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Case Series

Clinico-radiological correlation of reverse shoulder arthroplasty outcomes

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ABSTRACT

Positioning of prosthetic components is essential for the success and longevity of the prosthesis. Judging prosthetic implantation radiologically is always beneficial; plain radiographs and computed tomography can provide information regards inclination and version of glenoid component, besides, lateralization of prosthetic components. This study aims at postoperative radiological evaluation of component positioning of reverse shoulder prosthesis and correlating measured radiological parameters with clinical outcome. Radiological assessment was carried on by radiographs taking advantage of true anteroposterior projection, and midaxial two-dimensional computed tomography cut. Radiographs evaluated glenoid inclination in coronal plane (superior-inferior tilt) via global inclination angle, and critical shoulder angle. Center of rotation was evaluated by calculating acromion index. Additionally, acromiohumeral interval, and deltoid lever arm distance were documented. Midaxial CT cuts evaluated glenoid version. Each parameter was correlated to postoperative clinical outcome represented in range of motion and total functional scores. the mean acromion index revealed significant change to 63.82±9.06%, total medialization surged significantly with average 1.51 cm with a mean postoperative calibrated center of rotation-distance of 3.72±0.78 cm. The mean increase in acro-mio-humeral interval was 1.57 cm with a new postoperative value of 2.49±0.9 cm. The mean glenoid version declined to 5.7º±5º, however, this change was not significant. In conclusion, accurate positioning of shoulder prosthesis components with proper tensioning of soft tissue envelope within acceptable measurement parameters is considered crucial for stability and longevity of implant with the best clinical outcomes.

Keywords: Reverse, Shoulder arthroplasty, Radiological, AHI, Glenoid version

INTRODUCTION

Reverse shoulder arthroplasty (RSA) has been adopted to solve problems of rotator cuff arthropathy aiming at painless mobile joint in old age. Later, indications of RSA expanded to manage failed rotator cuff (RC) surgery, massive RC tear with chronic shoulder pseudo paralysis, previous arthroplasty, post-traumatic arthritis, and rheumatoid arthritis.[1]

RSA was focused on four crucial principles to obtain a stable construct while allowing the deltoid to compensate for an absent RC. Center of rotation (COR) was distalized and, inherently stable prosthesis, effective deltoid lever arm from the start of movement, and large glenosphere with small humeral cup to create a semi-constrained articulation.[2,3]

Positioning of prosthetic components is essential for the success and longevity of the prosthesis. Judging prosthetic implantation radiologically is always beneficial; plain radiographs and computed tomography (CT) can provide information regards inclination and version of glenoid component, besides, lateralization of prosthetic components. This study aims at postoperative radiological evaluation of component positioning of reverse shoulder prosthesis and correlating measured radiological parameters with clinical outcome.

CASE SERIES

After the approval of the institutional review board affiliated to Mansoura university with code number: MDP.19.10.27, this prospective study included thirteen patients with different shoulder pathologies; seven patients with RCA, four with post-traumatic sequalae, one with failed hemiarthroplasty, and a patient with degenerative OA associated with massive RC tear. Patients with active infection, deltoid paralysis, axillary nerve injury, and charcot arthropathy were excluded from our study. The procedure was discussed with all patients with possible outcome and complications, besides an informed consent was obtained for each patient. Enrolled patients were gathered as a single group including six males and seven females with mean age of 64±6.25years. All patients were admitted and underwent arthroplasty with trabecular Metal™ reverse shoulder system (Zimmer-Biomet) at Mansura university hospital affiliated to Mansoura university in the period from May 2018 to June 2019 and were followed till July 2022.

Preoperative radiological assessment was carried on by radiographs taking advantage of true anteroposterior (AP) projection, and midaxial two dimensional (2D) CT cut. Radiographs evaluated glenoid inclination in coronal plane (superior-inferior tilt) via global inclination angle (β angle), and critical shoulder angle (CSA). COR was evaluated by calculating acromion index. Additionally, acromiohumeral interval (AHI), and deltoid lever arm (DLA) distance were documented. Midaxial CT cuts evaluated glenoid version.

β angle was measured (Figure 1); angle between the line of glenoid fossa and supraspinatus fossa floor.[4] CSA: angle formed by a line from superior to inferior pole of glenoid and a line from inferior pole to lateral edge of the acromion (Figure 1). AHI was measured as distance from acromion under surface to the greater tuberosity perpendicular to acromial body long axis (Figure 2).[5] COR was calibrated starting with a perfect circle of humeral head defining center and measurement of the perpendicular from glenoid center, DLA (Figure 2) was measured by a line drawn from acromial lateral edge to humeral deltoid tuberosity, from this line, a perpendicular was drawn and measured to COR.[5] Acromion index (AI) (Figure 2) was calculated as a ratio of the distance from glenoid to acromial lateral edge over the distance from the glenoid to humeral head lateral edge.[5] Friedman method was used to assess glenoid version on 2-dimensional midaxial CT cut (Figure 3), as angle between a line perpendicular to transverse axis of scapula and a line parallel to glenoid face at or just below coracoid tip.[6]

Postoperative radiological assessment followed previously described parameters (Figures 4, 6 and 8), in addition to calculating RSA angle, distalization shoulder angle (DSA), and lateralization shoulder angle (LSA). RSA angle (Figure 5) was measured as angle between the inferior part of glenoid fossa and the perpendicular to supraspinatus fossa floor.[7] DSA and LSA (Figure 7) were calibrated relying upon three bony landmarks that normally remain intact postoperative: superior glenoid tubercle, most lateral border of acromion and most supero-lateral border of greater tuberosity.[8] All measurements were calibrated on the digital imaging and communication in medicine (DICOM) images using image J program software program, also, glenoid version was measured by the same program at the 2D midaxial cut taking the advantage of CT workstation (GE Optima CT520 16 slice) belonged to radiology department.

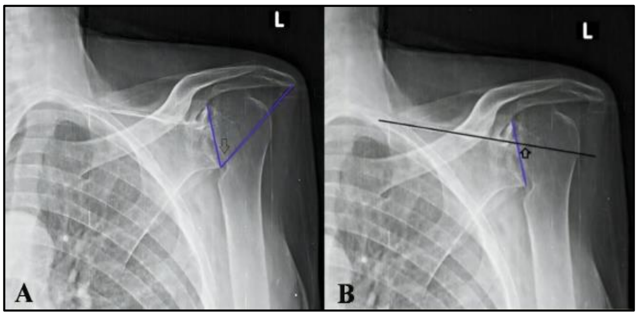

Figure 1 (A and B): Pre-operative radiographs of glenoid inclination measurment; CSA (black arrow) and beta angle (black arrow).

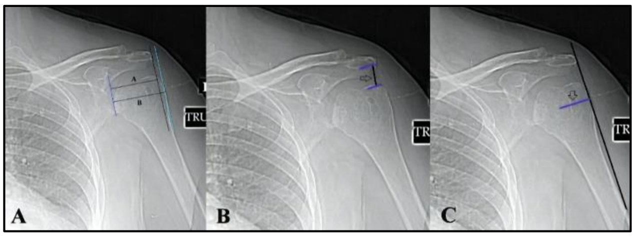

Figure 2 (A-C): Preoperative radiographs; AI (A/B), AHD (black arrow) and COR distance from line of pull (black arrow).

Figure 3: Preoperative 2D mid-axial CT cut showing glenoid version angle (angle between the two red lines).

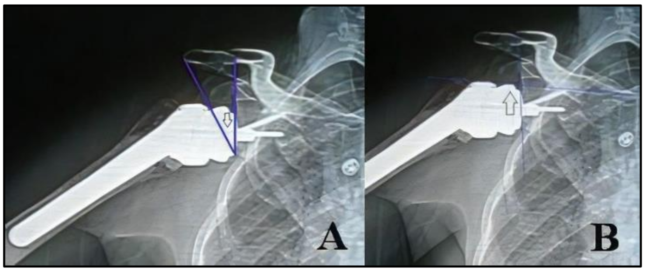

Figure 4 (A and B): Post-operative radiographs showing; CSA (arrow) and beta angle (arrow).

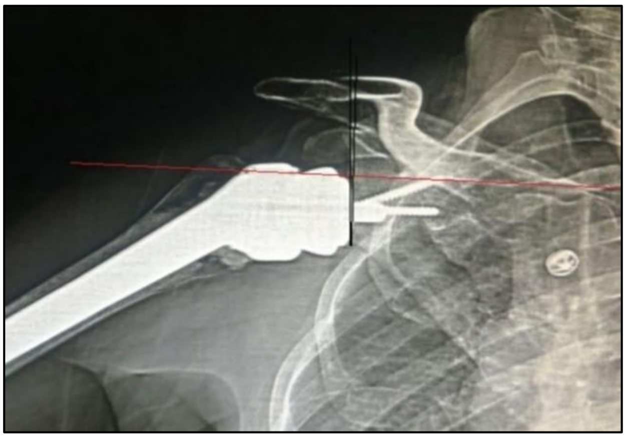

Figure 5: Post-operative radiographs of RSA angle (between the two black lines).

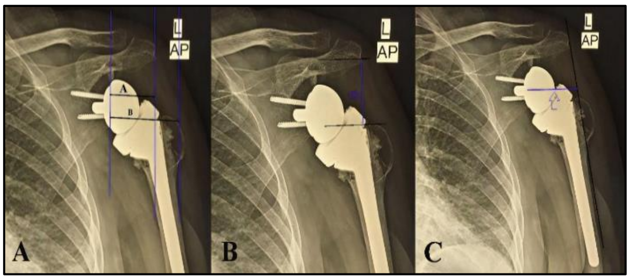

Figure 6 (A-C): Post-operative radiographs showing; AI (A/B), AHD (blue arrow), COR distance from line of pull (blue arrow).

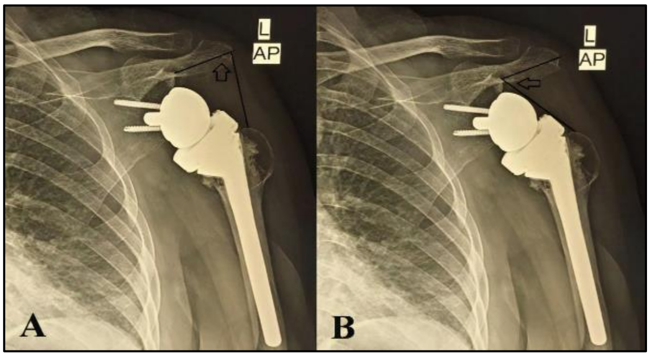

Figure 7 (A and B): Post-operative radiographs showing; LSA (black arrow), DSA (black arrow).

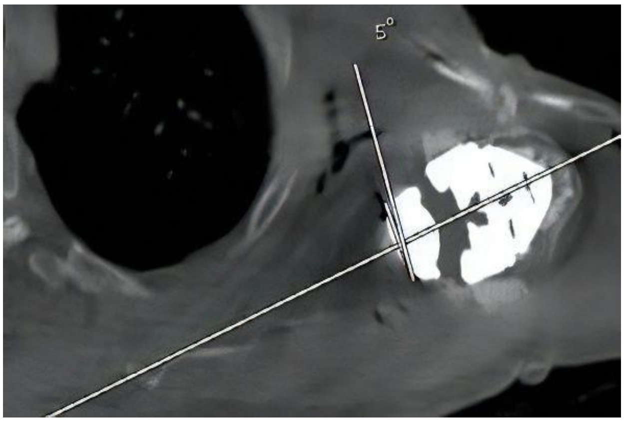

Figure 8: Post-operative 2D mid-axial CT cut showing glenoid version measurement (between the two vertical white lines).

Each postoperative radiological parameter was compared to its preoperative peer. Additionally, each was correlated to post-operative clinical outcome. Post-operative clinical evaluation was reported through painless active ROM measured by orthopaedic goniometer in degrees, constant-Murley score, and American shoulder and elbow surgeons' assessment scoring system (ASES score).[9,10] All patients were followed-up for at least 18months. Complications as instability, infection, scapular notching, and fractures were reported if found.

Resultant data were analysed using IBM SPSS Corp. released 2013. IBM SPSS Statistics for Windows, version 22.0. Armonk, NY: IBM Corp. Qualitative data were described using number and percent. Quantitative data were described using median (minimum and maximum) for non-parametric data and mean, standard deviation for parametric data after testing normality using Shapiro–Wilk test. Monte Carlo and Fischer exact test were used for corrections. Student t-test, Mann-Whitney, and ANOVA tests were used to compare 2 or more independent groups. Significance of the obtained results was judged at the (0.05) level. The Spearman's rank-order correlation was used to determine the strength of a linear relationship between two non-normally distributed variables.

Preoperative radiological assessment revealed a mean AHD of 0.9±0.4 cm. COR was identified at 2.21±0.74 cm from deltoid pull line. the means for beta angle and CSA were 78.2º±7.6º and 36.9º±6.5º. The mean AI was 87.8±20.1%. CT measurement indicated retroverted glenoid with a mean version of 9.8º±5.4º.

All patients were followed up for at least 18 months with a mean follow-up period of 21.3±4.1months. At last follow-up, patients showed improvement in mean ROM. The mean postoperative abduction and flexion ROMs were 74.5º±25º and 83.1º±29.8º. Additionally, the averages for postoperative Constant and ASES scores were 49.84±14.6 and 62.0±13.4.

Postoperatively, humeral side lateralization represented in mean AI revealed significant change to 63.82±9.06% (P=0.001), mean LSA and DSA were 85.7º±12º and 45.6º±12.7º. Whole Medialization surged significantly by average 1.51cm with a mean postoperative calibrated COR distance of 3.72±0.78 cm (p=0.003). The mean increase in AHD was 1.57cm (p=0.001) with a new postoperative value of 2.49±0.9cm. Glenoid inclination significantly changed with respect to mean CSA and RSA angles which showed significant change to 33.3º±3.6º (p=0.048) and 5.15º±5.6º degrees (p=0.003), respectively. Significant change in mean beta angle was reported and calibrated 88.08º±7º (p=0.003). The mean glenoid version declined to 5.7º±5º, however, this change was not significant (p=0.05).

As demonstrated in Table 1, no significant correlation between all postoperative radiological measured parameters and postoperative clinical outcome measures, except for, COR medialization that shows significant correlation with ASES score (p=0.026).

Preoperative shoulder pathology impacted outcome with best clinical outcome reported in cases with post-traumatic sequalae. Significant difference in terms of post-operative constant score was evident (p=0.03). Further details were reported in Table 2. No significant difference between post-operative clinical outcome was noted on comparing the impact of different glenosphere inclinations, however of them, inferior inclination showed the best clinical outcome with detailed results shown in Table 3. Patients with glenosphere inferior overhang experienced better outcomes when compared to those with no glenosphere inferior positioning, with significant change in in forward elevation ROM (p=0.0056), (Table 4).

Table 1: Correlation between post-operative radiological parameters and outcome.

Radiological parameter	P value			
	Abduction	Flexion	Constant	ASES
AHD	0.463	0.325	0.360	0.136
COR to line of deltoid pull	0.481	0.522	0.189	0.026*
Acromion index	0.152	0.596	0.947	0.883
Beta angle	0.150	0.114	0.687	0.085
RSA angle	0.940	0.618	0.579	0.989
CSA	0.195	0.121	0.135	0.157
DSA	0.259	0.152	0.543	0.122
LSA	0.010*	0.115	0.883	0.208
Version angle	0.147	0.385	0.391	0.289

(*): significant value.

Table 2: Correlation between shoulder pathology and clinical outcome.

Shoulder pathology	Abduction	Flexion	Constant	ASES
RCA	65.8º±21.5º	73º±26.3º	42.6 º ±5.2º	56.3º ±13º
Post-traumatic	82.5º±15.0º	82.5º±9.5º	54.5º ±14.1º	61.2º ±6.5º
Degenerative OA with massive RCT	70º±0.0º	60º±0.0º	20.0 º ±0 º	41.6 º ±0 º
P value	0.445	0.621	0.03*	0.33

(*): significant value.

Table 3: Impact of baseplate inclination on clinical outcome.

Baseplate inclination	Abduction	Flexion	Constant	ASES
Inclination (≤10º)	N=11, (RSA angle=5.81º±2.6º)			
	73.7º±22.7º	81.6º±30.6º	49.4º±15.4º	61.1º±12.2º
Inferior inclination (>10º)	N=1, (RSA angle= 14º)			
	90.0º±0.0º	100.0º±0.0º	51º±0 º	73.3º±0.0º
Superior inclination (<0º)	N=1, (RSA angle=-11º)			
	90.0º±0.00º	100.0º±0.0º	51º±0º	66.6º±0.0

Table 4: Correlation between glenosphere overhang and outcome.

Glenosphere overhang	Abduction	Flexion	Constant	ASES
No overhang (n=10)	71º±22.5º	79º±29.1 º	49.4º±15.9º	60.9º±13.1º
Inferior overhang (n=3)	91.6º±6.2º	102.6º±19º	50.6º±5.3º	67.1º±2º
P value	2.488	0.0056*	1.106	4.54

(*): significant value.

Intraoperative glenoid fracture occurred in one patient, that was managed be femoral head allograft and cemented fixation in the same setting. Unfortunately, the surgeon was not comfortable with glenoid base plate stability. Another case presented with early dislocation in her second follow-up visit one month after surgery and underwent open reduction twice; with exchange of liner in first attempt as well as with pectoralis major transfer at the last intervention.

DISCUSSION

RSA is considered a valuable surgical option to restore painless accepted ROM in patients with different pathologies. Recently, indications have widely expanded to include glenohumeral arthritis, failed RC surgery, previous arthroplasty, or a prior fracture.[11] Outcome is influenced by many factors related to surgical indication, surgeon's experience, implant design, positioning, and postoperative rehabilitation.[12] This prospective study aimed at evaluating radiological parameters of implanted prosthesis and correlating them to short term post-operative functional results of mean period of 21.3±4.1 months.

A considerable controversy exists about RSA ideal design and positioning. Little exists in literature regards radiographic measures, all available data is inconclusive.[5] Our study reported arm lengthening by 1.57 cm. Previous studies demonstrated a mean surge in lengthening and AHD by 2.5 cm and 2.3 cm. lengthening does not improve outcomes, however there is a debate upon its impact on ROM, lengthening might be influenced by glenosphere position, tilt, and size, polyethylene thickness, humeral stem type and height. Our study revealed an average increase in AHD by 1.57 cm with no correlation to ROM or outcomes. Proper lengthening is crucial for prosthetic stability with a sound tensioning. Lengthening of 1.5cm could be sufficient, however, more than 2.5cm is considered excessive lengthening.[13,14] It is still recommended to limit lengthening less than 2.5cm to limit acromion fracture, neurologic or deltoid injury.[15]

DSA represents a recent tool to judge inferiorization and lengthening, however, studies reported no significant correlation to either outcome or ROM.[16,17] A significant incline of DSA from 26.7 to 45.6 degrees was noted in our study with no significant correlation to outcome. This study showed a significant change in glenoid inclination. Mean CSA and RSA angle declined from 36.92º and 14.6º into 33.31º and 5.15º respectively. These declines improved ROM insignificantly concordant with previous results.[13,18,19] Furthermore, there was no significant difference in ROM and outcomes between superior, neutral, or inferior inclinations. Nevertheless, inferior inclination had the best results, coinciding with previous studies.[13,18,19] No consensus exists regards inferior inclination, as neck impingement in ER, adduction might increase owing to inevitable medialization required for seating an inferiorly tilted implant, that shortens scapular neck and approximates scapula and humerus, with impingement-related instability. Another theory states that 15º inferior tilt had most uniform compressive forces, least micromotion when compared to neutral and superior tilt. thus, tilt cannot be accused alone. Lateralized-COR design with inferior tilt yields the most uniform forces distribution. superior inclination with either lateralized or medialized-COR designs is better avoided.[13]

Overall lateralization represents an advantage of re-tensioning of remaining RC muscles, that could be judged by AI. larger value represents relatively more medial humerus. Not enough data exists in literature concerning the impact of AI.[13] our study reported a mean decline in AI from 87.8% to 63.8% with no correlation to outcome. Glenoid lateralization was not raised as separate entity due to the use of medialized-COR-designed prosthesis. Exact amount of lateralization is not yet quantified. Further studies are required to guide for perfect lateralization distance in different designs. Recently, LSA was proposed to assess lateralization, however, showed no significant correlation with outcome.[16,17] Similarly, there was no significant correlation in this study. COR distance from deltoid pull line showed average increase by 1.5 cm, with no correlation to ROM as previous studies.[13]

Glenosphere inferior overhang showed the best outcome in our study mimicking previous studies specially abduction ROM which can be explained by increased deltoid lengthening. Optimal inferiorization is not agreed upon, but probably within range 2-5 mm.[20,21]

Glenoid version changed from 9.8º±5.4º to 5.7º±5º with no correlation to outcome, concordant to recent studies reporting no clear relationship between version and ROM or outcome, however, IR might improve with retroversion on expense of ER. Thus, placement of baseplate positioning in neutral or retroversion less than 10º should be considered, more than 10º increases micromotion affecting prosthetic longevity.[22,23]

The role of computer-assisted intraoperative navigation has recently been described in literature; its role is still evolving. It helps to achieve a secure baseplate fixation with proper screws length and position. However, this requires learning time.[24]

The major limitation of our study was limited number of enrolled patients. A larger sample size would have been able to test for more precise interactions between independent variables. Another limitation was the wide spectrum of different shoulder pathologies. Also, the short-term follow-up that might underestimates the calculated correlations. Thus, further studies with specific shoulder pathology, larger number of patients, and longer-term follow-up could reach objective standards for proper joint stability.

CONCLUSION

Accurate positioning of shoulder prosthesis components with proper tensioning of soft tissue envelope within acceptable measurement parameters is considered crucial for stability and longevity of the reverse shoulder implant with the best clinical outcomes.

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