

SHOULDER ARTHROPLASTY IN OSTEOARTHRITIS: CORRELATION BETWEEN FUNCTION AND RADIOGRAPHIC PARAMETERS

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ABSTRACT

Objectives: To evaluate the correlation between radiographic parameters and functional assessments of patients with osteoarthritis of the shoulder who underwent shoulder arthroplasty and to describe the functional outcomes of this procedure in our institution. **Methods:** We evaluated 21 patients (22 shoulders) who underwent shoulder arthroplasty between 1998 and 2010 and with a minimum follow-up of 12 months. Clinical evaluation was performed using the Constant-Murley scale, UCLA, EVA and by measuring the active motion. We analysed preoperative (distance between the top of the head and the humerus and the acromion, superior migration, neck angulation, medial "offset", subluxation, glenoid erosion) and postoperative radiographic

parameters (rod inclination, migration of components and loosening). **Results:** Patients showed significant improvement in all parameters: flexion ($p = 0.0083$), abduction ($p = 0.0266$), external rotation ($p = 0.0062$), Constant-Murley ($p = 0.0001$), UCLA ($p < 0.0001$) and VAS ($p = 0.0002$). The superior migration of the humerus showed a significant correlation with UCLA and Constant-Murley scores ($p = 0.0480$ and $p = 0.0110$, respectively). The other radiographic parameters showed no correlation with the clinical outcomes. **Conclusion:** The superior migration of the humerus is related to worse clinical scores.

Level of Evidence IV, Case Series.

Keywords: Osteoarthritis. Glenohumeral joint. Arthroplasty.

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INTRODUCTION

The shoulder arthroplasty is used in the treatment of inflammatory or degenerative lesions of the glenohumeral joint, including osteoarthritis (OA), avascular necrosis, rheumatoid arthritis and post traumatic osteoarthritis.¹ In advanced OA, arthroplasty is the procedure of choice in cases where nonoperative treatment is unsuccessful, providing good results, with improved function and decreased pain.^{1,2}

Evaluation of preoperative radiographic parameters is paramount in planning arthroplasty,^{3,4} and aims to assist the reproduction of normal anatomy and correct anatomical secondary abnormalities to OA.⁵ Postoperative radiographic parameters are critical to the evaluation of predictions criteria and signs of arthroplasty loosening.³ The correlation between radiographic parameters and functional outcome is rarely reported. Signs of loosening have direct correlation with the long term functional outcome.⁶⁻⁸ Other parameters of the positioning of the prosthesis also correlate with the result: tilt neck (head shaft angle), diameter and

thickness of the humeral head, distance between the top edge of the head and the greater tuberosity of the humerus, humeral head retroversion, distance from the head of the humerus and the acromion, and medial and posterior offsets.^{3,9}

The primary objective of this study is to evaluate the correlation between radiographic parameters and functional assessments of OA patients undergoing shoulder arthroplasty. The secondary objective is to describe the functional outcomes of shoulder arthroplasty at our institution.

METHODS

Between 1998 and 2010, 66 shoulder arthroplasty, for the treatment of glenohumeral OA, were performed at Institute of Orthopedics and Traumatology, Faculdade de Medicina, USP. These patients were convened between August 2010 and August 2011, having attended for review 21 patients (22 shoulders). Patients who did not attend the reevaluation or those with clinical follow-up in less than 12 months were not included in the analysis.

All the authors declare that there is no potential conflict of interest referring to this article.

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Intervention

The procedures were performed under general anesthesia associated with interscalene block. Antimicrobial prophylaxis with second generation cephalosporin for 24 hours was used. The approach used was delto-chest, with detachment of the subscapularis tendon. Vacuum drain was used in all patients and maintained for 24 to 48 hours.

In the postoperative period, patients were kept in a sling for four weeks. Active movements for the elbow, wrist and fingers were initiated in the immediate postoperative period. Passive movement to the shoulder was started on the 10th postoperative day, limited to 20 degrees external rotation. After the 4th week, assisted and free active movements were initiated.

Outcomes

Patients were clinically assessed by the Constant-Murley and UCLA (University of California at Los Angeles) functional scales. The active range of motion and Visual Analogue Scale (VAS) for pain were also measured. The preoperative clinical data were obtained from hospital case notes.

To the radiographic study, anteroposterior, scapular plane profile and axillary profile views obtained from medical records and from a new series documented at the time of the patient's interview were used.

The following parameters were measured pre-and postoperatively:

- Distance between the top of the head and the greater tubercle of the humerus (Figure 1A);
- Distance between the top of the humeral head and the acromion (Figure 1B);
- Higher migration of the humeral head, measured through the Gothic arch (Figure 2);
- Slope of the humeral neck (head-shaft angle) (Figure 3);
- Offset of the humeral head (Figure 4);
- Subluxation of the humeral head (axillary radiograph in lateral view) (Figure 5);
- Presence of erosion in the glenoid cavity.

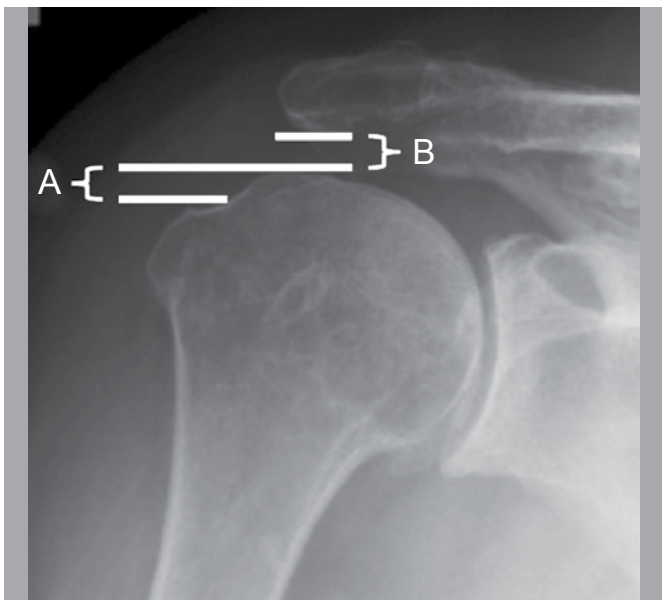


Figure 1. (A) Distance from the top of the head and greater tuberosity of the humerus. (B) Distance between the top of the humeral head and the acromion.

- On postoperative the following parameters were evaluated:
- Slope of the humeral stem (varus, valgus, or neutral);
 - Migration of the components of the humerus and the glenoid cavity;
 - Presence of signs of loosening of the components (signs of radiolucency greater than 1mm).

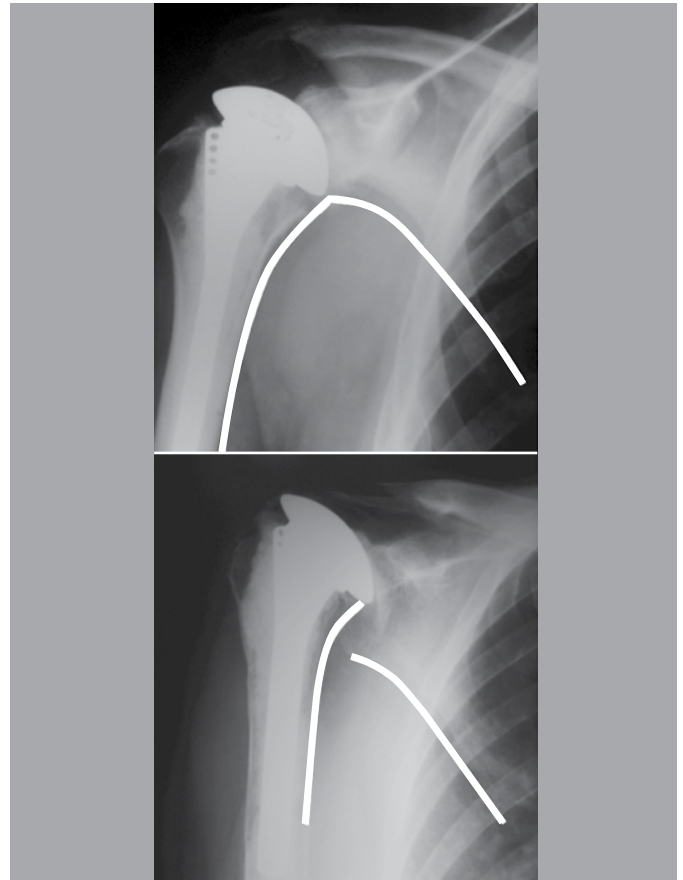


Figure 2. Migration of the top of the humeral head measured by the continuous line between the inferior portion of the glenoid and the lower portion of the head and neck of the humerus. (A) Normal Gothic arch, (B) modified Gothic arch.



Figure 3. Measurement of head-shaft angle pre-operatively.

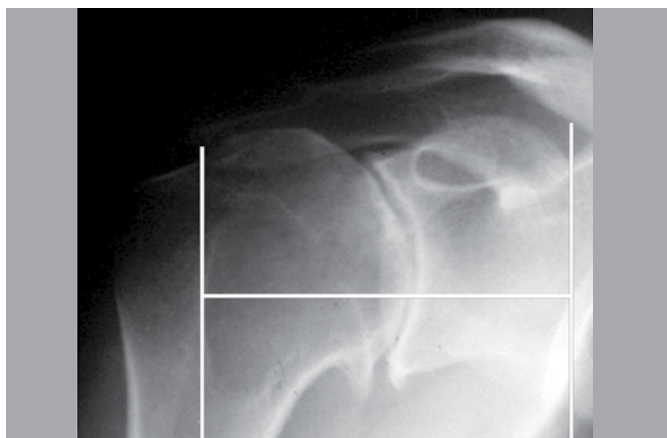


Figure 4. Offset of the humeral head, measured through the center of the shaft and the medial border of the scapula.

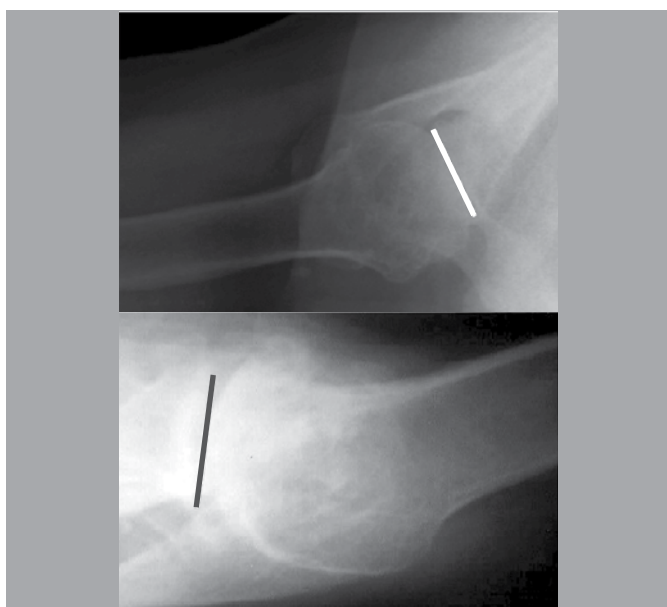


Figure 5. Evaluation of subluxation of the humeral head on the axillary radiograph in profile.

STATISTICAL ANALYSIS

Data normality was tested by the Shapiro Wilk test. The values of the functional scales and values of quantitative radiographic measurements were presented as mean and standard deviation. Categorical variables were presented as absolute values and percentages. The Wilcoxon test has been used for comparison between two quantitative variables related and the Mann-Whitney "U" test for comparison between two quantitative unpaired variables. To relate qualitative variables we used the Spearman correlation. In all cases a significance level of 5% ($\alpha = 0,05$) was used. The statistical softwares Stata® version 10.0 and the GraphPad Prism version 2.01® were used.

RESULTS

The age of patients ranged from 44 to 81 years, $64,63 \pm 10,41$ years on average. There was a predominance of females, with 14 cases (66.6%). The dominant limb was affected in 13 patients (59.1%).

The average follow-up time was $45,33 \pm 42,20$ months (minimum of 12 and maximum of 150 months).

Twenty Impol® brand prostheses were used (90.91%) one full Exactec® prosthesis (4.55%) and a partial DePuy [Johnson and Johnson]® prosthesis (4.55%).

Fourteen partial arthroplasties (66.3%) were carried out, three of them cemented (21.4%) and eight total arthroplasties, all of them cemented (36.4%).

Primary OA was the most common etiology, as shown in Table 1. The arch of motion improved significantly when comparing the pre- and postoperative status, according to Table 2.

The results of pre and postoperative evaluations (Constant, UCLA and VAS) can be seen in Table 2. Improvement was observed in all evaluations ($p < 0.001$). Correlation was observed between the etiology of osteoarthritis (primary and secondary) and functional outcomes of UCLA and Constant scales ($p = 0.0401$ and $p = 0.0273$, respectively).

The description and statistical analysis of quantitative radiological parameters (distance between the top of the head and greater tubercle of the humerus, the distance between the top of the humeral head and the acromion, cervicodiaphyseal and offset medial) can be observed in Tables 3 and 4. There were no significant radiographic changes from pre to post-operative, and when related to clinical scales as well, no significant difference was shown.

The subluxation of the humeral head greater than or equal to 25% was observed in both shoulders (9.09%) in the pre-operative period and in two other shoulders postoperatively. In either period, this parameter correlated with postoperative functional evaluations.

Regarding the slope of the humeral stem, the neutral position was present in nine shoulders (40.91%), valgus in nine shoulders (40.91%) and varus in four shoulders (18.18%), with no significant influence to the final functional outcome.

Table 1. Causes of osteoarthritis.

Illness	n	%
Primary Osteoarthritis	16	72,7
Osteonecrosis	2	9,1
Rheumatoid Arthritis	3	13,6
Arthrosis following fracture	1	4,6
Total	22	100

Table 2. Comparison between the arch of movement and functional evaluations and pain in pre and postoperative situations.

		Pre-operative			Postoperative			P
		Median	25	75	Median	25	75	
Arch of movement ¹	Flexion	72,5	60	100	100	90	130	0,0083
	Abduction	60	40	80	80	60	90	0,0266
	External Rotation	17,5	10	20	30	20	40	0,0062
Evaluations	Constant	21,5	14	43	50	33	57	0,0001
	UCLA	14	7	8	20	16	28	<0,0001
	VAS	9	8	10	5	2	7	0,0002

¹ Measured in degrees

Table 3. Evaluation of quantitative radiographic parameters in pre and postoperative situations.

Parameters	Pre-operative			Postoperative			P (Wilcoxon)
	Median	p 25	p 75	Median	p 25	p 75	
Distance between the top of the head and the major tuberosity of the humerus [*]	6	4	10	6,5	4	11	0,7460
Distance between the top of the humerus head and the acromion [*]	10	8	12,5	11	8	13	0,8241
Neck-shaft angle ^{**}	138	128	142	139	135	142	0,4322
Medial "Offset" [*]	61	49	65	58	52	65	0,7624

^{*}Measured in millimeters.

^{**}Measured in degree.

Table 4. Spearman correlation between quantitative radiographic parameters and functional and pain scales.

Parameters	UCLA		Constant		VAS	
	r	p	r	p	r	p
Distance between the top of the head and the major tuberosity of the humerus	0,0577	0,7986	0,1312	0,5607	0,09723	0,6669
Distance between the top of the humerus head and the acromion	0,2493	0,2632	0,3860	0,0760	-0,2512	0,2594
Neck-shaft angle	-0,0933	0,6797	-0,1855	0,4086	0,1228	0,5860
Medial "Offset"	-0,0752	0,7393	0,1270	0,5734	0,0554	0,8066

The erosion of the glenoid cavity was found in eight shoulders (36.36%) in the preoperative radiographs, and in four of them (50%) total arthroplasty was performed, while in the remaining four partial arthroplasty was done, with no statistical correlation with the final result.

The superior migration of the humerus occurred in seven shoulders (31.82%) in the postoperative period. The scales of UCLA and Constant were significantly different ($p = 0.0480$ and $p = 0.0110$, respectively) between the groups with and without this finding.

Radiographic signs indicating the risk of loosening of the prosthesis were found in three shoulders (13.64%). The mean follow-up of these patients was 103.18 months and no association was found with the cementing of the prosthesis or not.

In the comparative study between partial and total arthroplasty no significant difference regarding the scales Constant, UCLA and VAS ($p > 0.5$).

DISCUSSION

The shoulder arthroplasty for patients with severe OA shows satisfactory results, with lasting and reproducible improvement on functional and pain scales. Our study showed significant functional improvement after arthroplasties. Similar results are found in the literature.^{4,5,7,10}

The superior migration of the humeral component is associated with a worse functional outcome of the patients.¹¹ The standard measurement of this migration can be made through the height of the subacromial space³ or by breakdown of the so called "Gothic arch".¹² Our study found no correlation between the first measurement and functional outcomes. However, the superior migration evaluated by breaking of the Gothic arch positively correlated with a worse clinical outcome.

Although contradictory, the presence of correlation between superior migration of the humeral head and the absence of correlation between the height of the subacromial space can be explained by several factors. The evaluation of the subacromial space is influenced by the patient positioning, the slope

of the scapula, the arm rotation, retroversion of the prosthesis and the slope of the acromion or the presence of subacromial osteophytes. However, the top of the head migration, evaluated by breaking of the Gothic arch¹² has less dependence on the radiographic technique, and possibly has greater sensitivity to assess the superior migration of the prosthesis head.

The rotator cuff tear is a common cause of superior migration of the humerus and is directly related to worse outcomes in shoulder arthroplasty.^{11,13} It is also a risk factor for loosening of the glenoid.^{6,14} Other factors that can decrease the space are incorrect positioning of the humeral shaft, high-cut osteotomy of the humeral head, the eccentricity of the humeral head and large humeral head or long neck use.

The greater tuberosity of the humerus is positioned generally between 2 to 5mm below the top of the head. When the humeral component is positioned below the edge of the greater tuberosity, the joint rotation center descends relatively to the humerus, resulting in subacromial impingement due to the relatively higher position of the greater tuberosity. Acho que ficaria melhor: On the other hand, a high positioned head causes increased tension in the rotator cuff and also increased chances of polyethylene wear or erosion of the glenoid cavity.⁹ The supraspinatus tendon lying above the prosthesis head can cause later tendinopathy.^{9,15} In this situation increased tension in the capsule bottom also occurs, according to Nyffeler et al.¹⁶ There was no statistically significant correlations of this parameter with functional assessments.

Singh et al.¹⁰ found worse function in partial arthroplasty, but found no difference regarding to pain and state that both types of substitution (partial and total) improved the quality of life of patients with OA. In our study it was not possible to correlate the results for each type of arthroplasty due to the small number of patients.

In primary OA, there is usually eccentric posterior erosion of the glenoid cavity, which may cause posterior subluxation of the humeral head. These changes are associated with pain and loss of function.^{4,17} In our study, we did not find significant correlation between these function indicators and pain and subluxation.

The alteration of the medial offset relates to the displacement of the center of rotation and shows increase if the humeral head is bigger.¹⁸ A thicker glenoid component does not imply in an increased medial offset, because there is probably compensation by the use of a smaller humeral prosthesis head, adjusting the balance of tensions in the tissues.⁴ There was no correlation between this parameter and functional evaluations in our study.

The neck-shaft angle is on average $135^\circ \pm 5^\circ$, and prosthesis present, in general, a 130° to 135° angle.³ We found similar

values in the pre- and postoperatively situations. (Table 3) Regarding the slope of the humeral component, Matsen et al.¹⁹ found signs of radiolucency significantly lower in neutral position bolted prostheses. There was no correlation between the position of the rod and the final outcome.

Although we found no correlation between the risk of loosening and cementing or not the humeral component, Litchfield et al.²⁰ provided evidence that strength, range of motion and quality of life are better with the cemented fixation than with the uncemented one.

Most studied radiographic parameters showed no significant correlation with the outcome of functional scales. However,

this can be due to a type II error (false negative). We believe that the small size of the patient sample is the main limitation of our study.

Our study draws attention to the need for standardized radiographic evaluation pre- and postoperatively. This assessment should be a routine procedure for surgeons and the normal anatomy, determined by various radiographic parameters described, should be preserved and rebuilt in shoulder arthroplasty.

CONCLUSION

The superior migration of the humerus is related to worsening of functional indicators.

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