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Absence of scapular notching in lateralized reverse shoulder arthroplasty: a mid-term clinical and radiological evaluation

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Background: Lateralized reverse shoulder arthroplasty (LRSA) has been conceived to improve clinical and functional outcomes and reduce complication rates and scapular notching in comparison with medialized implant. The purpose of this study was to evaluate the mid-term clinical and radiological outcomes, the survival rate, and the health-related quality of life in a prospective series of patients who underwent LRSA and to identify the possible predictors of clinical outcomes.

Methods: We conducted a retrospective study on prospectively collected data of 29 patients who underwent LRSA. Thirteen (45%) patients suffered from primary osteoarthritis (OA), 12 (41%) patients suffered from cuff tear arthropathy, and 4 (14%) patients suffered from secondary OA due to fracture sequelae. Each patient was evaluated preoperatively and at follow-up by radiological and computed tomography and by assessing the range of motion, the Constant–Murley Score, and the short form 12.

Results: After a mean follow-up of 52.3 ± 17.4 (range, 24-101) months, a statistically significant recovery of the forward flexion, abduction, and external rotation range of motion as well as the Constant–Murley Score and short form 12 physical component values was reported. Higher postoperative functional outcomes were noted in patients suffering from primary OA in comparison with patients suffering from cuff tear arthropathy or secondary OA. No cases of scapular notching (0%) and just one case (3.4%) of grade 1 heterotopic ossification were observed.

Conclusions: Satisfactory clinical and radiological outcomes of LRSA can be expected after a mean 52.3-month follow-up, with no cases of scapular notching and exceptionally low rates of radiological complications.

The role of reverse shoulder arthroplasty (RSA) is nowadays well-established due to the expansion of indications and the evolution of implants. Since the first design of a semiconstrained RSA by Paul Grammont in 1985, advances in tribology, biomechanical features, and component fixation modalities have been accomplished to improve expected outcomes, with satisfactory clinical and radiological results, excellent postoperative quality of life, and acceptable complication rates having been demonstrated up to long-term evaluations.[2,8]

Implant geometry is progressively gaining momentum as a main field of interest in the setting of RSA designs and research.[16] Due to its initial indication for the treatment of massive rotator cuff tears with cuff tear arthropathy (CTA), RSA has been originally conceived to medialize and distalize the center of rotation (COR) of the glenohumeral joint by medializing the glenoid and the humerus with a 155° neck-shaft angle, thus increasing the deltoid lever arm and achieving to start active forward flexion and abduction even without a valid rotator cuff.[27] However, concerns appeared when expanding RSA indications, as the COR medialization may lead to a slackening of an intact rotator cuff, thus negatively affecting range of motion (ROM) and strength and posing a higher risk of instability.[20] Moreover, despite medialized RSA's additional aim was to position the COR to at the implant-bone interface to reduce shear

Ethical approval for this study was obtained from Magna Graecia University (ID: 0045/2002).

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forces on the glenoid implant, high rates of glenoid loosening and scapular notching have been observed.[7,13]

Lateralized RSA (LRSA) has been conceived to overcome the biomechanical deficiencies above. COR lateralization increases the distance from the bone-implant interface, leading to a higher moment of force and risk of earlier loosening of the implant[7,20]; however, the index implant design improves shoulder stability via a high compressive force due to both the deltoid and remaining cuff tension and decreases the risk of notching. A systematic review and meta-analysis showed that LRSA achieved better clinical and functional outcomes together with a drastic reduction in complication rates and scapular notching in comparison with medialized implant.[5]

The purpose of this study was to evaluate the mid-term clinical and radiological outcomes, the survival rate, and the health-related quality of life in a prospective series of patients who underwent LRSA and to identify the possible predictors of clinical outcomes.

Methods

Study population and demographics

An observational retrospective study on prospectively collected data was conducted on 46 patients (46 shoulders) who underwent LRSA from January 2015 to December 2021. The study protocol was approved by the local ethical committee and performed in compliance with the Helsinki Declaration. Informed consent was obtained from all participants included in the study.

The inclusion criteria were as follows: (1) patients who were older than 18 years of age at the time of the operation, (2) patients who underwent primary LRSA, and (3) a minimum 24-month follow-up. The exclusion criteria were as follows: (1) rheumatoid arthritis, (2) tumors, (3) acute proximal humeral fracture, (4) a history of alcohol or other substance abuse, (5) significant cognitive impairment, and (6) failure to understand or complete the questionnaires.

The data gathered included the patient's age at operation, sex, and diagnosis of the affected shoulder.

Operative technique and postoperative protocol

In this study cohort, an Equinoxe Reverse System (Exactech, Gainesville, FL, USA) was used in all patients. The implant's glenoid baseplate design has a built-in offset that distally shifts the glenosphere to a position that prevents humeral liner impingement on the inferior glenoid[19,21,27] and a humeral onlay stem with a 132.5° neck-shaft angle.[27] All surgical procedures were performed by one trained experienced shoulder surgeon (O.G) by using a deltoid-pectoral approach. Patients were operated on under general anesthesia with an interscalene nerve block in the beach-chair position. The glenoid baseplate was fixed into position with two 4.5-mm locking screws and a 38 or 42-mm standard glenosphere was used. The subscapularis was not repaired in any cases.

A surgical drain was used and removed one day after surgery. The patients used a 15°-to-30° abduction shoulder brace for 3 weeks postoperatively[6]; at discharge, passive-assisted and active-assisted ROM exercises were initiated, progressively allowing patients to return to daily living activities; exercises to strengthen the shoulder were permitted 2 months after surgery.

Clinical assessment

Preoperatively and at the last follow-up, each patient was evaluated using a standardized examination of the shoulder ROM, the Constant-Murley Score (CMS), and short form 12 (SF-12) mental (MCS) and physical (PCS) component summary scores.

A standardized examination of the shoulder was conducted with the patient's best effort at active direct forward flexion, abduction, and external and internal rotation.[4] In detail, patients performed flexion and abduction while standing and actively moving each outstretched arm simultaneously. External rotation was performed while patients were seated with the elbows at their sides in adduction, and internal rotation was evaluated based on a number corresponding to the maximum vertebral level actively reached.

The preoperative and last follow-up CMS were recorded for all the patients, and as in the previous study, a digital dynamometer (Myometer 500 N; Atlantech Medical Devices, Nottingham, UK) was used for power measurements. An absolute CMS < 30 or a CMS for pain <10 at the final follow-up were considered poor clinical results.[10]

Changes with surgery were compared to the minimum clinically important difference (MCID). For reference values of MCID, previously published data for each outcome were used: forward flexion MCID = 12°,[17,23] abduction MCID = 7°,[17,23] external rotation MCID = 3°,[17,23] and CMS MCID = 5.7 points.[17,22]

Patient satisfaction was noted, and patients were asked if they would undergo the same type of surgery again.

Radiological evaluation

A radiologic assessment was performed preoperatively and at the last follow-up. The radiological evaluation was based on an axillary radiograph, true anteroposterior views of the glenohumeral joint (ie, a 40° posterior oblique radiograph with external rotation of the humerus and a 40° posterior oblique radiograph with internal rotation of the humerus), and a scapular lateral view of the shoulder. Two trained authors (V.S and P.M) who were unaware of the patients' clinical features reviewed radiological studies. The preoperative radiographs were graded as previously described by Hamada[16] et al. Preoperative evaluation also included a magnetic resonance imaging assessment and computed tomography assessment of bone stock for proper planning.[11] On radiograms performed at follow-up, evidence of humeral radiolucencies was evaluated with the system described by Gruen et al,[9] as adapted to the shoulder.[3] Humeral loosening was defined as a radiolucent line of 2 mm or greater in 3 or more contiguous zones. Radiolucencies around the glenoid component were evaluated according to Melis et al[14]; glenoid loosening was considered to be present when 2-mm lucent lines or a shift in position between immediate postoperative and follow-up radiograms was noted or when the component was displaced. Heterotopic ossifications were evaluated according to the Brooker classification system as adapted to the shoulder.[26] Scapular notching was also assessed according to the criteria of Sirveaux et al.[24]

Statistical analysis

The normal distribution was determined by the Shapiro–Wilk test. Based on this preliminary analysis, parametric tests were adopted. The mean and standard deviation were reported for continuous variables, median and range were reported for discrete variables, and counts and percents were reported for categorical variables. The Student t-test and analysis of variance with least significant difference post-hoc analysis were used to evaluate the significance of differences between and among variables, respectively. Univariate linear regressions were performed on the whole population to test possible outcome predictors. Explanatory variables included in the analysis were the patients' age at surgery and the length of follow-up, while the postoperative ROM, CMS domains, and SF-12 domains were treated as outcomes of the variables. Survival curves were established with the Kaplan–Meier method. The occurrence of a poor clinical result, as explained above, was considered a failure. For the survival analysis, patients without failure were censored on the date of the competing endpoint or study end date, whichever occurred first.

To calculate the post-hoc power (1-β error probability and 2-tailed) achieved by the statistical tests, we considered the sample size, the observed effect size, and the α value of 0.05. A post-hoc power >80% was considered adequate to fully accept the results. SPSS Statistics 21.0.0.1 software (IBM Corp., Armonk, NY, USA) and G*Power 3.1 software (Institut für Experimentelle Psychologie, Heinrich Heine Universität, Düsseldorf, Germany) were used for database construction and statistical analysis. A P value < .05 was considered significant.

Results

Out of the initial cohort of 46 patients, 12 (26%) patients were lost to follow-up and 5 (11%) patients died of causes unrelated to the procedure, leaving 29 (63%) patients available for the study. There were 18 (62%) female patients and 11 (38%) male patients, averaging 71.8 ± 5.9 (range, 54-81) years at surgery. Thirteen (45%) patients suffered from primary osteoarthritis (OA), 12 (41%) patients suffered from CTA, and 4 (14%) patients suffered from secondary OA due to fracture sequelae. According to the Hamada[16] classification, 10 (34.5%) patients were stratified as grade 2, 7 (24.1%) patients as grade 3, 10 (34.5%) patients as grade 4, and 2 (6.9%) patients as grade 5. In all but two cases, a cementless stem was adopted: the cemented humeral stems were used in a 73-year-old female and in a 77-year-old male suffering from severe osteoporosis. The mean follow-up was 52.3 ± 17.4 (range, 24-101) months.

As reported in Table I, ROM significantly improved with surgery in all domains but internal rotation (100% power for all observations). Improvements were beyond the MCID in 23 (79%) cases for forward flexion, in 25 (86%) cases for abduction, and in 21 (72%) cases for external rotation. While the PCS domain significantly improved from 34 ± 7.4 preoperatively to 40.6 ± 9.2 postoperatively, no significant improvements with surgery were noted for MCS domain (100% power for both).

The CMS significantly improved from 32.6 ± 13.7 preoperatively to 57.2 ± 18.3 postoperatively (100% power), thus reaching an improvement beyond the MCID in 25 (86.2%) cases. A poor clinical result due to postoperative CMS < 30 or a CMS pain < 10 was noted in 8 (27.6%) patients. With these values considered an endpoint, survivorship was 96.3% at 2 years, 81.9% at 4 years, and 24.3% at 8 years (Fig. 1).

A subgroup analysis of patients was performed to test the influence of the diagnosis on postoperative outcomes. Preoperatively, the 3 groups of patients did not differ in their baseline demographic and clinical values. As reported in Table II, overall higher postoperative ROM, CMS, and SF-12 values in patients suffering from primary OA were detected via a statistical significance or a trend toward a statistical significance in the majority of analysis of variance assessments. Detailed least significant difference post-hoc analyses revealed that patients suffering from primary OA had higher active forward flexion (P = .017), abduction (P = .017), external rotation (P = .021), pain CMS domain (P = .044), ROM CMS domain (P = .031), and postoperative CMS (P = .024) compared to those who underwent RSA for secondary OA.

As reported in Table III, univariate regression analyses revealed that the patients' age at surgery does not behave as a predictor of postoperative ROM and SF-12; considering the CMS domains, lower CMS strength values were associated with higher age at surgery (P = .007). The length of follow-up does not behave as a predictor of postoperative ROM, CMS, and MCS SF-12 domain; lower PCS SF-12 values were associated with longer follow-up (P = .044).

The postoperative radiological complications evaluation revealed one case (3.4%) of glenoid loosening, with baseplate mobilization requiring revision surgery, one case (3.4%) of glenoid radiolucency of less than 2 mm below the baseplate, one case (3.4%) of humeral radiolucency of less than 2 mm located in zone 1, and one case (3.4%) of heterotopic ossification classified as grade 1. None of the patients showed medialization of the glenosphere or mobilization of the stem. No cases of scapular notching were observed.

Table I
Differences in range of motion, Constant–Murley Score, and physical and mental short form 12 between pre- and postoperative values.

	Preoperative mean ± SD*	Postoperative mean ± SD*	P value
Range of motion			
Flexion	84° ± 34.2	136° ± 40.2	***<.001***
Abduction	71° ± 34.5	116° ± 40.3	***<.001***
External rotation	17° ± 16.1	31° ± 16.3	***.007***
Internal rotation*	Buttock (Thigh-T12)	Sacroiliac joint (Thigh-T7)	.124
Constant–Murley Score			
Pain	5.9 ± 5.1	11 ± 4.7	***<.001***
ROM	13.2 ± 7.2	24.8 ± 10.4	***<.001***
ADL	7.4 ± 3.4	15.3 ± 5.5	***<.001***
Strength	5.5 ± 4.8	6 ± 5.5	.613
Total	32.6 ± 13.7	57.2 ± 18.3	***<.001***
Short form 12			
PCS	34 ± 7.4	40.6 ± 9.2	***.002***
MCS	41.9 ± 11.4	45.6 ± 9.4	.159

ROM, range of motion; *ADL*, activity of daily living; *PCS*, physical component summary score; *MCS*, mental component summary score; *LRSA*, lateralized reverse shoulder arthroplasty; *SD*, standard deviation.
Bold-italic indicates a statistical significance.
*As a discrete variable, internal rotation has been reported as median (range).

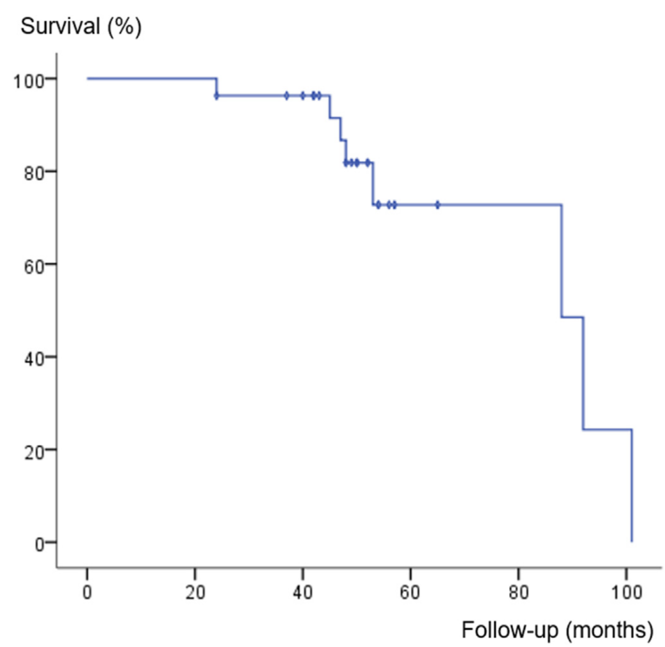

Figure 1 Kaplan–Meier curves of LRSA survival rate in whole population. *LRSA*, lateralized reverse shoulder arthroplasty.

Table II
Differences in postoperative ROM, Constant–Murley Score, and physical and mental short form 12 among diagnoses at the index procedure.

	Primary osteoarthritis mean ± SD*	Cuff tear arthropathy mean ± SD*	Secondary osteoarthritis mean ± SD*	P value†
ROM				
Flexion	153° ± 21.5	133° ± 48.5	96° ± 28.7	*.053*
Abduction	135° ± 27	107° ± 45.7	79° ± 33.3	***.041***
External rotation	36° ± 14.6	30° ± 16	15° ± 5.8	*.066*
Internal rotation*	L3 (Thigh-T7)	Sacroiliac joint (Thigh-T12)	Buttock (Thigh-Sacroiliac joint)	.430
Constant–Murley Score				
Pain	12.1 ± 3.3	11.6 ± 5.2	5.5 ± 3.3	***.036***
ROM	29.1 ± 7.1	23.8 ± 11.8	16 ± 9.5	*.086*
ADL	18.3 ± 3.6	13.7 ± 6.0	12 ± 5.5	*.050*
Strength	3.8 ± 1.7	8.2 ± 7.4	5.6 ± 4	.171
Total	63.5 ± 12.7	57.4 ± 20.2	39.3 ± 17.9	*.073*
Short form 12				
PCS	42.1 ± 8.9	43.0 ± 8.2	29.4 ± 5.0	***.022***
MCS	42.4 ± 10.5	47.8 ± 6.8	48.0 ± 9.4	.355

ROM, range of motion; *ADL*, activity of daily living; *PCS*, physical component summary score; *MCS*, mental component summary score; *SD*, standard deviation.
Bold-italic indicates a statistical significance.
*As a discrete variable, internal rotation has been reported as median (range).
†Italic indicates a trend towards a statistical significance (*P* values of less than 0.1).

Table III
Linear univariate regressions on the effect of patients' age at surgery and length of follow-up on clinical outcomes.

	Age at surgery		Follow-up	
Range of motion				
Flexion	β = 0.008	*P* = .970	β = −0.103	*P* = .610
Abduction	β = 0.066	*P* = .745	β = −0.195	*P* = .329
External rotation	β = −0.158	*P* = .431	β = −0.136	*P* = .497
Internal rotation	β = −0.083	*P* = .681	β = 0.011	*P* = .958
Constant–Murley Score				
Pain	β = 0.074	*P* = .713	β = −0.350	*P* = .073
ROM	β = −0.071	*P* = .723	β = −0.142	*P* = .481
ADL	β = 0.063	*P* = .756	β = 0.040	*P* = .842
Strength	β = −0.503	***P* = *.007***	β = −0.010	*P* = .960
Total	β = −0.156	*P* = .438	β = −0.162	*P* = .420
Short form 12				
PCS	β = −0.180	*P* = .369	β = −0.391	***P* = *.044***
MCS	β = −0.178	*P* = .373	β = 0.076	*P* = .707

ROM, range of motion; *ADL*, activity of daily living; *PCS*, physical component summary score; *MCS*, mental component summary score.
Bold-italic indicates a statistical significance.

Twenty-five (86.2%) patients were satisfied and declared that they would have undergone the same operation again.

Discussion

In the present study, the overall clinical and radiological outcomes of LRSA were successful after a mean 52.3-month follow-up, and 86.2% of patients were satisfied with surgery. A statistically significant recovery of the forward flexion, abduction, and external rotation ROM, as well as the CMS and PCS SF-12 values, was reported. Higher postoperative functional outcomes were noted in patients suffering from primary OA in comparison with patients suffering from CTA or secondary OA. No cases of scapular notching and just one case of grade 1 heterotopic ossification were observed.

Lateralized designs of RSA have been introduced to decrease the rate of radiological complications in comparison with Grammont-style implant. Accordingly, the systematic review and meta-analysis by Cho et al[5] demonstrated that LRSA leads to a 2.5-fold decrease of scapular notching and a 2-fold decrease of heterotopic ossifications. Therefore, on the basis of our previously published mid-term results of medialized RSAs[3] reporting a 71% rate of scapular notching and a 47% rate of heterotopic ossifications, an average 28% rate of scapular notching and an average 24% of heterotopic ossifications should have been expected in the current series of lateralized implants. As a main finding of this study, no cases of scapular notching (0%) and just one case (3.4%) of grade 1 heterotopic ossification were observed after a mean 52.3-month follow-up; such extremely low rates are even lower than expected. Caution should be exercised when interpreting these data: indeed, despite the majority of radiological complications and notching having irrelevant clinical impact as suggested by Spiry et al,[25] our previous study comparing results at a mean of 5 years and 12 years after RSA assessed that the length of follow-up was a positive predictor of both scapular notching rate and grading.[2,3] In this light, a long-term follow-up might show higher rates of radiological complications. However, such distinctive feature, together with a significant increase in both life expectations and high demand elder individuals, leads us to believe that a proper and to-point discussion with the patient on the expected complications is mandatory.[15]

The impact of COR lateralization on clinical outcomes following RSA has been widely explored. Cho et al[5] found that LRSA had slightly superior American Shoulder and Elbow Surgeons score and CMS compared to Grammont-style implants; postoperative ROM, as measured by forward flexion and external rotation, did not differ between the groups, while external rotation improvement with surgery was significant higher in lateralized designs. Accordingly, Hao et al[12] demonstrated that LRSA achieved greater postoperative external rotation and its gain rate with surgery in comparison with medialized RSA. In the current series, we found mean postoperative CMS of 57.2 points, forward flexion of 136°, abduction of 116°, and external rotation of 31°. Surprisingly, these values appear to be lower than those we found in our previous series of medialized RSA at both mid-[3] and long-term.[2] We can recognize the difference in the initial diagnoses as a bias that impedes the proper comparison of results. Indeed, our previous series on medialized RSA included patients suffering from primary OA, CTA, and even patients suffering from massive rotator cuff tears without CTA. It should be considered that the least diagnosis allows to achieve optimal postoperative clinical results in terms of ROM, American Shoulder and Elbow Surgeons, and CMS, as recently suggested.[1] In the current series on lateralized RSAs, we did not include patients without OA, and we included patients suffering from secondary OA due to fracture sequelae. Our results may therefore be justified by the subgroup analysis we performed, revealing that patients suffering from secondary OA exhibited the lower CMS and ROM among groups. We may argue that both the chronic onset of the disease and the presence of anatomical, biomechanical, and functional impairments due to fracture sequelae might have affected the results.

A certain limitation of the present study is the small cohort of patients who were assessed, representing 63% of the initial patients. This might alter the generalizability of our results. Given the retrospective nature of the design of this study and the lack of a control group, potential bias cannot be excluded, but post-hoc power analysis supported the present results. While the evaluation of a single-surgeon cohort of procedures has certain benefits due both the standardized procedures and the homogeneity of patients' evaluation, intrinsic biases due to the lack of comparison among different techniques, learning curves, and setting have to be considered. The prospective nature of the data collection methods, the use of validated and standardized functional and radiological assessments, and either sample size or follow-up, comparable with the largest and longest series available on LRSA,[18] represent considerable strengths of the present study.

Conclusions

Clinical and radiological outcomes of LRSA were successful after a mean 52.3-month follow-up, with no cases of scapular notching and exceptionally low rates of radiological complications. Higher postoperative functional outcomes were noted in patients suffering from primary OA in comparison with patients suffering from CTA or secondary OA. Future studies with larger sample sizes and longer follow-up may help confirm the results of the present study.

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