Correlation Between Implant Positioning and Functional Outcomes in Partial Shoulder Resurfacing

Correlação entre posicionamento do implante das artroplastias parciais de recobrimento do ombro e os resultados funcionais

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Abstract

Objective The present study aimed to correlate functional outcomes and implant positioning in a case series of partial shoulder resurfacing arthroplasties.

Methods A total of 25 patients were assessed for range of motion, functional outcome per the University of California at Los Angeles (UCLA) score and radiographic findings. Pre- and postoperative data were compared. In addition, patients were grouped according to the cervical-diaphyseal angle (CDA) determined by an anteroposterior radiography and to the retroversion angle (RVA) determined by an axillary radiography. A CDA from 130° to 140° and a RVA from 20° to 40° consisted in ideal positioning (anatomical standard). Data were analyzed using the Wilcoxon signed-rank test, analysis of variance (ANOVA) followed by the Kruskal-Wallis test or the Mann-Whitney test as appropriate.

Results The mean follow-up time was 48.3 months (12 to 67 months). The postoperative functional score (31.5) was higher than the preoperative score (15.5) (p < 0.001). In 6 patients, the implant was in anatomical positioning, while implant positioning was considered “nonstandard” in 19 subjects. Seven patients had a CDA < 130°, and 14 patients had a CDA ranging from 130° to 140°; in addition, the CDA was > 140° in 4 subjects. The RVA was up to 20° in 15 patients and ranged from 20° to 40° in 10.

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Keywords
- arthroplasty,
- replacement,
- shoulder joint
- shoulder prosthesis
- prosthesis design

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Introduction

The general goal of shoulder arthroplasty is to restore joint mechanics and function. This is achieved through proper balance of soft parts, correct implant selection, and restoration of joint anatomical parameters. Partial shoulder resurfacing arthroplasties show functional outcomes equivalent to those obtained with conventional hemiarthroplasties, with the advantage of preserving bone stock, reducing fracture risk, and causing less surgical trauma, resulting in better postoperative recovery and less pain. In addition, it provides accurate anatomy reestablishment and corrects humeral articular surface offset, retroversion and inclination, improving the lever arm of the deltoid muscle and rotator cuff. However, data from the largest registry of shoulder arthroplasties reveal that partial resurfacing procedures account for only 3% of the total number of shoulder replacements, in contrast to 9.5% for conventional hemiarthroplasties. The present study aimed to correlate the functional outcomes of partial shoulder resurfacing arthroplasties with radiographic positioning of the implants.

Material and Methods

Study Type and Patient Selection Criteria

This was a retrospective analysis of a case series of patients submitted to partial shoulder resurfacing arthroplasty from...
January 2008 to December 2012 at a tertiary hospital from the Brazilian Unified Health System (SUS, in the Portuguese acronym). All 25 patients identified at the institutional Arthroplasty Registry were included in the study. The exclusion criteria were patients who underwent a resurfacing arthroplasty associated with a procedure for glenoid treatment, shoulder arthroplasty using a humeral component with nails, and those who did not agree to voluntary participation in the research. The present study was approved by the institutional Research Ethics Committee under CAAE number 26207914.0.0000.5273.

Surgical Technique
All patients were submitted to the same surgical technique, consisting of a deltopectoral approach, subscapular tenotomy for joint exposure and its trans-osseous reattachment at the end of the procedure. All cases received a Global CAP prosthesis (DePuy, Warsaw, Indiana, USA) (►Figure 1). Rehabilitation was performed according to the institutional protocol. A sling was used for 6 weeks after surgery to protect the subscapular suture.

Data Collection
Preoperative data were collected from the institutional Arthroplasty Registry database. Patients were invited to attend our Clinical Research Center to answer a questionnaire and perform a late postoperative clinical evaluation and a radiological test.

Clinical-Functional Assessment
The clinical-functional evaluation was based on the University of California at Los Angeles (UCLA) score and active range of motion (ROM) determination with a goniometer according to the American Academy of Orthopaedic Surgeons (AAOS) criteria. Medial rotation was measured by vertebral segments and was scored as described by Friedman et al. Therefore, patients able to reach the hip were scored as 1; buttocks, 2; sacrum, 3; L5 to L4, 4; L3 to L1, 5; T12 to T8, 6; and T7 or higher, 7. Radiographic evaluation was carried out using anteroposterior (AP), lateral scapular, and axillary views. The cervical-diaphyseal angle (CDA) was measured on AP radiographies, whereas the retroversion angle (RVA) was determined in axillary position as proposed by Rydholm et al. (►Figure 2). Measurements were made using the image viewing software mDicon Viewer version 3.0.0 (MicroData, MV Informática Nordeste, PE, Brazil), which allows drawing lines and calculating angles.

Group Stratification
To correlate implant positioning with clinical-functional outcomes, the patients were divided into two groups according to the angles measured by radiographs. Subjects with a CDA ranging from 130° to 140° and with a RVA ranging from 20° to 40° were considered within the “anatomical standard”, while those outside this range were deemed “nonstandard.” The clinical-functional evaluation was performed based only on the CDA. The patients were divided into three groups: with a CDA < 130°, CDA ranging from 130° to 140°, and CDA > 140°.

Statistical Analysis
Data were organized in a Microsoft Office Excel 2007 (Microsoft Corp., Redmond, WA, USA) electronic spreadsheet, and the statistical analysis was performed using GraphPad Prism software version 8.2.1 for macOS (GraphPad Software, San Diego, CA, USA). Data were analyzed using the Wilcoxon test.
signed-rank test for pre- and postoperative comparison. Mean values were compared between two groups using the Mann-Whitney test and between three groups using the Kruskal-Wallis test. A p-value < 0.05 was considered statistically significant.

Results

The mean follow-up time was of 48.3 months (from 12 to 67 months). Table 1 lists demographic data and primary diagnoses. The average time from the onset of symptoms to the surgical procedure was 6 years, 9 months (ranging from 6 months to 20 years). Revision surgery was performed in 8 out of 25 patients (32% of the cases), with an average follow-up time of 48 months. There was 1 case of subscapularis tendon rupture 4 months after surgery. The patient underwent surgical treatment with transosseous tendon reattachment and was kept in the study.

Functional assessment was significantly better at the postoperative than at the preoperative period (Figure 3). The median UCLA score increased from 15.5 at the preoperative period (range: 4 to 27) to 31.5 (range: 14 to 35) at the postoperative period (p < 0.001). The median (minimum–maximum) anterior flexion angle increased from 100° (20° to 180°) to 140° (90° to 180°) (p = 0.0004). Lateral rotation increased from 40° (−30° to 70°) to 50° (0° to 80°) (p = 0.009), whereas the medial rotation score increased from 5 (2 to 6) to 6 (4 to 7) (p = 0.0007).

Six patients presented the implant in anatomical position, with the CDA and RVA within the “anatomical standard;” the remaining 19 subjects presented “nonstandard” CDA and/or RVA. Applying this criterion to group patients, postoperative clinical-functional outcomes were not statistically different (p > 0.05 in all parameters) between subjects with standard or nonstandard values. In these groups, median values

| Parameter | Number of patients |
|-----------|--------------------|
| Age (years old) | 46.2 (14.67) |
| mean (standard deviation) | 46 (18–78) |
| Gender | |
| male | 14 (56%) |
| female | 11 (44%) |
| Affected side | |
| right | 15 (60%) |
| left | 10 (40%) |
| Primary diagnosis | |
| osteoarthrosis | 13 |
| osteonecrosis | 6 |
| trauma sequela | 3 |
| tumor | 3 |

**Fig. 3** Pre- and postoperative clinical-functional assessment of patients submitted to partial shoulder resurfacing arthroplasty from January 2008 to December 2012. (A) University of California at Los Angeles (UCLA) clinical score. (B) Anterior flexion angle. (C) Lateral rotation angle. (D) Medial rotation score. A p-value < 0.05 represents a statistically significant difference between groups. Wilcoxon signed-rank test.
(minimum–maximum) were, respectively, 27 (14 to 35) and 33 (20 to 35) for the UCLA score; 135° (90° to 180°) and 150° (90° to 180°) for anterior flexion angle; 32.5° (0° to 60°) and 50° (0° to 80°) for lateral rotation angle; and 6 (2 to 7) and 6 (4 to 7) for the medial rotation score (► Figure 4).

The patients were grouped according to the CDA to determine whether this parameter could predict functional improvement. The CDA was <130° in 7 patients, ranged from 130° to 140° in 14 subjects, and was >140° in 4 patients. The functional evaluation using CDA alone as a parameter for patient stratification revealed no statistically significant difference between groups (p < 0.05). In these groups, the median values (minimum–maximum) were, respectively, 29.5 (20 to 35) versus 30 (14 to 35) for the UCLA score; 140 (90 to 180) versus 150 (90 to 180) for anterior flexion angle; 50 (15 to 70) versus 60 (10 to 80) for lateral rotation angle; and 6 (2 to 7) versus 6 (4 to 7) for the medial rotation score (► Figure 5).

Likewise, when patients were grouped according to the RVA alone, postoperative clinical-functional outcomes were not significantly different (p > 0.05) when the RVA was ≤20° or ranged from 20° to 40°. The RVA was ≤20° in 15 patients, and ranged from 20° to 40° in 10 subjects, within the ideal anatomical standard. In these groups, the median values (minimum–maximum) were, respectively, 33 (20 to 35) and 30 (14 to 35) for the UCLA score; 150 (90 to 180) and 135 (90 to 160) for anterior flexion angle; 50 (0 to 80) and 35 (0 to 70) for lateral rotation angle; and 6 (4 to 7) and 5.5 (2 to 6) for the medial rotation score (► Figure 6).

**Discussion**

Resurfacing arthroplasties are indicated for patients with degenerative or inflammatory diseases of the shoulder. Like stem-based prostheses, resurfacing procedures allow surgeons to manage version and inclination, humeral head thickness and offset5,12,13 with the advantage of being a simpler, less invasive technique14 that provides greater bone stock preservation and presents a lower incidence of complications, such as periprosthetic humeral fractures.15 However, the main cause of arthroplasty failure is related to the implant technique and positioning.16 It is extremely difficult to determine the optimal component position during surgery due to the struggle in achieving adequate joint exposure and to the geometric deformity of the humeral head articular surface.13,17,18

Normal shoulder anatomy presents great variability, which hinders reproducibility in surface prosthesis positioning.13 These changes in individual anatomy can affect joint biomechanics after surgery, interfering with its function. Inaccurate dimensioning or positioning of a
Fig. 5  Postoperative clinical-functional evaluation of patients submitted to partial shoulder resurfacing arthroplasty grouped according to the cervical-diaphyseal angle. (A) University of California at Los Angeles (UCLA) clinical score. (B) Anterior flexion angle. (C) Lateral rotation angle. (D) Medial rotation score. A p-value > 0.05 represents statistical equality between groups. Analysis of variance (ANOVA) followed by the Kruskal-Wallis test.

Fig. 6  Postoperative clinical-functional evaluation of patients submitted to partial shoulder resurfacing arthroplasty grouped according to retroversion angle. (A) University of California at Los Angeles (UCLA) clinical score. (B) Anterior flexion angle. (C) Lateral rotation angle. (D) Medial rotation score. A p-value > 0.05 represents statistical equality between groups. Mann-Whitney test.
humeral head resurfacing prosthesis can result in altered joint version and inclination.\textsuperscript{19,20} Therefore, we evaluated the correlation between implant positioning and postoperative ROM in 25 partial shoulder resurfacing arthroplasties operated consecutively in a single reference center and with an average follow-up time of 4 years. Functional outcomes demonstrated that partial shoulder resurfacing arthroplasties improved UCLA scores, which assess pain and functionality. These outcomes are equivalent to those of partial shoulder arthroplasty using stems, and also agree with other series on shoulder resurfacing arthroplasties showing functional improvement.\textsuperscript{12,13,18}

Regarding implant positioning, our series identified only 8 out of 25 patients with anatomical reconstruction of the proximal extremity of the humerus with CDA and RVA values according to the criteria used here. These findings contradict the claim that partial shoulder resurfacing arthroplasties allow a reproduction of the normal humeral anatomy.\textsuperscript{21} Even though angular parameters guide the procedure, there is no correlation with functional outcomes, and, therefore, these values cannot predict surgical success. The lack of correlation between implant positioning and functional outcomes in our study is consistent with other publications. A radiographic study from Coutié et al.\textsuperscript{22} evaluated 31 partial resurfacing arthroplasties for an average follow-up time of 22 months. The authors concluded that the axillary view was insufficiently reproducible for implant version assessment. Rydholm et al.\textsuperscript{11} evaluated 72 patients who underwent partial resurfacing arthroplasties with a follow-up time of 4.2 years and found no correlation between implant position and functional outcomes. Deladerrière et al.\textsuperscript{10} used computed tomography (CT) images from the pre- and postoperative periods to assess whether the surgical procedure restored anatomical parameters. They demonstrated that, in comparison with initial parameters, there was no statistically significant correlation between the eventual implant version alteration and the lateral offset. In contrast, the medial humeral offset and anteversion increased by 3.47 mm and 4.23°, respectively.

One limitation of our study was the lack of overstuffed evaluation associated with partial resurfacing arthroplasty. Geervliet et al.\textsuperscript{23} performed a radiographic study to evaluate the anatomical restoration of the humeral head. A deviation from the rotational center > 5 mm, defined as overstuffing, was a predictor of failure, that is, indication for revision surgery. Another limitation was the use of radiographs for measurements because, theoretically, values may vary according to the positioning of the arm or of the scapula.\textsuperscript{22}

Finally, our results suggest that the anatomical positioning of the implant is inaccurate. This may be due to natural anatomical variations of the proximal humeral extremity, ongoing deformities from the degenerative joint disease, and procedural technical difficulty.

**Conclusion**

Our results demonstrate that partial shoulder resurfacing arthroplasties improve UCLA functional scores assessing pain and functionality. Implant positioning, assessed by cervical-diaphyseal and retroversion angles, is not correlated with clinical-functional outcomes of the prosthesis and, therefore, it is an inaccurate measure of surgical success.

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**Conflict of Interests**

The authors have no conflict of interests to declare.

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