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Intraoperative and anatomic dimensions of the coracoid graft as they pertain to the Latarjet-Walch procedure

Dipit Sahu, MS, Jairam Jagiasi, MS*

Department of Orthopaedics, Dr. R. N. Cooper Hospital & HBT Medical College, Juhu, Mumbai, India

Background: Our objective was to study the anatomic and intraoperative coracoid measurements with an aim to closely replicate the Latarjet-Walch technique and find the similarities and dissimilarities in our population.

Methods: In the cadaveric study, 20 shoulders in 10 fresh cadavers were dissected, and the coracoid length, width, and thickness were measured. In the intraoperative study, 10 patients underwent the classic Latarjet procedure according to the Walch technique. The harvested coracoid graft was analyzed for the length of the coracoid, the distance of the inferior hole from the lateral margin of the coracoid graft, and the width of the coracoid graft at the inferior and superior hole.

Result: The average distance from the tip of the coracoid to the trapezoid insertion was 25.4 mm (standard deviation [SD], 1.7 mm). The mean width of the undersurface of the coracoid was 14.2 mm. The average length of the graft after harvesting was 25.1 mm (SD, 1 mm). The average distance between the lateral border and the inferior hole was 5.5 mm (SD, 1.1 mm). We used 25-mm malleolar screws in 3 shoulders and 30-mm malleolar screws in 7 shoulders.

Conclusion: The"7-mm" rule of Walch could be followed in our population. The medial surface width of the coracoid in our Indian morphology was an average of 7 mm; hence, malleolar screws of 30 and 25 mm were used to fix the graft on the glenoid.

Level of evidence: Anatomy Study; Cadaveric Dissection

Keywords: Latarjet; unstable shoulder; coracoid measurements; coracoid length; graft positioning; coracoid graft fixation screws

Shoulder instability is frequently treated by the Latarjet procedure, which involves the transfer of the coracoid process along with the conjoint tendon to the glenoid edge. Latarjet described this procedure in 1954, and it was further modified by Patte et al.[13,17] Walch modified the procedure and used 2 malleolar screws to fix the coracoid on the glenoid.[6,26] Later, Burkhart et al[2] described the congruent arc modification of the classic Latarjet procedure. The difference between the classic and the congruent arc modification is based on how the coracoid graft is positioned on the glenoid. Whereas the undersurface of the coracoid is placed against the glenoid in the classic Latarjet procedure, the medial surface is used in the congruent arc modification.[16]

In the classic Latarjet technique, as described by Walch and colleagues,[28] the coracoid is harvested distal to the

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*Reprint requests: Jairam Jagiasi, MS, Department of Orthopaedic Surgery, Dr. R.N. Cooper Hospital & HBT Medical College, Juhu, Mumbai 56, India.

E-mail address: orthopaedicscooper@gmail.com (J. Jagiasi).

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insertion of the trapezoid ligament. The "7-mm rule" says that to appropriately position the graft on the glenoid and to avoid its lateral overhang, the glenoid is predrilled with a 3.2-mm drill bit at the 4 to 5 o'clock position (right shoulder) or the 7 to 8 o'clock position (left shoulder) position and 7 mm from the glenoid articular margin.[27,28] The graft is then fixed on the glenoid with two 4.5-mm malleolar screws of 35 mm in length as the typical size of the screw.[28]

Our experience says the size of coracoid is smaller in the Indian settings. Our objective with this study was to evaluate the anatomic and intraoperative coracoid measurements with an aim to closely replicate the technique by Walch et al and find the similarities and dissimilarities with the technique in our population.

The purpose of the cadaveric study was:

1. To measure the length of the coracoid graft distal to the coracoclavicular ligament that may be available for harvesting during the Latarjet procedure.
2. To measure and analyze the width of the undersurface and the medial surface of the coracoid.

The purpose of the intraoperative study was:

1. To measure the length of the coracoid graft obtained after harvesting in the Latarjet procedure and assess whether the length is sufficient to be fixed with 2 malleolar screws.
2. To analyze whether the 7-mm rule can be applied in our patient population.
3. To measure the size of the malleolar screws most commonly used to fix the graft on the glenoid

Materials and methods

The study was done in 2 parts, a cadaveric study and an intraoperative study.

Cadaveric study

We dissected 20 shoulders in 10 fresh cadavers (8 men and 2 women) of Indian origin with an average age of 45 years (range, 28-60 years). We removed the skin, subcutaneous tissues, and overlying muscles to expose the coracoid with all its ligament and muscular attachments. The cadavers were free of any pathology on gross examination. The coracoid was clearly defined along with all the attachments of the conjoint tendon, pectoralis minor tendon, coracoacromial ligament, and trapezoid ligament (Fig. 1). We defined the most prominent distal projection of the coracoid as its tip. A digital caliper was used to measure the distance between the tip of the coracoid and the distal attachment of the trapezoid ligament.

We osteotomized the coracoid just distal to the distal insertion of the trapezoid ligament. All of the soft tissues around the coracoid were removed. We then measured the width of the undersurface and the medial surface of the coracoid at its tip, middle part, and the base. These paired values were compared with the *t* test for any significant difference. $P < .05$ was considered significant.

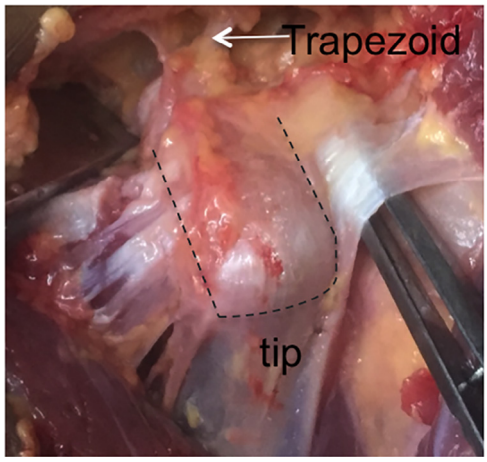

Figure 1 Cadaveric dissection of the coracoid with preserved trapezoid ligament and conjoint tendon.

Intraoperative study

In the intraoperative part of the study, we collected data during the open Latarjet procedure performed by 1 surgeon (D.S.). We included 10 consecutive patients (9 men, 1 woman) who underwent the classic Latarjet operation between January and April 2018. Patients were an average age of 24 years (range 19-36 years). The indications for the operation were recurrent shoulder instability with or without glenoid/humeral bone loss and with or without hyperlaxity. The procedure was done according to the Walch technique of the classic Latarjet.[28] The important steps were as follows:

We used a folded towel underneath the scapular medial border and the inferior angle to reduce the inclination of the glenoid relative to the trunk.

We harvested the coracoid with the help of a right-angled saw that has a width of 0.6 mm. The coracoid was harvested at the junction of the horizontal and vertical limb after visual and physical verification, staying as close to the distal insertion of the trapezoid ligament as possible. The saw was directed from medial to lateral and perpendicular to the medial margin. We preferred to use a 3.2-mm drill bit to drill 2 holes in the center of the width of the coracoid approximately 1 cm apart and at equal distance from the superior and inferior end. This would enable us to use 4.5 malleolar screws through the coracoid in the final step of the procedure. If the harvested coracoid appeared smaller, if the 3.2-mm hole appeared to be crowding near each other, or if the hole appeared to violate the superior/inferior margin of the coracoid bone, a 2.7-mm drill bit was kept ready as the next option.

A 3.2-mm drill bit was used to drill the first hole in the glenoid at the 4 to 5 o'clock position (right shoulder) or the 7 to 8 o'clock position (left shoulder), at a distance of 7 to 9 mm from the glenoid articular margin. The glenoid may be angulated anteriorly by 38° relative to the trunk in the sagittal plane.[19] The inclination of the glenoid articular surface has to be visualized and respected while drilling for the screws. To visualize the entire glenoid articular surface, we used a Hohman retractor inferiorly and a Trillat retractor (Axone Medical, Villefranche-sur-Saône, France) in the glenohumeral joint space, to retract the humeral head laterally. Thus, the all-around inclination of the glenoid from the anterior to posterior margin could be visualized, and a 3.2-mm drill bit was held parallel to the glenoid articular surface while making both the holes for the malleolar screws.

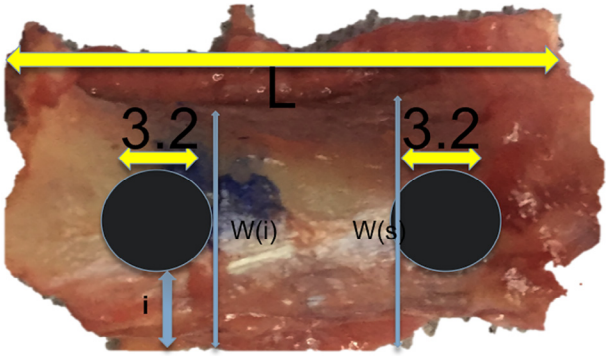

Figure 2 Coracoid graft with 2 holes of 3.2 mm and measurements: *L* length of the coracoid, (*i*) distance of the inferior hole from the lateral border, *W(i)* width of the coracoid at the inferior hole, *W(s)* width of the coracoid at superior hole.

The coracoid was brought out and fixed to the glenoid via the inferior hole with one 30-mm malleolar screw.

The position of the graft was checked visually and with the help of an osteotome to ensure that the graft was flush or 1 to 2 mm medial to the articular margin. The graft was then rotated in the satisfactory position to avoid any lateral overhang of the superior part of the graft. The second hole was drilled in the glenoid through the superior hole of the coracoid. A depth gauge was used to measure the size of the screw. We decided to use the 30-mm malleolar screw as the typical screw because of the smaller thickness of the coracoid (as per our surgical experience and initial pilot cadaveric results) and change it later if needed. If the superior screw size was different from the inferior screw, then the inferior screw was changed to match the size.

The following measurements were done after harvesting and preparing the coracoid with the help of a vernier caliper (Fig. 2):

1. The length of the coracoid, measured from the tip (L).
2. The distance of the inferior hole from the lateral margin of the coracoid graft (i).
3. The width of the coracoid graft at the inferior hole (w(i)).
4. The width of the coracoid graft at the superior hole (w(s)).

The sizes of the screws used during the procedure were also recorded.

Statistical analysis

We compared the 2 groups (cadaveric and intraoperative measurements) for the size of the coracoid graft and the width of the undersurface using the *t* test and the demographic data using the Fisher exact test. Correlation statistics were performed to determine the influence of the glenoid bone defect on the size of the malleolar screw.

Results

Cadaveric

The average distance from the tip of coracoid to the distal attachment of the trapezoid ligament was 25.4 mm (SD, 1.7 mm; Table I). This distance was free of any trapezoid ligament attachment. Although the measured values were smaller in specimens from women, a statistical comparison was not done because of the high male-to-female ratio in a small sample size.

The mean width of the undersurface of the coracoid was 14.2 mm (SD, 1.5 mm). The mean width at its base, middle part, and the tip was 14.8 mm (SD, 0.9 mm), 14.8 mm (SD,1.2 mm), and 13.2 mm (1.7 mm), respectively. This was significantly larger than the mean width of the medial surface of the coracoid at the base (mean, 7.1 mm; SD, 0.7 mm), the middle part (mean, 6.9 mm; SD, 0.6 mm), and the tip (mean, 6 mm; SD, 0.6 mm; $P < .0001$) between each paired comparison of undersurface and medial surface base, middle part, and tip. There was no significant difference between the left and the right side for any of the observed values.

Intraoperative

The average length of the graft after harvesting was 25.1 mm (SD, 1 mm; range, 24-27 mm; Table II). The average distance between the lateral border and the inferior hole was 5.5 mm (SD, 1.1 mm; range, 4-8 mm). The average width of the graft was 14.2 mm (SD, 1.3 mm; range, 14-17.2 mm) at the level of the inferior hole and 14.3 mm (SD, 0.9 mm; range, 13-16 mm) at the superior hole. A 3.2-mm drill bit was used to make the holes in each case. We used 25-mm malleolar screws in 3 patients and 30-mm malleolar screws in 7 patients.

We found no significant differences between the 2 groups (cadaver and intraoperative) in sex distribution ($P = 1$), size of the graft ($P = .6$), and width of the undersurface ($P = .35$). The size of the glenoid bone defect had no influence on the size of the malleolar screw that was used to fix the graft ($P = .96$).

Discussion

Several different variations of the Latarjet technique have been described with several different screws.[3,8,9,12] However, many surgeons throughout the world follow the technique recommended by Walch (described in his experience of 2000 cases).[21,23,26,29] With this study, we wanted to study the morphologic dimensions of the coracoid graft in the Indian population. We also wanted to analyze how the technique described by Walch and colleagues can be replicated in our population and whether the size of the harvested coracoid would allow us to fix it with 2 malleolar screws.

Our cadaveric study proves that in the Indian population, the mean length of the coracoid available for harvesting is less than 25.4 mm. Intraoperative measurements done after harvesting the coracoid confirmed our cadaveric measurements because we found that the average length of the harvested coracoid graft was 25.1 mm. In the cadaveric study, all of the soft tissues around the coracoid were removed, so we could visualize and measure all around the coracoid with its soft tissue attachments and perform the osteotomy without any soft tissue obstruction to the placement of the osteotome.

Table I Cadaveric measurements of the coracoid

Specimen	Sex	Coracoid measurements (mm)													
		Distance from the coracoid tip to coracoclavicular ligament (trapezoid)		Under surface						Medial surface					
				Base		Middle		Tip		Base		Middle		Tip	
		Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1	Female	24.0	22.0	15.0	15.0	14.0	14.0	12.0	11.0	7.0	7.0	7.0	7.0	6.0	5.0
2	Male	25.8	26.0	13.4	14.2	13.0	13.0	12.0	11.0	7.6	7.6	7.1	7.0	5.5	6.0
3	Male	25.1	24.8	16.0	17.0	16.4	16.3	15.2	15.0	8.6	7.3	8.2	5.5	5.8	5.0
4	Male	24.7	24.3	14.0	13.3	13.0	13.4	13.0	13.5	7.0	7.0	7.0	6.4	6.3	4.3
5	Male	25.2	25.7	15.3	15.6	15.5	15.6	13.6	13.4	7.3	7.5	7.3	7.0	5.5	6.6
6	Male	26.0	25.0	15.0	15.0	15.0	14.0	12.0	12.0	7.0	7.0	7.0	6.0	6.0	6.0
7	Male	25.0	25.0	16.0	14.0	15.0	15.0	14.0	13.0	6.5	6.8	7.0	7.5	6.5	6.0
8	Male	29.0	29.0	15.0	15.0	14.0	15.0	10.0	11.0	6.0	6.0	6.5	6.5	7.0	6.0
9	Female	23.0	24.0	14.0	15.0	16.0	16.0	15.0	16.0	6.0	6.0	7.0	7.0	6.0	6.0
10	Male	27.0	27.0	14.0	14.0	16.0	15.0	17.0	14.0	8.0	8.0	6.0	8.0	6.0	8.0

Table II Intraoperative measurements after harvesting the coracoid

Patient	Length of the graft	Distance of the inferior hole from the lateral border	Width at inferior hole	Width at the superior hole	Sizes of the screw used	Glenoid bone defect
	L (mm)	i (mm)	w(i) (mm)	w(s) (mm)	(mm)	(%)
1	25	8	17.2	15	30	0
2	25	6	12.2	13	30	20
3	26	6	14.2	15	30	8
4	27	5	14.2	15	30	5
5	26	5	13.2	13	30	15
6	24	5	14.2	16	25	15
7	24	6	15.2	14	25	12
8	25	5	14	14	30	12
9	25	5	14	14	25	0
10	24	4	14	14	30	5

L, length of the coracoid; *i* distance of the inferior hole from the lateral border; *w(i)*, width of the coracoid at the inferior hole; *w(s)*, width of the coracoid at superior hole.

The surgical approach to the coracoid is usually done through a small 4-cm to 5-cm incision. Harvesting the coracoid through this miniopen approach is challenging because the medial muscle mass and soft tissues tend to push the osteotome or the saw distally, reducing the size of the graft. The lateral margin and lateral part of the undersurface of the coracoid is also not visible during the osteotomy. However, we harvested the coracoid in a controlled and precise manner with the help of a right-angled saw that has a thickness of 0.6 mm, directing it from the medial to the lateral border.

Because we were aware that a smaller coracoid graft will make the placement of screw holes too close to each other, we tried to place the saw as proximal and near to the trapezoid ligament as possible.

We also found that the harvested length of the coracoid always allowed us to use two 4.5-mm malleolar screws to fix it to the glenoid edge.

The average medial surface width measured in our cadaveric study was 7 mm, which is smaller than that found in other Western studies.[1] In addition, the coracoid was thinnest at the tip (6 mm). This explains why we used 30-mm and 25-mm malleolar screws during the Latarjet procedure and not the typical 35-mm as recommended by Walch and colleagues.[26,28] To ensure adequate fixation and union of the graft, the screws are recommended to have bicortical purchase in the glenoid.[22,28]

We found that the average width of the undersurface of the graft measured at 3 different sites (base, middle part, tip) in cadavers was 14.8 mm, 14.8 mm, and 13.2 mm. We also found that the intraoperatively measured width of the undersurface did not vary throughout the harvested coracoid length (14.2 mm and 14.3 mm at the level of the inferior and superior hole, respectively). The average distance of the lateral margin of the coracoid from the inferior hole was 5.5 mm.

If we account for the 3.2-mm hole in the middle part of the width, it would mean that the hole was placed 7.1 mm (1.6 mm + 5.5 mm) from the lateral margin. Thus, a hole drilled at 7 mm from the glenoid margin will avoid any overhang of the graft. This meant that the 7-mm rule could be followed in our population. The aim of the 7-mm rule is to position the graft flush or 1 mm to 2 mm medial to the glenoid to avoid any lateral overhang of the coracoid and prevent development of joint cartilage damage and osteoarthritis.[27]

We also found that the undersurface of the coracoid is wider than the medial surface throughout its length; hence, the classic Latarjet provides a bigger surface of coracoid graft for healing with the glenoid compared with the congruent arc Latarjet technique. This was also found in an earlier anatomic and biomechanical study.[16]

The size of the coracoid graft should be maximized for several reasons. Graft nonunion, graft fracture, fibrous union, and graft osteolysis are the common complications of the procedure.[4,7,23,28] Hence, a larger piece of the coracoid bone should be harvested to minimize the known complications and maximize the chances of healing of the graft with the glenoid.[27] If we wish to use two 4.5-mm screw and leave 3 mm of bone on each side of the screw with 1 cm of bone bridge between 2 screws, a 25-mm size should suffice (3 mm × 2 + 10 mm + 9 mm). However, using two 4.5-mm malleolar screws would be difficult if the size of the graft decreases further. Lafosse et al[12] have recommended the use of 3.5-mm screws. If the size of the graft is smaller, 3.5-mm screws should be used. A recent study found no biomechanical difference in the use of 3.5-mm and 4-mm screw size.[24] However, malleolar screws were not included the study.

Differences have been found in Indian and Western bony morphology and dimensions.[10] The safe length of coracoid osteotomy in our study is also smaller than that recommended in other studies. Intraoperatively, an average length of 26.4 mm was obtained during the classic Latarjet procedure by Young et al.[27] They reported wide variations in their size of the coracoid, and their biggest size was 32 mm. Intraoperatively, we found our average size was 25.1, and the biggest size was 27 mm. In addition, because we had a single-surgeon series, the technique was constant and yielded smaller variation in the sizes of the coracoid.

No other study has attempted to explain the intraoperative dimensions of the coracoid after harvesting. Kraus et al[11] used computed tomography (CT) scan data to measure the surface area of the coracoid graft after fixation and found an average area of 1.51 cm^2. They did not comment on the length and width of the graft separately.[11] Several other anatomic studies have recommended that a length of 2.5 cm to 3 cm of coracoid can usually be obtained distal to the trapezoid ligament.[5,25] Terra et al[25] found that the average distance from the tip of the coracoid to the trapezoid ligament was 3.3 cm. Dolan et al[5] said that the safe distance of osteotomy in their study was 2.85 cm.

However, there may be differences in what might be predicted in the anatomic studies compared with what might be the actual length of the coracoid obtained during surgery.[11] During the surgery, the junction of the horizontal and vertical part of the coracoid can be seen, but the trapezoid ligament may not be completely appreciated. Because it is desirable to preserve the attachment of the coracoclavicular ligaments,[18] the insertion of the trapezoid ligament will potentially limit the site of the osteotomy. Because we wanted to analyze our cadaveric measurements compared with intraoperative findings, we decided to do both cadaveric and intraoperative measurements.

The width of medial surface in our study was less than that found in other cadaveric studies.[14,18,20] Armitage et al[1] in their CT scan study found that the thickness of the coracoid was 10.5 mm, which is also bigger than the thickness we found in our study (7 mm). However, they measured the coracoids in the CT scan data of the shoulders whereas we measured the coracoid directly during the surgery and in the cadavers. We can argue that this finding may also be due to differences in the bony morphology of the Indian and Western population.

Whereas Rios et al[18] studied the thickness at the base, Ljungquist et al[14] studied distal to the knee of the coracoid. We studied at the tip, the middle part, and also at the base. Moreover, we measured the coracoid after the osteotomy to simulate the surgical procedure, whereas the other authors measured it in the intact coracoid.

The typical screw length in Walch series has been 35 mm with a range from 30 to 40.[28] In our series, however, the typical screw length was 30 mm and the range was 25 to 30 mm because our coracoid has narrower medial surface. This would also mean that Indian morphology might allow only small-diameter screws when fixing the medial surface of the coracoid via the congruent arc method. However, we did not study this aspect of the procedure, and it needs to be explored further. The size of the glenoid bone defect had no relation with the size of the malleolar screw. This can be explained by the fact that in cases with glenoid erosion, the bone loss is wide at the glenoid edge, whereas at a depth of 7 to 9 mm, where we typically drill the holes, the bone defect is minimal.[15]

The limitations of this study are that we studied only 10 patients and 10 cadavers, with a high male-to-female ratio, so we could not statistically compare the measurements between men and women. Another limitation was that we only studied the classic technique of Latarjet and with one type of screw system, so we cannot generalize our findings to other Latarjet variants using different types of screws.

Conclusion

The length of the cadaveric coracoid available for harvest and intraoperatively harvested coracoid in the Latarjet procedure was 25.4 mm and 25.1 mm, respectively. The average width of the undersurface of the cadaveric and intraoperatively harvested coracoid was 14.2 mm and

14.2 mm (at the level of inferior hole), respectively; hence the 7-mm rule of Walch could be followed. The medial surface width of the coracoid in our Indian morphology was an average of 7 mm, which is smaller than that found in Western morphology; hence, malleolar screws of 30 and 25 mm were used to fix the graft on the glenoid.

Disclaimer

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