GLENOID AND CORACOID DIMENSIONS AND THEIR IMPLICATIONS IN THE LATARJET OPERATION: A DRY BONE STUDY

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ABSTRACT

Background: The coracoid process is widely used as a graft in patients with recurrent anterior shoulder instability with significant glenoid bone defects. However, no local studies have determined the coracoid dimensions and correlated them to the glenoid dimensions.

Objective: To measure the widest anteroposterior (AP) diameter of the glenoid cavity, the length, width and thickness of the coracoid process, compare these with other populations, determine the amount of coverage the thickness and width of the coracoid process can afford in case of bony glenoid deficiency and the adequacy of the coracoid process to safely accommodate fixation screws used in the Latarjet and congruent-arc Latarjet procedures.

Methods: The dimensions were measured using digital vernier callipers on dried scapulae that were not deformed. The ratio between coracoid thickness and width to the glenoid AP diameter was determined as the percentage cover that particular dimension can provide to the deficient glenoid.

Results: A total of 26 scapulae were obtained. Average AP diameter and height of the glenoid was 25.1mm and 36.2mm respectively. Average coracoid length, width and thickness was 22.3mm, 13.3mm and 7.7mm respectively. There was no significant difference between the right and left sides in all the dimensions. The average coverage provided by the coracoid thickness (Latarjet procedure) was 30% with coracoid width providing average coverage of 50% (congruent-arc Latarjet procedure). The coracoid width could safely accommodate the 3.5mm and 4.5mm screws while coracoid thickness offered a very thin margin round the screws.

Conclusion: The coracoid process can cover glenoid defects of between 30% and 50% and while it may safely accommodate the 3.5mm and 4.5mm screws if oriented for the classic Latarjet operation, care is needed especially if the congruent-arc Latarjet is planned as coracoid thickness may not be adequate to accommodate the fixation screws.

Keywords: Coracoid process, Glenoid, Latarjet, Congruent-arc Latarjet

INTRODUCTION

The shoulder joint, being the most mobile joint in the body is also the most unstable, and most frequently dislocated, accounting for nearly 50% of all dislocations (1). Among the factors that predispose to recurrence of dislocation is a significant glenoid bony defect. Quantification of the glenoid bony defect helps in decision-making as to the appropriate treatment modality. Glenoid defects more than 20-25% of the glenoid width have been shown to be associated with recurrent instability, even after adequate soft tissue repair (2,3). In these patients, restoration of the glenoid width is advocated for by using a bony graft. Frequently, the coracoid process is used as a locally available autograft. The tip of the coracoid may be used, as in the Bristow operation (4) or 2-3cm of the coracoid used as in the Latarjet procedure (5,6). The Latarjet procedure has been shown to have low recurrence rates of dislocation with excellent functional outcome (7,8). In the standard Latarjet procedure, the coracoid process is osteotomised at its axilla and secured to the deficient anterior glenoid margin with its lateral edge parallel to the glenoid, thus closing the glenoid defect (5,8). In the congruent-arc Latarjet, the osteotomised coracoid process is rotated 90 degrees about its axis such that its inferior surface is parallel to the glenoid (9).This is done when the glenoid defect is much larger than can be covered with the classic Latarjet procedure, especially in the "inverted-pear" glenoid (9,10).

The coracoid process is fixed to the scapular neck using two 3.5mm cortical screws (8) or 4.5mm malleolar screws (6). It has been shown that failure of fixation is more likely to occur when a single screw is used. This may be bending, breakage, or migration of the screw and non-union (11). The low recurrence rates after the Latarjet procedure have been attributed to the adequate restoration of the deficient glenoid and the tenodesis effect of the conjoint tendon and muscles attached to the coracoid process (10,12,13).

Consequently, the dimensions of the coracoid process in relation to the glenoid have important implications in the success of these bony procedures. The coracoid process must be of adequate size to afford adequate restoration of the deficient glenoid. It must also be adequate to safely accommodate the fixation screws, as intraoperative fracture of the coracoid may occur (14).Though the ideal screw to use in the Latarjet procedure has not been determined, Müller et al (15) found that the hold of a screw dimishes at it approaches 40% of the diameter of the bone. However, some studies in the thoracic spine have shown that pedicle screw size should be at least 0.5mm less than the diameter of the pedicle, beyond which there is a risk of violation of the pedicle wall (16). As the Latarjet procedure has gained popularity and with no local studies on the same, the authors sought to determine the dimensions of the glenoid, the coracoid process, determine how much cover it can furnish the glenoid and whether it can safely accommodate the fixation screws.

MATERIALS AND METHODS

Dried scapulae were obtained from the Departments of Human Anatomy, Egerton University and Kenyatta University, Kenya. Only skeletally mature specimens were used. Specimens that were deformed, those with previous fracture or surgery and those with post-mortem damage were excluded from the study.

The following dimensions were measured using a digital vernier calliper: the widest anteroposterior (AP) diameter and superoinferior (SI) height of the glenoid, the length, width and thickness of the coracoid process. The length of the coracoid process was measured from the axilla of the coracoid to the tip, the width was taken as its mediolateral extent and the thickness was taken as its narrowest anteroposterior dimension. This is shown in Figures 1 and 2. Each of the dimensions was taken by one investigator three times and the average obtained.

Figure 1
Measurement of coracoid width

Figure 2
Measurement of coracoid thickness

For the classic Latarjet operation, the amount of coverage that can be provided by the coracoid was determined by dividing the thickness of the coracoid process with the AP diameter of the glenoid. For the congruent-arc Latarjet, the coverage obtained by the coracoid was determined by dividing the width of the coracoid process with the AP diameter of the glenoid. For the respective operation, the adequacy of the dimensions to safely and securely accommodate the fixation screws was determined. This was the adequacy of the coracoid to accommodate the 3.5mm cortical and 4.5mm malleolar screws commonly used in the Latarjet procedure. The data obtained was analysed using Numbers® version 5.1(Apple Inc). For comparisons, a p value of <0.05 was taken as being significant.

RESULTS

A total of 26 scapulae were obtained. Fourteen were from the right side and 12 were from the left side. Tables 1 and 2 show the various dimensions obtained. Table 3 shows the ratios between the coracoid thickness and width to glenoid AP diameter. There was no significant difference between the glenoid and coracoid dimensions of the right and left scapulae.

Average and minimum coracoid width and thickness were both more than the diameter of the 3.5mm and 4.5mm screws. Glenoid AP diameter and coracoid width were more strongly positively correlated, compared to glenoid AP diameter and coracoid thickness, with coefficients of correlation of 0.6 and 0.5 respectively. Figure 3 shows the correlation between glenoid AP diameter and coracoid thickness. Table 4 shows a comparison between the results obtained and the dimensions from other studied populations.

The glenoid dimensions obtained in the current study are similar to those obtained in studies on Nigerian specimens. However, the glenoid dimensions obtained in the Indian study are less than those obtained in this study.

Table 1
Glenoid dimensions

Specimens	Glenoid AP diameter(mm)			Glenoid height(mm)		
	Minimum diameter	Maximum diameter	Average diameter	Minimum height	Maximum height	Average height
All specimens	20.3	30.2	25.1	30.2	42.8	36.2
Right scapulae	22.0	30.2	25.3	31.9	41.4	36.5
Left scapulae	20.3	28.2	24.7	30.2	42.8	35.9
p value			*0.39*			*0.46*

Table 2
Coracoid dimensions

	Coracoid length(mm)			Coracoid width(mm)			Coracoid thickness(mm)		
	Minimum length	Maximum length	Average length	Minimum width	Maximum width	Average width	Minimum thickness	Maximum thickness	Average thickness
All specimens	17.1	26.9	22.3	10.3	17.0	13.3	5.2	9.3	7.7
Right scapulae	17.6	26.9	22.5	11.2	17.0	13.4	5.2	9.3	7.6
Left Scapulae	17.1	26.5	22.0	10.3	16.9	13.3	5.8	9.0	7.7
p value			0.30			0.36			0.18

Table 3
Coracoid to glenoid dimension ratios

	Coracoid thickness/glenoid AP diameter (classic Latarjet)			Coracoid width/glenoid AP diameter(congruent arc Latarjet)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
All specimens	0.2	0.4	0.3	0.4	0.7	0.5
Right scapulae	0.2	0.3	0.3	0.4	0.7	0.5
Left scapulae	0.3	0.4	0.3	0.5	0.7	0.5

Figure 3

Correlation between glenoid AP diameter and coracoid thickness

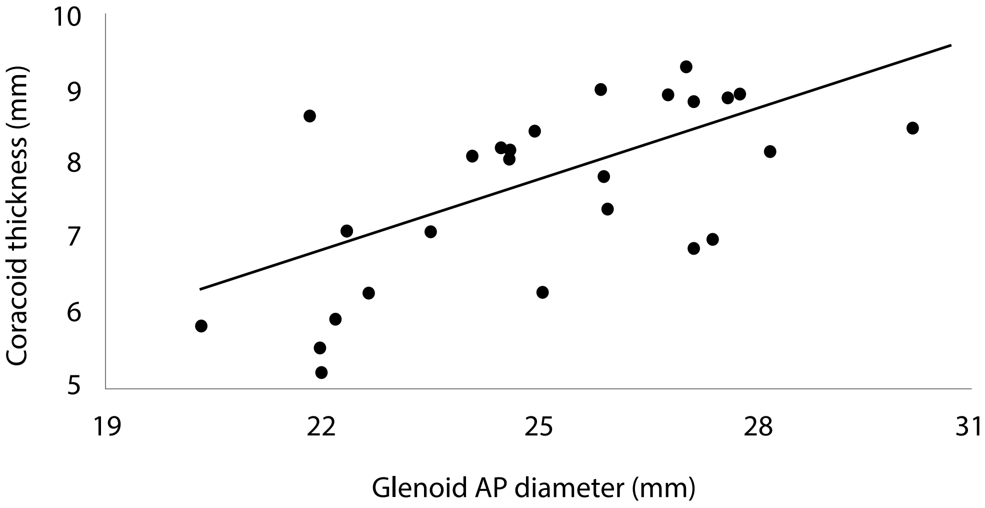

Table 4

Comparison with other populations

Author	Study type	Study population	Glenoid AP diameter (mm)	Glenoid height (mm)	Coracoid length (mm)	Coracoid width (mm)	Coracoid thickness (mm)
Current study	Dry bone	Kenyan	25.1±2.45 (20.3-30.2)	36.2±2.94 (30.2-42.8)	22.3±2.74 (17.1-26.9)	13.3±1.75 (10.3-17.0)	7.7±1.21 (5.2-9.3)
Bueno *et al* (16)	Dry bone	Brazilian	26.38± 2.69 (20.03-32.35)			14.51±1.90 (9.60-19.31)	8.37±0.93 (6.61-9.76)
Aigbogun *et al* (17)	Dry bone	Nigerian	25.15±3.60	36.87±3.94			
Silva *et al* (18)	CT measurement on live subjects	Brazilian			27.00±3.80 (17.70-40.05)		9.16±6.38 (5.20-15.80)
Akhtar *et al* (19)	Dry bone	Indian	23.63±2.50	35.80±3.14			
Osuagwu *et al* (20)	Dry bone	Nigerian	26.00±0.03	38.00±0.04			

DISCUSSION

The study has shown average AP diameter of the glenoid to be 25.07mm with average glenoid height being 36.19mm. These dimensions are generally similar to those obtained in other studies using different measurement modalities (17,18,20,21). The coracoid dimensions were slightly less than those found in Brazilian studies using direct measurement on dry bone and CT scans (17,19).

It has been shown that glenoid defects more than 20-25% of the glenoid width are associated with recurrent dislocation even after repair of the soft tissues (2). Such defects require augmentation with a bone graft. Consequently, the bone graft chosen should be of sufficient size to cover such a deficiency. In the standard Latarjet operation, the coracoid autograft is oriented in such a way that its lateral surface is parallel to the glenoid, thus closing the deficiency in the glenoid (5). In this study, the dimension relevant to the performance of the classic Latarjet operation is the coracoid thickness. The average coracoid thickness to glenoid width ratio was 0.3(30%), with a range of 0.2-0.4 (20-40%). This means that, on average, if the classic Latarjet operation is employed, the coracoid autograft can cover defects involving 20-40% of the width of the glenoid. In none of the specimens was the ratio less than 20%. Only one specimen had a ratio of less than 25%. These results are similar to those obtained by Bueno *et al* (17), who found a coracoid thickness to glenoid width ratio of between 25%-37%, with an average of 30%.

Where the glenoid bone loss is more than can be covered through the classic Latarjet operation, the coracoid process can be turned 90 degrees such that its inferior surface is parallel to the glenoid, in the so called congruent-arc Latarjet procedure (9,10). This brings the slighter wider dimension of the coracoid width to bear on the glenoid defect. In the current study, this would offer coverage of glenoid defects involving between 40%-70% of the width, with an average of 50%. Bueno *et al* (17) found similar coverage of between 43%-70% in a study on Brazilian specimens. A potential drawback of orienting the coracoid process for the congruent-arc Latarjet procedure is that the slightly smaller dimension, the coracoid thickness, is what would be required to accommodate the fixation screws. The average thickness obtained in the current study was 7.65mm, with a minimum of 5.23mm and a maximum of 9.30mm. Whilst these dimensions are greater than the diameter of the screws, it is of note that, in some of the specimens, the difference between the coracoid thickness and the screws was as little as less than 1mm. Müller *et al* (15) determined that a screw loses its holding power once its diameter approaches 40% of the diameter of the bone. Applied to the specimens in the current study, it would require that the coracoid thickness be at least 8.75mm and 11.25mm to safely accommodate the 3.5mm and 4.5mm screws respectively. However, some studies in the thoracic spine have shown that pedicle screws be at least 0.5mm less than the diameter of the pedicle, otherwise there is a risk of violation of the pedicle (16). Extrapolated to the results in the current study, this would mean that, with careful introduction, the coracoid thickness can accommodate the 3.5mm and 4.5mm screws, as the difference between the minimum coracoid thickness and the screws is 1.73mm and 0.73mm respectively. As these are very narrow margins, the surgeon needs to then bear in mind that the congruent-arc Latarjet is less tolerant of screw malposition. Specific coracoid guides would be useful in such instances. It is generally desirable that the coracoid be able to offer a safe margin round the fixation screw. There is a risk of not achieving firm fixation and intraoperative fracture if the size of the graft is not adequate. Intraoperative fractures of the coracoid have been reported and these could be due to the size of the graft being insufficient to accommodate the hardware (14). These intraoperative fractures have been shown to affect healing of the transferred coracoid to the scapula and should therefore be avoided as much as possible (22). It would be prudent then that if the congruent-arc Latarjet operation is anticipated that the surgeon obtains coracoid measurements by use of CT scans, and from the dimensions obtained decide on the appropriate screw size to use.

CONCLUSION

This study has shown that the coracoid process can adequately afford coverage of glenoid defects involving 30% of its width in the classic Latarjet procedure. When oriented for the congruent-arc Latarjet, the coracoid process can adequately cover, on average, defects involving up to 50% of the glenoid width. The coracoid process can also safely accommodate the fixation screws when placed for the classic Latarjet procedure. If the congruent-arc Latarjet is to be undertaken, the surgeon needs to bear in mind that the coracoid thickness may offer only a thin margin round the screws. It may be advisable in such instances to use the 3.5mm screws. It would also be wise to obtain the dimensions preoperatively using CT scans.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare. No funding was received from any source for this study.

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