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Does the position of the scapula in relation to the glenopolar angle change the preferred treatment of extra-articular fractures?

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KEYWORDS

Scapula
3D computed tomography
3D CT
Glenopolar angle

ABSTRACT

Objective: To analyse the glenopolar angle (GPA) at different inclinations of the scapula using 3D CT, to test the hypothesis that the result could change the indication from conservative treatment to surgery.
Materials and Methods: Analysis of 30 3D CT images of patients' scapulae, measuring the GPA. The GPA was measured with scapulae at 0° and at 20° and 30° of internal and external rotation. Angles were compared by age, sex and examiner for the different angles of rotation of the scapulae.
Results: The GPA of scapulae in rotation tended to be smaller than the GPA without rotation, and the larger the degree of rotation, the more the angle was underestimated. Additionally, for the same degree of rotation, internal rotation was associated with greater underestimation of the GPA than external rotation. Two different examiners achieved an excellent level of agreement between angle measurements. The GPA with the scapula at 0° was significantly higher among elderly patients. The variation in GPA with the scapula in rotation (20° and 30°) in relation to the GPA without rotation was significantly greater for female patients.
Conclusions: As the rotation of the scapula was displaced from the scapula in the coronal position (GPA 0°), both in internal rotation and in external rotation, the GPA reduced. Therefore, rotational displacement may lead to an error in GPA measurement, resulting in incorrect indication of treatment. It is recommended that whenever possible, GPA measurements should be taken in neutral rotation, with the scapula in a neutral position at 0°.

Introduction

Scapular fractures account for 0.4 to 1% of all fractures and, with relation to the pectoral girdle, they occur in 3 to 5% of injuries [1]. Diagnosis and classification of these fractures can be difficult, leading to failure to diagnose or delayed diagnosis [2–6]. Although there are accepted criteria for surgery and known risk factors for instability of scapula fractures, there are not yet well-defined measurement techniques for determining medialisation, lateralisation, translation, or angular deformities [7–9].

The glenopolar angle (GPA) is the angle formed by a line connecting the most cranial and most caudal points of the glenoid cavity and a line connecting the most cranial point of the glenoid cavity with the most caudal point of the body of the scapula. The resultant angle quantifies the articular surface of the glenoid with relation to the body of the scapula. Bestard et al. consider that the range of normal GPA is from 30 to 45° [10].

Extra-articular fractures of the scapula are rare and the majority are treated conservatively [11–15]. Little is understood about these fractures and there is no consensus on radiographic measurements or surgical indications. In older literature, indications were limited to series of cases with recommendations for radiographic measurements, including the GPA, as a guide for when to choose surgery [7,12,13,16–25]. However, interpretation of radiographic images of the scapula shows they can prove difficult to analyse. Several studies of the outcome of patients with scapular fractures report poor results when the GPA is small [17,26,27]. More recent studies have established 3D CT as the standard tool for measurements to indicate the type of treatment to choose for these fractures [7,12,13,16–25].

The objective of this study was to analyse the GPA at different inclinations of the scapula using 3D CT, to test the hypothesis that the results might change the treatment indicated.

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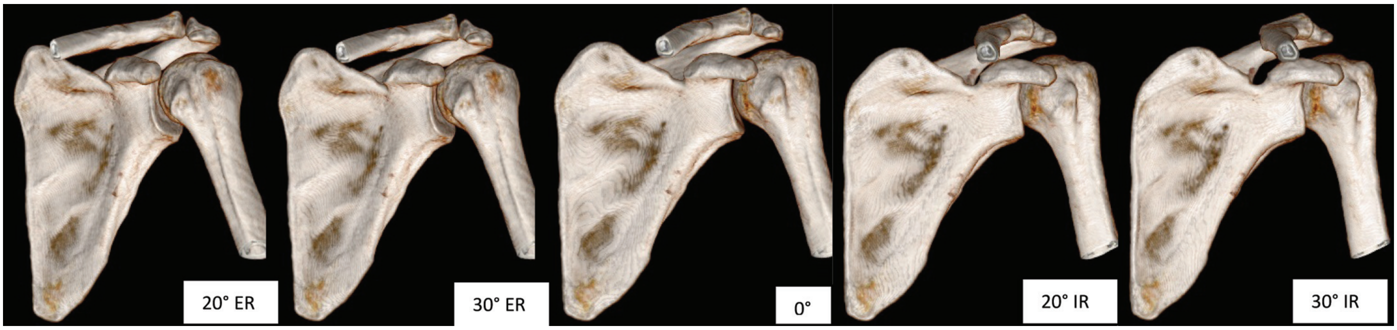

Fig. 1. 0°= scapula in neutral position; 20° ER = 20° external rotation; 30° ER = 30° external rotation; 20° IR = 20° internal rotation; 30° IR = 30° internal rotation.

Materials and methods

This is a retrospective study conducted at the Hospital Santa Teresa, Petrópolis, Rio de Janeiro, Brazil. Thirty sets of 3D CT images of patients' scapulae were analysed, measuring the GPA. All images were from patients who had suffered a proximal fracture of the humerus. The study was analysed and approved by the local ethics committee and free and informed consent forms were not required because the data were extracted from computer images. Cases of patients aged over 18 years, for whom 3D CT images of the scapula were available, were included. Images were excluded if the patient had a prior fracture of the scapula, glenoid fracture, bone tumours, osteoarthrosis of the glenohumeral joint, congenital abnormalities, or metabolic disease.

For the purposes of this study, we assumed that the standard method for measurement of GPA on a computer 3D reconstruction CT image was with the scapula positioned as coronal as possible (true antero-posterior [AP]), in Grashey projection, which was defined as 0°. This position was considered the gold standard. Two researchers then measured the GPA of the scapulae at 0° and in 20° and 30° of internal and external rotation, at different times, using the same goniometer (Figure 1). The resulting angles were compared between groups based on age and sex and between the different rotations. The GPAs of the 30 patients were measured using a validated method [16].

Methodology

Statistical analysis was performed using IBM SPSS (Statistical Package for the Social Sciences) for Windows, version 22.0, Armonk, NY, USA. To characterise the sample and conduct descriptive analysis of the behaviour of the variables, data were summarised by calculating descriptive statistics and frequency distributions. Interexaminer agreement was analysed by calculating Intraclass Correlation Coefficients (ICC), using the two-way mixed ANOVA model and the indicator of interest in this study was analysis of consistency. For inferential analysis of qualitative variables, the significance of associations between variables was investigated using the chi-square test or Fisher's exact test. Two complementary proportions were compared using the Binomial test. In the Inferential Analysis of Quantitative Variables, the hypothesis of normal distribution was analysed using the Kolmogorov-Smirnov test (KS) and the Shapiro-Wilk test (SW). As distributions were not normal, two independent groups were compared using the Mann-Whitney nonparametric test, paired comparisons of the angles measured were conducted using the Wilcoxon test, and correlations were analysed with Spearman correlation coefficients. The significance of the correlation coefficient was investigated using the Correlation Coefficient Test. All discussions are based on a maximum significance level of 5%.

Table 1
Principal statistics for age of patients, by sex

Sex	Mean	Median	Min.	Max.	SD	CV	Number of patients
Female	71.5	66.0	56.0	98.0	12.7	0.18	13
Male	51.2	49.0	20.0	94.0	18.2	0.35	17
Overall	60.0	61.0	20.0	98.0	18.8	0.31	30

Source: Hospital Santa Teresa, Petrópolis, Rio de Janeiro, Brazil.
CV: coefficient of variation; SD: standard deviation.

Results

This study comprised 30 patients, 17 male and 13 female. Patients were aged from 20 to 98 years, with a mean age of 60 years. Principal statistics for the age of the entire sample and in subsets separated by sex are shown in Table 1.

Table 2 lists the results for each examiner for measurements of glenopolar angles without rotation (GPA 0°), with 20° of external rotation (GPA 20° ER), with 30° of external rotation (GPA 30° ER), with 20° of internal rotation (GPA 20° IR) and with 30° of internal rotation (GPA 30° IR). There was a low degree of variability between angles, as shown by all coefficients of variation being less than 0.13. The distributions of angles for each examiner are illustrated in a Boxplot, shown in Figure 2.

Wilcoxon tests were used to conduct paired comparisons of the angles measured, for each examiner, and all p values for all comparisons were equal to 0.000. Therefore, there is evidence to reject the null hypothesis that the angles compared are equal.

Table 3 lists the distribution of frequencies of variations between angles of scapulae in rotation and without rotation, by examiner. A pattern emerged in the differences between angles in rotation and without: the angle in rotation was rarely larger than the angle without rotation.

Table 4 lists the variation between angles of scapulae with rotation and without rotation, per examiner. The coefficients of variation show that there is a large degree of variability in the

Table 2
Principal statistics for angles measured by each examiner

Angle	Examiner	Mean	Median	Min.	Max.	SD	CV
GPA 0°	1	40.3	40	32	50	3.2	0.08
	2	40.1	40	34	48	2.5	0.06
GPA 20° ER	1	37.7	38	30	48	3.4	0.09
	2	37.9	38	30	46	3.1	0.08
GPA 30° ER	1	34.4	34	26	44	3.5	0.10
	2	34.1	34	26	42	3.2	0.09
GPA 20° IR	1	36.3	36	28	46	3.3	0.09
	2	36.7	36	30	46	3.0	0.08
GPA 30° IR	1	32.4	33	26	44	3.4	0.11
	2	32.2	32	24	44	3.8	0.12

Source: Hospital Santa Teresa, Petrópolis, Rio de Janeiro, Brazil.
CV: coefficient of variation; GPA: glenopolar angle; ER: external rotation; IR: internal rotation; SD: standard deviation.