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Effect of retroversion of the humeral component on functional outcomes in reverse total shoulder arthroplasty

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Abstract

The recommended humeral stem retroversion angle (HSRA) is 0 to 30 for reverse shoulder arthroplasty (RSA). The literature contains few clinical studies on this topic. We aim to assess the effect of the HSRA determined by computerized tomography (CT) on the range of motion (ROM) of the joint, the functional score, and the activities of daily living (ADL) in patients who have undergone RSA. Patients who underwent RSA surgery were retrospectively analyzed. Patients implanted with a HSRA less than 25° on CT scan were categorized in Group I, and patients with a greater angle in Group II. ROM, the Constant Murley score (CMS), American Shoulder and Elbow Scores (ASES), and ADL were used for the functional evaluation at the final follow-up control. Our study comprised 40 patients; Group I comprised 21, and Group II of 19 patients. The mean age was 70.5 years in Group I and 68.9 years in Group II. The mean follow-up time was 14.9 months in Group I and 13.8 months in Group II. At the last follow-up, the external rotation was 39.6±6 in Group I and 46.4±5.7 in Group II, while the internal rotation was Lumbar vertebra 1 in Group I and Lumbar vertebrae 3 in Group II ($p=0.028$ and <0.001). After surgery, functional scores and ADL significantly increased in all patients. When the groups were compared, the results of the patients in Group I were significantly higher. While ROM increased significantly after RSA in both groups, internal rotation and related ADL were better in the patients implanted with less retroversion. In view of our results, implantation at 20° retroversion would be suitable for better results and higher satisfaction.

Keywords: Cuff tear arthropathy, glenohumeral arthritis, reverse shoulder arthroplasty, humeral component, retroversion

Introduction

Due to the unsuccessful results of the anatomical total shoulder prosthesis, Grammont developed the reverse total shoulder arthroplasty (RSA) as an alternative in 1985, which follows a new philosophy [1]. Originally used for cuff tear arthropathy (CTA) treatment, and nowadays, RSA has been used for proximal humeral fractures, refractory glenohumeral instability, and proximal humeral neoplasia due to the reported successful clinical outcomes [2-4].

The clinical results after RSA, especially the range of motion, are influenced by the implant's characteristics and the component's position [5,6]. Humeral stem retroversion angle (HSRA) affects the post-operative internal and external rotation and activities of daily living (ADL), such as eating, washing hair, washing back, and performing hygiene and care activities [4].

In a recent study investigating the humerus's retroversion angle, 1104 cadavers were examined, and an average value for the retroversion of the humerus of 25°±7° was determined [7]. In the literature, many authors have recommended the optimal humeral component retroversion angle to be between 0° and 30° [1,4,8-10]. However, this recommendation is mostly in expert opinion, and clinical studies are quite rare [4].

CITATION
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In our study, the actual HSRA is measured on the postoperative computerized tomography images of the humerus of patients who underwent RSA using the method described by Boileau et al. [11] and the effects of retroversion on range of motion (ROM), functional scores, and ADL will be evaluated. We hypothesized that internal rotation will increase with the decrease in postoperative retroversion and that this difference will impact ADL and postoperative patient satisfaction.

Material and Methods

Before the start of the study, approval was obtained from the Bilecik Şeyh Edebali University Faculty of Medicine Ethics Committee (decision number: 291300, date: 06.11.2024). We retrospectively analyzed the patients who underwent surgery for reverse shoulder arthroplasty between January 2020 and January 2024. Patients who had a follow-up period of more than six months, had undergone surgery for rotator cuff arthropathy and primary glenohumeral osteoarthritis, were between 60 and 85 years old, and agreed to participate in the study were included in the study. Patients who had operated for non-reconstructable proximal humerus fractures, who had neurological disease, who had a history of infection in the same joint were excluded from the study. Patients were divided into two group; those with a retroversion angle of fewer than 25 degrees in the CT measurements were categorized in Group I, and those with a retroversion angle of more than 25 degrees in Group II.

The preoperative data of the patients were retrieved from their medical records (age, gender, operated limb, etiology). Preoperative and postoperative functional evaluations were made with ROM, American Shoulder and Elbow Score (ASES), and Constant-Murley score (CM), while ADL evaluation was made with four criteria determined from ASES criteria; eating, back washing, hair washing, managing hygiene, and grooming activities. Radiological examinations of the patients were performed at the final follow-up with CT imaging of the operated shoulder (Figure 1). An independent orthopedics and traumatology specialist made humeral component retroversion measurements at the last follow-up examination in January 2024.

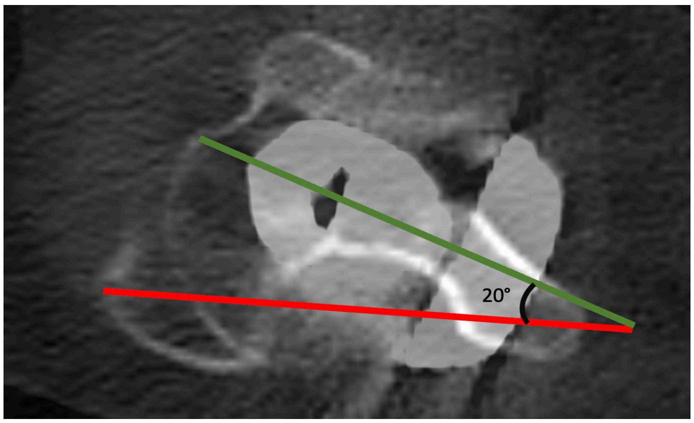

Figure 1. Measurement of humeral component retroversion using axial humerus CT slices; Red line intracondylar axis, green line humeral component axis

The operations were performed by a single surgeon (M.G.) in a single center. The TPM Reverse Shoulder System (Tıpmed, İzmir, Türkiye) with a lateralized humerus and lateralized glenoid component was used in all patients who underwent surgery.

All patients were operated in the beach chair position via the deltopectoral approach. In all patients, the subscapularis muscle was peeled from the lesser tuberosity by peeling, and a marking suture was placed (Figure 2). The humeral head was cut in 20 or 30 degrees of retroversion using the incision guide, which referred to the forearm axis (Figure 3). The intramedullary canal was again prepared by reaming the intramedullary canal at 20 or 30 degrees retroversion about the forearm axis (Figure 4). After the glenoid had been loosened all round, all patients were tilted downwards by 15 degrees and the central canal of the glenoid was prepared. The metaglene component was implanted so that the glenoid rim was not exceeded and an eccentric glenosphere with a diameter of 41 mm and an offset of 3 mm was implanted in all patients. A 44 mm humeral tray was used in all patients. After preparation and implantation of the glenoid and humeral stem, the appropriate humeral tray and insert thickness were determined by verifying the tension of the deltoid muscle and the associated tendon using trial components, the dislocation status during external rotation, and the tension during traction in the longitudinal direction of the humerus. After irrigation of the area, components of the same size as the test components were implanted into the humerus, and the joint was reduced. After implantations, the subscapularis tendon, which had previously been peeled and placed with a marker suture, was tenodesized using the Mason-Allen suture method. After a drain was placed, the wound was closed, the shoulder was slung, and the surgery concluded.

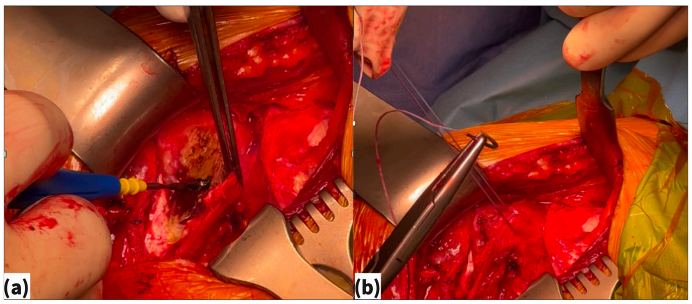

Figure 2. Peeling of the subscapularis tendon from the lesser tubercle (**a**), passing of marker sutures to perform tenodesis of the subscapularis tendon at the end of the surgery (**b**)

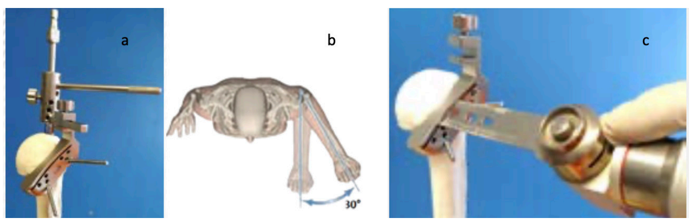

Figure 3. Placement of the humerus cutting guide (**a**), Calculation of the forearm axis (**b**), Making the humeral head cutting (**c**)

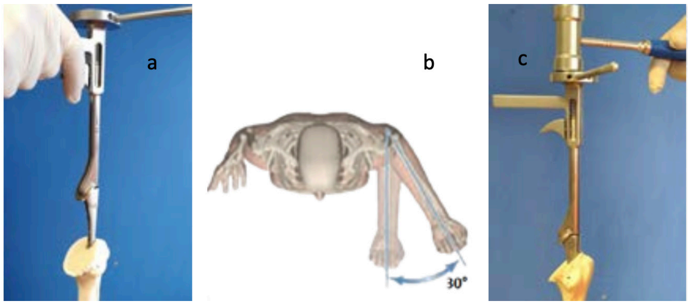

Figure 4. Preperation of the humeral intramedullary canal; Anterior aspect (**a**), Measurement of the forearm axis (**b**), Lateral aspect (**c**)

The shoulder was immobilized for 3 weeks after the surgery. On the first day of surgery, passive abduction and forward flexion movements were started for all patients. Pendulum movements were begun after the edema, and pain decreased at the first-week follow-up. Active-assistive exercises were started at second week control, and active ROM exercises were started at fourth week control within a tolerable range.

Statistical Analysis

The data were analyzed using SPSS Statistics Software (version 23.0, IBM Corp.). The distribution of the data was evaluated using the Shapiro-Wilk test. The categorical data were assessed with the Pearson Chi-square, Fisher exact, and Fisher-Freeman-Halton tests. The parametric and non-parametric data were assessed using the Student's t-test and Mann-Whitney U test. The dependent groups (for non-normally distributed data) were evaluated using the Wilcoxon test. A p-value of <0.05 was considered significant in all the tests.

A power analysis based on literature data prior to the start of the study resulted in a sample size of 32 patients in order to achieve the desired power of >0.8. The postoperative ASES score was analysed as the primary outcome.

Results

We identified 52 patients who underwent RSA during the study period. Twelve patients did not want to participate; thus, 40 patients were included in this study. The mean age of the patients was 69.8±5.2 years, and the mean follow-up period was 20.4±9.9 months. Group 1 comprised 21 patients (14 female and seven male), and Group II comprised 19 (13 female and six male). (Table 1) The mean value of overall humeral retroversion was 24.75°±5.6°, while it was measured at 20.41°±1.5° in Group 1 and 30.02°±4.1° in Group 2 (p<0.05).

Table 1. Characteristics of our patients participating in the study

	Group 1 (n=21)	Group 2 (n=19)	p
Age (year)*	70.58±4.19	68.92±6.39	0.392
Gender (female/male)**	14/7	13/6	0.233
Operated limb (right/left)[a]	13/8	11/8	0.623
Follow-up period (month)[ß]	14.94±11.98	13.85±7.19	0.920
Complicationa (notching/dislocation/infection)	1/1/1	2/1/0	0.882

[a]Chi-square test was used, *Student-t test was used, **Fisher Exact test was used, [ß]Mann Whitney-U test was used

When comparing CMS and ASES between the groups pre-operatively, Group II exhibited better preoperative CM score (39.6±2.3 vs 40.4±2.3; p=0.338) and ASES (25.8±5.6 vs 26.3±6; p=0.748) score but the differences were not statistically significant.

When comparing the post-operative CM and ASES scores between the groups, Group I had a better postoperative CM score (84.5±1.6 vs 80.1±2; p<.001) and ASES score (85.2±2.9 vs 78.4; p<0.001) and the differences statistically significant (Table 2).

Table 2. Evaluation of functional scores in the pre- and postoperative period

	Group 1	Group 2	p
ASES (Preoperative)	25.82±5.67	26.35±6.03	0.748
ASES (Postoperative)	85.29±2.97	78.42±2.87	**<0.001**
CMS (Preoperative)	39.64±2.37	40.42±2.37	0.338
CMS (Postoperative)	84.52±1.66	80.14±2.03	**<0.001**

ASES: American Shoulder and Elbow Score, CMS: Constant Murley Score; Mann Whitney-U test was used

In the assessment of ADL, the participants were asked about their ability to cope with hygiene and care activities, washing their back and hair, and their eating behavior. In both groups, it was found that the patients were mainly unable to perform these activities or had difficulties doing so in the preoperative phase.

In the postoperative phase, it was observed that activities of daily living improved significantly in all patients, but especially the management of hygiene and care activities and back washing improved statistically significantly in group 1 (p=0.006 and p=0.018, respectively) (Table 3).

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Table 3. Evaluation of changes in daily living activities before and after surgery

	Preoperative		p	Postoperative		p
Managing hygiene[a]						
	Group 1	**Group 2**		**Group 1**	**Group 2**	
Unable to do	-	-	0.008	-	-	**0.006**
Very difficult	16	10		-	-	
Somewhat difficult	5	9		5	4	
Not difficult	-	-		16	15	
Back washing*						
	Group 1	**Group 2**		**Group 1**	**Group 2**	
Unable to do	12	12	0.999	-	-	**0.018**
Very difficult	9	7		4	10	
Somewhat difficult	-	-		17	9	
Not difficult	-	-		-	-	
Eating[a]						
	Group 1	**Group 2**		**Group 1**	**Group 2**	
Unable to do	-	-	0.242	-	-	0.242
Very difficult	7	9		-	-	
Somewhat difficult	14	10		7	8	
Not difficult	-	-		14	11	
Hair comb*						
	Group 1	**Group 2**		**Group 1**	**Group 2**	
Unable to do	-	-	0.576	-		0.242
Very difficult	17	14		-	-	
Somewhat difficult	4	5		7	5	
Not difficult	-	-		14	14	

[a]Chi-sqare test was used,* Fisher Exact was used

While a significant improvement in joint range of motion was observed in all movements compared to the preoperative period, the values of internal rotation were significantly higher in patients in group 1 (Group 1 L1 vertebrae (T12-L3), Group 2 L4 vertebrae (L1-L3); p<0.05), forward flexion and abduction were similar (0.243 and 0.376 respectively) (Figure 5). External rotation was higher in group II (p=0.028) (Table 4).

Table 4. Examination of joint range of motion

	Group I	Group II	p
	Preoperative		
Forward flexion*	81.7±7.8	84.2±7.8	0.387
Abduction*	81.1±8.2	83.5±8.4	0.493
External rotation*	28.5±4.5	28.9±3.4	0.606
Internal rotation**	L4 vertebrae	L4 vertebrae	0.219
	Postoperative		
Forward flexion*	137.0±13.1	135.2±13.5	0.243
Abduction*	125.8±7.9	123.9±14.3	0.376
External rotation*	39.6±6.0	46.4±5.7	**0.028**
Internal rotation**	L1 vertebrae	L3 vertebrae	**<0.001**

*Mann Whitney-U test was done, **Fisher Freeman Halton was used

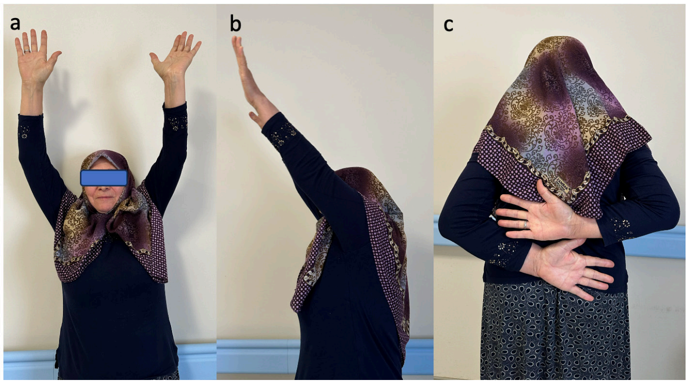

Figure 5. Joint range of motion of our patient in Group 2; abduction (**a**), forward flexion (**b**), internal rotation (**c**)

Complications were observed in a total of six patients: Scapular notching in three patients, dislocation in two patients and periprosthetic joint infection in one patient.

Discussion

Our study showed that the RSA surgery had successful results in both groups. The CMS (p<.001), ASES (p<.001), back washing and hygiene activities (respectively p=0.006 and 0.018), and internal rotation (P<.001) were significantly better in Group I.

In a cadaver study, Gulotta et al. examined the effects of implantation at 20 and 40 HSRA on the amount of internal and external rotation without impingement and instability They reported that as retroversion increased, the relative ratio of ER increased while IR decreased [12]. Stephenson et al. found similar results in relation to increasing HSRA, noting that IR was better at 20° humeral anteversion than at 40° humeral retroversion (128°±9° vs. 83°±8°) [10]. On the other hand, a study by Rhee et al. compared the results of humeral components implanted at a retroversion of 0° and 20°. In this study, although internal rotation was not statistically significant between the groups in terms of functional outcomes and activities of daily living, it was reported that internal rotation was better in patients implanted at a lower retroversion (or L2 vertebra versus L3 vertebra) [4]. In our study, higher HSRA was associated with more external rotation, and lower HSRA was associated with more internal rotation in our patients, which is consistent with the literature. To better maintain internal rotation, implantation at low HSRA would be appropriate, especially in patients whose hygiene and cleaning needs should be protected.

Studies investigating the effects of HSRA on clinical outcomes are quite limited. The first clinical studies reported that patients implanted in the neutral version had better ADL and CM scores [13,14]. In the clinical study by Rhee et al., it was observed that although the ROM was not affected by retroversion, backwash, and fixation bra activities, especially those related to internal rotation, were better in patients implanted at 0° [4]. A recent study by Oh et al. found that anatomical implantation was associated with better ROM and functional outcomes [15]. A study conducted by Favre et al. reported that implantation of a humeral component in the neutral version is associated with better internal rotation, more excellent intrinsic stability, and more favorable functional outcomes [8]. As is well known, the head of the humerus is retroverted about 20° in relation to the intercondylar axis [16,17]. When examining the outcomes of the patients included in our study, both the ROM and functional outcomes of our patients in whom we implanted at 20°, close to the neutral version, were found to be better, which is in line with the literature. When we analyzed our functional results, we found that the CMS and ASES results were better in Group I patients, as they achieved better results in all movements except external rotation. Implantation should be performed at a lower HSRA as it provides a better range of motion and better functional results.

Instability is one of the most common complications after reverse shoulder replacement [18]. The literature reports that instability after RSA is between 2.4% and 30% [19-21]. Factors contributing to postoperative instability include inadequate soft tissue tension, malpositioning of the implant, and failure to repair the subscapularis tendon [20,22]. Demographic factors that are associated with instability after RSA include male gender and obese patients [23]. Patients with previous open shoulder surgery or patients with complicated diagnoses can also pose a challenge for the restoration of dynamic soft tissue fixation. In such patients, there is a proven risk of dislocation after RSA [22]. Two patients in our study developed dislocations in the early postoperative period (one in the third and the other in the fourth week). Our patient, who developed a dislocation in the third week after surgery, had discontinued sling therapy in the early phase, and our other patient had previously undergone surgery with an anterolateral open mini-incision on the same shoulder due to a rotator cuff tear. No dislocation was found when the positions of the humeral and glenoid components were examined.

Limitations

Our study has some limitations: it is a retrospective study, glenoid component position and muscle atrophy levels were not included in the evaluation. Also, the follow-up period was short. However, the strengths of our study are that the operations were performed by a single surgeon using the same implant, which eliminates the risk of bias, that the functional outcomes were assessed by two independent reviewers using more than one scoring system, and that the measurement of retroversion was performed using CT slices to determine the true retroversion angle.

Conclusion

Significant functional improvement can be achieved in patients operated on for CTA and primary glenohumeral osteoarthritis with RSA. Considering our results, implantation of a humeral component at 20° or less retroversion seems to be associated with a better postoperative functional outcome and a more significant internal rotation.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Institutional review board approval was obtained from the Bilecik Şeyh Edebali University Clinical Research Ethics Committee (decision number: 291300, date: 06.11.2024).

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