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Better Constant Scores and Active Forward Elevation Using Deltopectoral Versus Anterosuperior Approach for Reverse Shoulder Arthroplasty: Matched Cohort Study

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Abstract

Purpose: To determine, from a sizable cohort of reverse shoulder arthroplasty (RSA), whether the deltopectoral (DP) or anterosuperior (AS) approach grant better outcomes at a minimum follow-up of 24 months.
Methods: The authors reviewed 743 RSAs in patients with primary osteoarthritis (OA) with or without rotator cuff lesions and secondary OA due to rotator cuff tears. The DP approach was used in 540 and the AS approach in 203. Pre- and post-operative constant scores (CSs) and shoulder range of motion were recorded.
Results: Of the initial cohort of 743 shoulders, 193 (25.7%) were lost to follow-up, 16 (2.1%) died, and 33 (4.4%) were revised; 540 shoulders were operated using DP approach (73%), of which 22 were revised (4.1%), while 203 were operated using the AS approach (27%), of which 11 were revised (5.4%). Propensity score matching resulted in two groups: 172 shoulders operated by DP approach, and 88 shoulders operated by AS approach. Comparing outcomes of the matched groups at 2 or more years also revealed that, compared to the AS approach, the DP approach resulted in significantly better post-operative CSs ($67.3 \pm 14.0°$ vs 60.8 ± 18.3, $P = 0.017$), active forward elevation ($137° \pm 27.4°$ vs $129° \pm 29.8$; $P = 0.031$).
Conclusion: At 2 or more years following RSA, the DP approach granted significantly better CS (by 6.5 points) and active forward elevation (by 8°) compared to the AS approach. The differences observed are clinically relevant and must be considered to manage patient expectations following RSA and for selecting surgical approach depending on their functional needs.
Level of evidence: III, comparative study

Keywords

Reverse shoulder arthroplasty, RSA, anterolateral approach, superolateral approach, constant score, range of motion

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Introduction

Reverse shoulder arthroplasty (RSA) is an effective treatment for glenohumeral osteoarthritis, cuff tear arthropathy, massive rotator cuff tear (RCT), and proximal humeral fractures.[1,2] The outcomes of RSA continue to improve as surgeons and manufacturers enhance implant design, positioning, and surgical techniques.[3,4]

The two most common surgical approaches for RSA are deltopectoral (DP) and anterosuperior (AS) (aka superolateral). Both approaches allow for safe and reproducible exposure of

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the glenoid and humerus, but differ in terms of muscle incisions and tendon releases required. The DP approach preserves the deltoid and enables better assessment of humeral anatomy, but requires disinsertion of the subscapularis.[5] The AS approach provides direct exposure of the glenoid while preserving the subscapularis, though numerous authors reported difficulties with glenoid baseplate positioning.[4,6,7] The choice between the two approaches depends primarily on surgeon preferences, but could also depend on patient-specific parameters, such as surgical antecedents and functional requirements.[4]

A recent systematic review that compared the DP versus AS approach for RSA in shoulders with cuff tear arthropathy found no differences in pain relief or range of motion (ROM).[8] The authors concluded that further large-scale studies are required to address clinical gaps allowing in-depth comparison of the two approaches. The purpose of this study was therefore to determine, from a sizable cohort of RSA, whether the DP or AS approach grant better outcomes at a minimum follow-up of 24 months. The hypothesis was that there would be no significant differences between the two approaches in terms of survival, complications, clinical scores, or ROM.

Materials and Methods

The authors retrospectively reviewed records of 716 patients (743 shoulders) that received RSA between January 2015 and August 2017 at 10 centres (Figure 1). Inclusion criteria were primary RSA for treatment of primary osteoarthritis (OA) with or without partial or complete rotator cuff lesions or secondary OA due to RCT (aka cuff tear arthropathy) with a minimum follow-up of 2 years. Exclusion criteria were patients operated for rheumatoid arthritis, or fractures, as well as shoulders with surgical antecedents, posttraumatic sequalae, or that had adjuvant latissimus dorsi tendon transfer. All patients provided written informed consent for the analysis and use of their data, and the study was approved in advance by the institutional review board (IRB COS-RGDS-2022-11-006-GODENECHE-A).

Surgical Technique

At eight centres, the DP approach was used exclusively (n = 434), while at one centre, the AS approach was used exclusively (n = 118), and at another centre the DP approach was used in some (n = 22), but the AS approach was used where preservation of the subscapularis was deemed beneficial (n = 31). In the 456 shoulders operated by DP approach, the subscapularis was detached in 429 and repaired after detachment in 403. In the 149 shoulders operated by AS approach, the subscapularis remained intact. On the glenoid side, surgeons had a choice of using additional bony increased offset RSA which could be symmetric or asymmetric, depending on the extent of necessary glenoid lateralization and/or bone defect compensation (Table 1). On the humeral side, surgeons had the choice of using inlay or onlay stems, each with different neck shaft angles and implanted with or without cement (Table 2).

Rehabilitation

Shoulders were immobilized using a sling, and passive ROM exercises were initiated on the first post-operative day. Depending on surgeon assessment, active ROM exercises started after 6 weeks, under supervision of physiotherapists.

Radiographic Assessment

All patients had preoperative radiographs, computed tomography arthrography (CTA), and/or magnetic resonance imaging (MRI) scans of their shoulders to confirm their

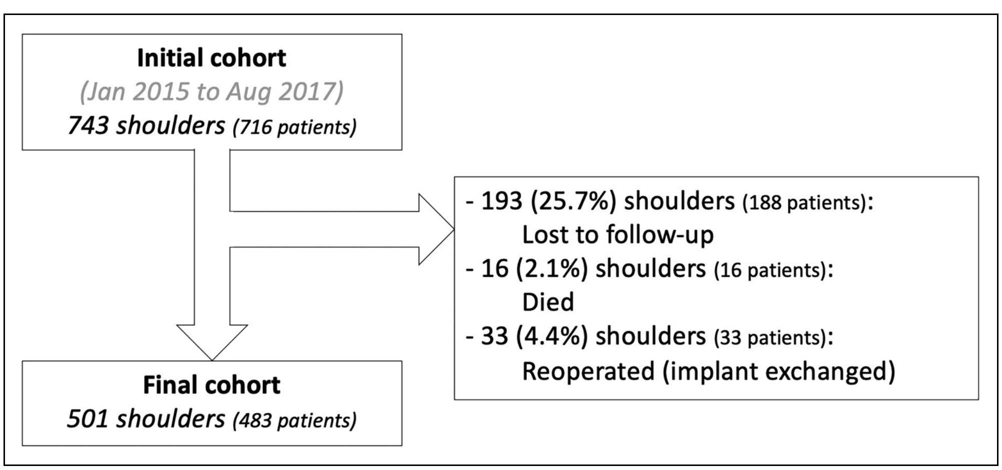

Figure 1. Flowchart of the study cohort.

Table 1. Demographics (2:1 Age, Sex And Diagnosis Matched Cohort).

	Deltopectoral (n = 172)		Anterosuperior (n = 88)		
	Mean ± SD	Range	Mean ± SD	Range	*P-value*
Age at index surgery (*years*)	72.6 ± 8.2	(51-91)	72.3 ± 8.8	(51-92)	
BMI (*kg/m²*)	27.3 ± 5.4	(17.9-49.5)	28.8 ± 6.0	(19.1-43.7)	
Women	102 (59%)		59	(67%)	*0.280*
Dominant arm	113 (66%)		55	(63%)	*0.681*
Aetiology					*0.989*
Primary OA without RCT	14 (8%)		7	(8%)	
Primary OA with RCT	22 (13%)		10	(11%)	
Secondary OA due to RCT	51 (30%)		28	(32%)	
Irreparable mRCT	85 (49%)		43	(49%)	
Profession					*0.556*
Active	20 (12%)		13	(15%)	
Retired	146 (85%)		73	(83%)	
Missing	6 (3%)		2	(2%)	
Activity level					*0.003*
Regular	49 (28%)		18	(20%)	
Occasional	39 (23%)		47	(53%)	
Sedentary	30 (17%)		23	(26%)	
Missing	54 (31%)		0	(0%)	
Fatty infiltration					
SSP - Functional muscle (0/1/2)	60 (35%)		31	(35%)	*0.565*
- Non-functional muscle (3/4)	73 (42%)		45	(51%)	
Missing	39 (23%)		12	(14%)	
ISP - Functional muscle (0/1/2)	65 (38%)		41	(47%)	*0.565*
- Non-functional muscle (3/4)	64 (37%)		34	(39%)	
missing	43 (25%)		13	(15%)	
SSC - Functional muscle (0/1/2)	96 (56%)		65	(74%)	*0.050*
- Non-functional muscle (3/4)	33 (19%)		10	(11%)	
missing	43 (25%)		13	(15%)	
TM - Functional muscle (0/1/2)	111 (65%)		74	(84%)	*0.002*
- Non-functional muscle (3/4)	18 (10%)		1	(1%)	
missing	43 (25%)		13	(15%)	

Abbreviations: SD, standard deviation; BMI, body mass index; OA, osteoarthritis; RC, rotator cuff; mRCT, massive rotator cuff tear; CTA, cuff tear arthropathy; SSP, supraspinatus; ISP, infraspinatus; SSC, subscapularis; RCT, rotator cuff tear.

aetiology. Primary OA was confirmed where glenohumeral joint narrowing was observed on radiographs, together with sclerotic osteophytes on the humeral head, and acromiohumeral distance >6 mm on radiographs, as defined by Neer et al.[9] Primary OA was further subdivided to distinguish shoulders with no rotator cuff lesions from those with any partial or complete rotator cuff lesions observed on MRI or CTA. Secondary OA was confirmed where glenohumeral joint narrowing was observed on radiographs, together with proximal humeral migration, due to large or massive rotator cuff lesions observed on MRI or CTA. Secondary OA includes cuff tear arthropathy, and shoulders with no humeral necrosis or subacromial impingement. Fatty infiltration of the supraspinatus, infraspinatus and subscapularis was graded using the classification of Goutallier et al,[10] and dichotomized as either functional (Goutallier classification 0, 1 or 2) or non-functional (Goutallier classification 3 or 4).[11]

Outcome Assessment

The authors recorded pre- and post-operative clinical outcomes (constant score (CS) and ROM (active forward elevation, external rotation with the elbow on the side (ER1) and internal rotation with the hand at the back (IR1)). Internal rotation was dichotomized as either functional (L3, T12, T7/T8) or non-functional (GT, buttock, sacrum). In addition, perioperative complications were recorded.

Statistical Analysis

A priori sample size calculation indicated that 60 patients per group were needed to determine a significance in minimal clinically important difference (MCID) in CS of 5.7 points between the groups,[12] assuming equal standard deviations of 9.4 points,[13] with a statistical power of

Table 2. Intraoperative data.

	Deltopectoral (n = 172)		Anterosuperior (n = 88)		
	N	(%)	N	(%)	*P*-value
Subscapularis management (*only for deltopectoral approach*)					
Left intact	9	(5%)			
Detached	163	(95%)			
Osteotomy	2	(1%)			
Peeling	21	(12%)			
Tenotomy	140	(81%)			
Repaired after detachment	157	(91%)			
Not repaired after detachment	6	(3%)			
BIO-RSA	111	(65%)	59	(67%)	*0.891*
Stem design					*0.016*
Inlay	52	(30%)	14	(16%)	
Onlay	120	(70%)	74	(84%)	
Stem fixation					*0.696*
Cemented	15	(9%)	9	(10%)	
Uncemented	155	(90%)	79	(90%)	
Hybrid	2	(1%)	0	(0%)	
Stem type					*0.886*
Short	120	(70%)	63	(72%)	
Long	51	(30%)	25	(28%)	

Abbreviations: BIO-RSA, bony increased offset reverse shoulder arthroplasty.

0.95. Continuous variables were summarized as means, standard deviations, and ranges, whereas categorical variables were summarized as numbers and proportions. Shapiro-Wilk tests were used to assess the normality of distributions. Differences between normally distributed groups were assessed using the student's t test, whereas differences between skewed groups were evaluated using the Wilcoxon rank sum test (Mann-Whitney U test). Differences in proportions of categorical variables were assessed using χ-squared tests. To enable comparison of outcomes between the DP and AS approaches, propensity scores were estimated for each patient using a logistic regression model, to obtain two similar groups in terms of age, sex, and preoperative indication. A 2:1 nearest neighbour algorithm with a caliper of 0.4 was applied to match patients using their corresponding propensity scores. Statistical analyses were performed using R version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria). A P-value <0.05 was considered statistically significant.

Results

Of the initial cohort of 743 shoulders, 193 (25.7%) were lost to follow-up, 16 (2.1%) died of causes unrelated to surgery, and 33 (4.4%) were revised with implant exchange (14 infection, 10 instability, 6 glenoid loosening, 2 fracture, and 1 for unknown reasons) (Figure 1).

Comparison of Revision Rates (Initial Cohort)

Of the initial cohort, 540 were operated using the DP approach (73%), of which 22 were revised with implant exchange (4.1%; 9 infection, 8 instability, 4 glenoid loosening, and 1 fracture), while 203 were operated using the AS approach (27%), of which 11 were revised with implant exchange (5.4%; 5 infection, 2 instability, 2 glenoid loosening, 1 fracture, 1 for unknown reasons).

Comparison of Complications and Scores (Matched Groups)

Propensity score matching resulted in the following two groups (Table 2): 172 shoulders operated by DP approach, and 88 shoulders operated by AS approach. For the DP approach, nine post-operative complications were noted (5.2%), six of which required reoperation without implant removal (3.5%), while for the AS approach, four complications were noted (4.5%), one of which required reoperation (1.1%) (Table 3). There were four peri-prosthestic fractures in the DP group (2.3%; 2 scapular, 2 humeral), and three in the AS group (3.4%; 3 humeral).

Comparing CSs of the matched groups at 2 or more years revealed that, the AS approach resulted in significantly lower post-operative scores ($67.3 \pm 14.0°$ vs 60.8 ± 18.3, $P = 0.017$) (Table 4). Comparing ROM of the matched groups at 2 or more years also revealed that, the AS approach resulted in significantly lower post-operative active forward elevation ($137° \pm 27.4°$ vs $129° \pm 29.8$; $P = 0.031$), but greater post-operative external rotation ($27° \pm 20.6°$ vs $39° \pm 20.9°$, $P < 0.001$). It is

Table 3. Post-operative complications treated conservatively or by reoperation without implant removal.

	Deltopectoral (n = 172)		Anterosuperior (n = 88)	
	N	(%)	N	(%)
Intraop humeral fracture	5	(2.9%)		
Intraop glenoid fracture	1	(0.6%)		
Dislocation				
Subluxation	1	(0.6%)		
Infection	1	(0.6%)		
Glenoid loosening	1	(0.6%)		
Humeral loosening				
Periprosthetic fracture	4	(2.3%)	3	(3.4%)
Neurologic	2	(1.2%)	1	(1.1%)

Table 4. Pre- and post-operative clinical and functional outcomes.

	Deltopectoral (n = 172)		Anterosuperior (n = 88)		
	Mean ± SD	Range	Mean ± SD	Range	*P-value*
Follow-up *(years)*	3.0 ± 0.9	(2.0–5.3)	3.7 ± 1.0	(1.9–5.5)	*<.001*
Constant Score *(0–100)*					
Preoperative total CS	26.8 ± 12.1	(4–65)	32.9 ± 12.7	(6–71)	*<.001*
Pain	4.8 ± 3.0	(0–15)	5.5 ± 4.0	(0–15)	*0.210*
Activity	6.3 ± 3.0	(0–15)	7.6 ± 3.4	(2–19)	*0.036*
Mobility	14.4 ± 7.8	(2–36)	15.9 ± 8.4	(4–36)	*0.350*
Strength	1.0 ± 1.9	(0–10)	2.2 ± 5.2	(0–21)	*0.570*
Post-operative total CS	67.3 ± 14.0	(21–95)	60.8 ± 18.3	(18–88)	*0.017*
Pain	13.6 ± 2.5	(5–15)	15.3 ± 3.6	(5–15)	*0.039*
Activity	16.9 ± 3.4	(4–20)	15.3 ± 4.2	(5–20)	*0.004*
Mobility	29.0 ± 7.3	(4–40)	27.3 ± 8.6	(2–40)	*0.220*
Strength	7.3 ± 4.7	(0–22)	5.9 ± 4.2	(0–18)	*0.030*
Net improvement total CS	40.3 ± 16.0	(−2–74)	30.4 ± 19.5	(−8–71)	*<.001*
Active forward elevation *(°)*					
Preoperative	83.3 ± 38.5	(0–180)	79.9 ± 39.8	(20–180)	*0.204*
Post-operative	136.6 ± 27.4	(20–180)	128.6 ± 29.8	(30–180)	*0.031*
Net improvement	53.2 ± 41.7	(−50–145)	53.3 ± 39.5	(−30–130)	*0.780*
External rotation *(°)*					
Preoperative	11.1 ± 20.2	(−30–90)	19.6 ± 16.8	(−40–60)	*<.001*
Post-operative	26.9 ± 20.6	(−40–90)	39.2 ± 20.9	(0–80)	*<.001*
Net improvement	15.6 ± 24.4	(−80–90)	18.0 ± 21.7	(−20–75)	*0.610*
Internal rotation					
Preoperative					*0.182*
Functional (L3, T12, T7/T8)	56 (33%)		30 (34%)		
Non-functional (Sacrum, GT, buttock)	114 (66%)		40 (45%)		
missing	2 (1%)		18 (20%)		
Post-operative					*0.493*
Functional (L3, T12, T7/T8)	108 (63%)		59 (67%)		
Non-functional (Sacrum, GT, buttock)	63 (37%)		28 (32%)		
missing	1 (1%)		1 (1%)		

Abbreviations: L, lumbar; T, thoracic; GT, greater trochanter; CS, constant score.

worth noting that preoperative external rotation was already significantly greater for shoulders operated by the AS approach ($P < 0.001$), and that there were no significant differences between the two approaches in terms of net improvement of either active forward elevation ($P = 0.780$) or external rotation ($P = 0.610$). There were no significant differences between the two approaches in terms of post-operative internal rotation ($P = 0.493$).

Discussion

The most important findings of the present study were that, at 2 or more years following RSA, the DP approach granted significantly better CSs (and greater net improvements thereof) and active forward elevation (but not greater net improvement thereof) compared to the AS approach. These findings partly refute the hypothesis, as there were statistically significant and clinically relevant differences in outcomes of the two surgical approaches: the DP could grant better postoperative CSs (by 6.5 points) and active forward elevation (by 8°).

RSA medializes the centre of rotation, to increase the lever arm of the deltoid muscle,[1] and thereby compensate for rotator cuff deficiency. Patients with better preoperative shoulder function may have less to gain from RSA compared to patients with compromised ROM and strength.[14] Several studies[4,6,7] found that the AS approach provides satisfactory outcomes, as it provides a straight exposure of the glenoid while preserving the subscapularis muscle, even though positioning the glenoid baseplate is more difficult.[6] On the other hand, Gadea et al[5] postulated that the DP approach is better at preserving the deltoid and at assessing humeral anatomy. As one of the drawbacks of the DP approach is the disinsertion of the subscapularis tendon, a new approach was introduced by Lädermann et al;[15] an anterior approach that spares both the subscapularis and the deltoid muscles.

In the present study, the AS approach granted significantly greater external rotation, but the net improvement between approaches was comparable, and the DP approach granted significantly greater active forward elevation and CSs, which exceeded the MCID of 5.7 points.[12] These findings are in disagreement with a recent systematic review that found no 'important differences' in clinical outcomes between shoulders operated by DP versus AS surgical approach.[8] This systematic review included only one article that reported CS at 2 years for shoulders operated by DP versus AS surgical approach, to treat mRCT or cuff tear arthropathy, but did not included primary OA, which could explain our contrasting findings.[16] The lack of evidence and conflicting findings warrant further research, to elucidate how surgical approach affects clinical and functional outcomes of RSA, in shoulders with different indications for surgery.

There is still limited information on the indications and factors that are associated with poor clinical outcomes following RSA. A study by Hartzler et al[17] found poor early functional outcomes of RSA for the treatment of massive RCTs, which could be due to the degeneration of the rotator cuff muscles that could lead to greater mechanical stress on the deltoid muscle, resulting in faster degradation of its function.[18] Furthermore, there is conflicting evidence in the literature on factors that affect outcomes of RSA such as age, sex, and BMI.[19,20] Favard et al[21] found that older patients scored worse in absolute CS compared to their younger counterparts. The reasons are not yet fully understood, but are likely to be associated with the strength and ROM subcomponents of the CS, suggesting a possible impairment of muscle strength, which may also be due to the approach used. Furthermore, this study has several limitations that must be considered when interpreting the findings. First, in this large multicenter cohort, the data was collected retrospectively, and there are some significant differences in the baselines characteristics of patients operated by the different surgical approaches (eg, inlay or onlay stem). Second, 25.7% of patients were lost to follow-up, and it is therefore likely that some patients with complications or poor outcomes were not represented; however, it is important to note that the outcomes of the present study were collected between 2020 and 2021, during which clinical assessment was difficult due to the COVID pandemic. Third, intraoperative management of the subscapularis was inconsistent among patients operated by the DP approach, and depended on surgeon preference. Fourth, the authors did not perform logistic regressions to identify risk factors for complications and revisions, as the numbers were too small.

Conclusion

At 2 or more years following RSA, the DP approach granted significantly better CSs (by 6.5 points) and active forward elevation (by 8°) compared to the AS approach. The differences observed are clinically relevant and must be considered to manage patient expectations following RSA and for selecting surgical approach depending on their functional needs.

Authors' Contributions

CN, conceptualization, project administration, data collection, interpretation of findings, and writing; JB, conceptualization, data collection, interpretation of findings, and writing; JG, conceptualization, data collection, interpretation of findings, and writing; LH, conceptualization, data collection, interpretation of findings, and writing; PM, conceptualization, data collection, interpretation of findings, and writing; DG, conceptualization, data collection, interpretation of findings, and writing; JK, conceptualization, data collection, interpretation of findings, and writing; ReSurg, project administration, data analysis, statistics, interpretation of findings, and writing; SoFEC, conceptualization, interpretation of findings, and writing; AG, conceptualization, project administration, interpretation of findings, and writing.

Declaration of Conflicting Interests

CN and LH report fees from DePuy Synthes outside of the submitted work. JK reports personal fees and other from VIMS. JB and FS report consulting for Wright Medical outside the submitted work. JGa and AG report fees from Tornier SAS outside of the submitted work. JGu reports fees from moveUP outside of the submitted work. DG reports consulting and royalties from moveUP outside the submitted work. LNJ reports consulting and royalties from 3S Ortho. FVR, AH, LN, MS, PM, LP, RA report no conflicts of interest.

Ethics Approval and Consent to Participate

Informed consent was obtained from all individual participants included in the study. The study was approved in advance by the institutional review board (IRB COS-RGDS-2022-11-006-GODENECHE-A).

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