothesized that patients who underwent RTSA would yield satisfactory clinical outcomes and implant longevity would be verified with low readmission, complication, and revision surgery rates.

Materials and Methods

Between 2005 and 2017, 105 patients (115 shoulders) underwent RTSA due to MIRCTs without glenohumeral arthritis in our department. Data were collected retrospectively to evaluate clinical outcomes, reoperation rate and complications as intra-operative or post-operative events with a negative influence on patient outcomes. All procedures were performed by the same surgeon. Each patient was followed up at 1-, 3- and 6-months post-operatively and then at 1 year, at 2 years, and every 4 years thereafter. All 115 performed RTSAs during the study period had complete follow up and met the inclusion criteria for long-term post-operative analysis. All patients participated voluntarily and did not receive any compensation. They were all preoperatively informed in an oral and written manner about their options of treatment. Written consent was obtained from all patients.

Patients eligible for this study were males or females older than 65 years with clinically, radiologically and intra-operatively confirmed diagnosis of symptomatic massive, irreparable rotator cuff tears without arthritis. Inclusion criteria were tears of more than two tendons, proximal migration of the humeral head (type IA of Hamada and Favard classification), fatty degeneration of the rotator cuff muscles (stages III and IV of Goutallier classification) and active elevation less than 105 degrees.[22–24] Patients with pseudoparalysis (active forward elevation of less than 45° with preserved passive range of motion and chronic onset, without a recent traumatic event or no active external rotation with full passive external rotation lagging back to −40°) were not included in the study.[25]

Exclusion criteria were previous surgical repair of rotator cuff tears, bio-reverse shoulder arthroplasty, RTSA combined with latissimus dorsi transfer and patients with impaired deltoid function.

Twenty-nine (29) of 105 patients were male (27.6%) and seventy six (76) patients were female (72.4%). The mean age of the selected patients was 76 years (range 65-87 years, SD: 8.8). The mean follow up was 112.8 months (range 60-204 months). Contralateral RTSA was performed in 9.5% of the patients

Clinical examination was performed by two experienced shoulder physicians of our department. Pain was assessed using a visual analog scale for pain (pVAS) and active range of motion (ROM) was measured by a handheld goniometer. Shoulder function was evaluated according to Constant-Murley (CM) score which was obtained for each patient before surgery and at last-follow up.[26] Radiographic evaluation with bilateral plain radiographs in internal and external rotation and pre-operative planning with the use of 3D-Computed Tomography (CT) was performed in all patients. Additional imaging control with Magnetic Resonance Imaging (MRI) was obtained in all patients in order to define the characteristics of MRCTs (Massive Rotator Cuff Tears) and identify any other concomitant lesions. Radiologic evaluation with plain radiographs was also performed post-operatively. In case of neurologic deficit immediately after surgery, electromyography (EMG) was performed at 3 to 4 weeks post-operatively. Radiographic analysis was conducted and complications and other adverse events as well as satisfaction rate were recorded at last-follow up.

All procedures were performed with the patient under general anesthesia in a beach chair position by the same senior surgeon. The same type of shoulder prosthesis was used in all cases (Fx, Humelock Reverse Shoulder Prosthesis). A standard deltopectoral approach was utilized in all cases. After soft-tissue release, the humeral neck was cut at a retroversion angle between 10° and 20° based upon surgeon's preference. For glenoid preparation, the glenoid guide was placed flush with the inferior border of the glenoid or slightly overhanging. Glenoid reaming was performed over the guide pin and then the baseplate was fixed with inferior tilt 10° to the glenoid with a central peg with a post length of 6 mm and two anteroposterior and two superoinferior screws. The glenosphere size was 36 mm in 76 cases and 40 mm in 39 cases. Before insertion of the humeral component, manual reaming was performed, and a retroversion guide attached to a handle parallel to the forearm axis was used to determine the retroversion of the humeral implant. All humeral stems were cementless. Three drill holes were made on the lesser tuberosity for subscapularis repair with the use of a bone-tunneling suture technique. After reduction of humeral stem trial, soft tissue tension and glenohumeral joint stability was assessed. Tenodesis of the biceps and subscapularis repair was performed in all patients.

All patients followed the same rehabilitation protocol. A shoulder sling with a 3-point strapping system was used for 3 weeks post-operatively. Wrist and elbow ROM exercises were encouraged at the first post-operative day 3 times per day. Passive mobilization of the shoulder joint was allowed 2 weeks after surgery. At this time, only forward elevation and abduction were allowed. Active assisted exercises started at 4 weeks post-operatively. Active elevation exercises were started at 6 weeks after surgery, overhead activities were started at 2 months after surgery and weight-lifting and sports were allowed at 6 months post-operatively. The rehabilitation protocol was individualized in each case based on patients' motivation and tolerance.

Statistical analysis was performed using SPSS Version 17, statistical software (SPSS, Chicago, IL). Numerical variables were expressed in their mean value and Standard Deviation (SD) if continuous and in their median value and Interquartile Range (IQR) if discrete. Normally distributed continuous numerical variables were further analyzed with the t-test, while non-normally distributed continuous and discrete numerical variables with the Wilcoxon (Mann Whitney U) rank sum test. Categorical variables were expressed as percentages and were compared with the chi-square of Fischer's exact test. Statistical significance was set at the level of $p < 0.05$.

Results

The mean CM score increased from 29 (range, 21 to 34) before surgery to 68.1 (range, 57 to 81, SD: 7.1) at the final follow-up evaluation. The mean pVAS score improved from 7.4 (range, 6.3 to 8) before surgery to 1 at last follow up.

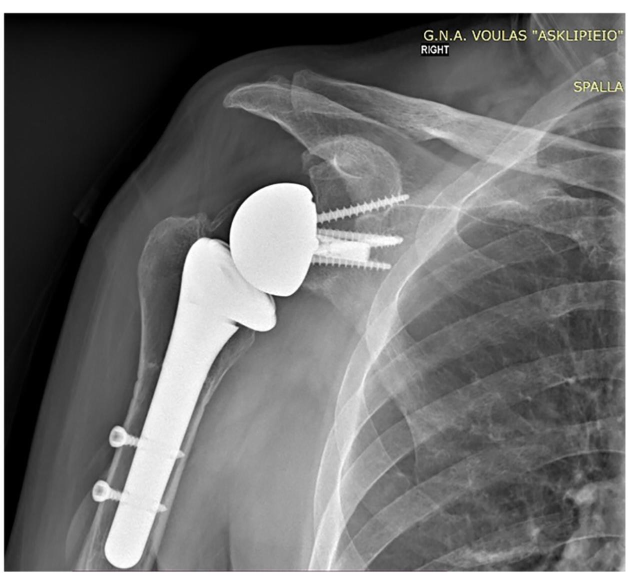

Figure 1. Anteroposterior radiograph of the right shoulder at 12 years after reverse total shoulder arthroplasty.

The mean forward flexion increased from 80 (range, 20 to 105) before surgery to 155 (range, 130 to 170, SD: 13.1) post-operatively. The mean abduction increased from 85 (range, 30 to 105) pre-operatively to 140 (range, 120 to 165, SD: 13.1) at last follow up. The mean external rotation at 0 degrees improved from 0 (range, −20 to 10) before surgery to 10 (range, 0 to 30, SD: 11.8) after surgery and the mean external rotation at 90 degrees improved from −10 (range, −30 to 0) to 0 (range, −10 to 25, SD: 9.8). There was no statistically significant improvement in external rotation post-operatively ($p < 0.05$). The mean internal rotation improved from buttock before surgery to lumbosacral junction after surgery according to CM score (Vrotsou). Seventy-seven (77) of 105 patients (73.5%) returned to their daily activities and work at 3 months after surgery. The mean post-operative satisfaction rate was 94% (range, 88% to 100%).

Scapular notching was reported in 50 of 115 shoulders (43.5%). According to the Nerot–Sirveaux classification system mild scapular notching (grade 1 or 2) was observed in 47 of 115 cases (40.9%) and a moderate-to-severe notching (grade 3 or 4) was observed in 3 cases (2.6%).[27] The complications included 4 cases of hematoma (3.5%) drained surgically immediately post-operatively, 3 early shoulder dislocation events (2.6%) (Figure 1) and 1 late dislocation event (0.9%) and a transient axillary nerve palsy in 2 of 115 shoulders (1.7%) which resolved at 2 and 5 months post-operatively respectively. Other complications related to intra- or post-operative fractures included four non-displaced acromion fractures (3.5%) which were treated conservatively and two periprosthetic humeral fractures (1.7%) after fall at 3 months and 1 year post-operatively. Infection occurred in three shoulders (2.6%), which were treated surgically. Seven cases (6%) underwent revision surgery due to instability, periprosthetic fractures and infection.

Discussion

Except for mainstay surgical indications, MIRCTs without concurrent arthritis are an increasing indication of RTSA. Short-term and mid-term results of RTSA performed in patients with MIRCTs without arthritis demonstrated significant improvement in pain, clinical outcomes and functional scores compared to the preoperative pain levels and shoulder function. The purpose of this study was to analyze the long-term clinical outcomes of RTSA in patients older than 65 years with MIRCTs without glenohumeral osteoarthritis in relation to the potential complications of the procedure at 9.4 years post-operatively.

A recent systematic review by Viswanath et al demonstrated the results of 666 RTSAs performed in patients with MIRCTs without glenohumeral osteoarthritis. The mean age of the patients was 70. 2 years (range, 60-75.8 years). With a mean follow up of 44 months (range, 2.9-93 months), the mean postoperative active elevation was 135 degrees and the mean increase of active elevation after surgery was 58.2 degrees (range, 35.6-79 degrees). The mean Constant Score was 63.4 with a mean increase of 33 points at last follow up.[18] Ernstbrunner et al also showed the long-term results of 29 RTSAs in total and 9 RTSAs (31%) performed for MIRCTs without arthritis with a mean follow up of 11.7 years (range, 8-19 years). The study by Ernstbrunner et al reported a mean increase of post-operative active elevation of 53 degrees (from 64 degrees pre-operatively to 117 degrees after surgery) and a mean increase of 35 points of CM (from 24 points to 59 points) at last follow up.[28] Compared to the previous studies, our study showed a higher increase rate of 75 degrees of mean active elevation at 9.4 years post-operatively, while the mean increase of 39 points of CM was similar to that demonstrated by Viswanath et al and Ernstbrunner et al at the final follow-up evaluation.[18,28]

Another systematic review by Sevivas et al demonstrated the results of 266 RTSAs performed in 257 patients with MIRCTs without arthritis, with a mean follow up of 47.4 months (range, 34-61.4 months). The authors reported a mean increase of 12 degrees of external rotation at last follow up.[29] These results are similar to those demonstrated by our study, as the mean increase of external rotation at 0 and 90 degrees of abduction was 10 degrees at last follow up. The increase of mean external rotation was not statistically significant. Ernstbrunner et al also reported no statistically significant increase in active external rotation at 11.7 years post-operatively.[29]

The rate of patients returning to work at 4 months after RTSA has been shown to be up to 65% while the rate of patients returning to the same level of sports activity at 5 months after RTSA ranges from 60% to 86%.[7,30] The study by Rauck et al demonstrated an overall satisfaction rate of 71% at 2 years after RTSA in 161 patients with a mean age of 71.4 years.[30] Pre-operative factors that were associated with better clinical outcomes and higher satisfaction rate were ASA class I, no history of previous shoulder surgery and no work-related shoulder pain.[7] Similarly, our study reported high satisfaction rate of patients undergoing RTSA at long-term follow up. All patients returned to their daily-working activities and 73.5% of patients returned to the same sports activity level at 1 year post-operatively. The satisfaction rate was higher in this group (73.5%) of younger and more active patients who were still working and were more motivated during the rehabilitation after surgery.

Recent systematic reviews reported significant improvement in pain, ROM and function of patients undergoing RTSA for MIRCTs but the long-term overall complication and reoperation rates have been shown to be up to 29% at 2 years post-operatively (Thon). Scapular notching as the mechanical abutment of the humeral component against the neck of the scapula is a common complication followed by prosthetic instability.[1,2,4,5,21,31] The frequency rate of postoperative dislocation ranges from 2% to 31% whereas the rate of recurrent instability ranges from 15% to 45% and it is associated with inadequate soft tissue balance, superior inclination of the glenosphere, mechanical impingement, active infection and subscapularis deficiency.[2,3,31–33] Increased lateral offset and inferior tilt of 0 to 10 degrees have been shown to decrease scapular notching whereas subscapularis repair depends on deltoid function, posterior rotator cuff tension and glenosphere or humeral lateralization.[2,3,34]

Other adverse effects of RTSA include loss of active external rotation, periprosthetic stress fractures, decreased lever arm of external rotators, impaired function of the recruited deltoid fibers during abduction, infection, separation of the conjoint tendon, neurologic injuries, hematoma, glenoid loosening and inadequate preservation of the bone stock of the greater tuberosity.[1,5,21,32,35] The frequency rate of periprosthetic fractures ranges from 0.9% to 7.2%.[31] This rate is higher in patients with poor bone quality and use of immunosuppressive drugs.[11,31]

Scapular notching is reported in up to 96% of patients at 3 months after RTSA without clinical significance.[6,7,36,37] Half of the patients have been shown to present with moderate- to-severe scapular notching post-operatively.[37] The inferiorly tilted position of the glenoid component might result in impingement of the humeral cup on the neck of the scapula leading to limited passive ROM and shoulder instability due to humeral implant subluxation and glenoid wear or even screw fracture.[6,15,35–37] Polyethylene wear, component loosening, scapular notching and inferior clinical outcomes have been associated with superior glenoid baseplate inclination.[6,38]

The meta-analysis by Jang et al underlined the negative effect of scapular notching on functional scores and active elevation in absence of inferior glenoid tilt.[36] Kennon et al further showed decreased overall rate of scapular notching in the lateralized group compared to patients undergoing glenoid-based medialized RTSA at 10 years post-operatively.[5] The study by Ernstbrunner et al showed a high rate of scapular notching in 20 of 29 patients (95%) whereas scapular notching of grade 2 or higher was reported in 10 of 29 patients (34.5%) at 11.7 years post-operatively.[28] Our study demonstrated lower rates of scapular notching at 9.4 years after surgery compared to the study by Ernstbrunner et al[28] Scapular notching was reported in 50 of 115 patients (43.5%) and moderate-to-severe notching (grade 3 or 4) was observed in 3 of 115 patients (2.6%). The reported rate of scapular notching could be the result of uptilt glenosphere in early cases or lack of humeral lateralization.

The study by Kennon et al demonstrated an overall revision surgery rate of 6% and complication rate of 16% with a mean follow up of 10 years after primary RTSA.[5] The reported complications included shoulder dislocation, infection, stress fractures, periprosthetic fractures and neurologic injuries.[5] These results are similar to the results of our study with an overall complication rate of 10.5% and reoperation rate of 6% in patients with primary RTSA performed 5 to 17 years ago. The reported revision rate is not significantly high considering that four of seven cases of revision were the result of postoperative traumatic events. Furthermore, compared to these results, Ernstbrunner et al demonstrated higher complication and reoperation rates of 38% and 26% accordingly at 11.7 years post-operatively.[28]

Most studies reported post-operative infection and shoulder dislocation as the most common causes of hospital readmission.[7] Studies with mid-term follow up reported post-operative infection rates as high as 6.4%.[7] The most common cause of shoulder infection was *Cutibacterium acnes,* and it was associated with male gender.[7] Late shoulder dislocation at 3 weeks post-operatively was more common than early dislocation and it was associated with male gender, obesity, polyethylene wear, deficient subscapularis, history of previous shoulder dislocation and high rate of recurrent instability.[7] Sanchez-Sotelo et al also underlined the high risk of shoulder dislocation after RTSA in patients with deficient posterosuperior rotator cuff without repair of the subscapularis.[15] Compared to the study by Thon et al three cases of infection (2.6%) were reported in our study at long-term follow up while 1 late and 3 early events of shoulder dislocation (3.5%) were reported post-operatively. All four shoulder dislocation events were traumatic. Subscapularis was repaired in all four cases. Compared to these results, Ernstbrunner et al reported one early and three late dislocation events at 11.7 years after surgery. The authors underlined the presence of infection in one of three cases of late shoulder dislocation. The overall dislocation rate was 17%.[28]

The incidence rate of acromion and scapular spine fractures after RTSA ranges from 1.3% to 4.3% and it is higher with increasing follow up.[1] Our study reported post-operative acromion fractures in 4 of 115 shoulders (3.5%). These fractures could be associated with excessive lateralization of the glenosphere combined with subscapularis repair leading to increased stress forces on the acromion as demonstrated by biomechanical studies.[1] Periprosthetic humeral fractures were reported in 2 of 115 patients (1.7%) and they were caused by fall after surgery.

Our study reported axillary nerve injury in 2 of 115 cases (1.7%) with complete recovery at 2 and 5 months after surgery respectively. Kim et al demonstrated higher incidence rate of axillary nerve injury (41.2%) after RTSA followed by radial nerve injury (12%) in 182 cases with a mean follow up of 58.5 months.[39] In the study by Kim et al post-operative neurologic complications mostly included deficits of the axillary, radial and musculocutaneous nerves as a result of arm lengthening in RTSA compared to anatomic shoulder arthroplasty.[39] The negative effect of arm lengthening and brachial plexus traction or soft-tissue tension on post-operative neurologic function could be avoided with moderate increase of the lateral offset.[39]

This study has several limitations. The study design was retrospective, and the clinical data were collected from self-reported joint registry questionnaires while ROM was measured based on clinical examination performed by two health-providers leading to the concern for interobserver reliability. This study is also subject to selection bias as there was no randomization between the implant designs selected by the primary surgeon. On the other hand, the study was controlled, based on prospectively collected data, using strict inclusion-exclusion criteria, a well-described surgical technique performed by a single, experienced in shoulder surgery surgeon in a single center and a variety of clinical and functional outcomes which were significantly improved at long-term follow up.

Conclusion

RTSA yields satisfactory outcomes in patients older than 65 years suffering from MIRCTs without glenohumeral arthritis, with high satisfaction and low readmission rates with a mean follow up of 9.4 years post-operatively. The optimal management of MIRCTs without arthritis remains controversial in younger patients. The success of RTSA is a matter of combination of soft-tissue tension and choice of prosthesis depending on the anatomy of the patient and the quality of the rotator cuff and the deltoid. As younger and younger patients undergo reverse shoulder arthroplasty, optimization of the implants in addition with balanced restoration of the rotator cuff and load redistribution of the native shoulder joint becomes the main challenge in the new era of shoulder surgery.

Declaration of Conflicting Interests

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