The pectoralis major tendon as a reference for restoring humeral length and retroversion with hemiarthroplasty for fracture

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The success of anatomic reattachment of the tuberosities in proximal humeral fractures, treated with hemiarthroplasty, correlates with functional results. The purpose of this study was to determine the value of the upper edge of the pectoralis major insertion (PMI) as a landmark to establish the proper height and version of hemiarthroplasty implanted for proximal humeral fractures. Twenty cadaveric humeri were studied by CT scan to analyze the relationship between the PMI and humeral height and retroversion. The mean distance from the PMI to the tangent to the humeral head was 5.64 cm. The mean distance of the PMI to the posterior fin of the prosthesis was 1.06 cm. The mean angle between the PMI and the posterior fin of the prosthesis was 24.65°.

The upper edge of the pectoralis major insertion constitutes a reproducible reference point to restore proper humeral height and retroversion in hemiarthroplasty for proximal humeral fracture. (J Shoulder Elbow Surg 2008;17:947-950.)

Shoulder hemiarthroplasty is an established treatment for complex proximal humeral fractures, but the functional results obtained are often poor and unpredictable.3,4,8,9,12,13,14,17,19 One of the reasons for poor outcomes is malposition of the tuberosities on the prosthesis. The ability to restore proximal humeral anatomy in these complex fractures is of critical importance to obtain proper placement and secure fixation of the tuberosities to the prosthesis.2,3,14 Several methods have been proposed to restore proximal humeral height, such as the tension of the long head of the biceps, radiologic control of the distance between the prosthetic head and the undersurface of the acromion, and use of jig devices to assist in prosthesis positioning.2

Humeral head retroversion is so highly variable that several authors recommend implanting the prosthesis in a standard retroversion of 30°-40°, while others use the bicipital groove as a landmark. However, it has been documented that the bicipital groove shifts medially from proximal to distal, giving different values depending on the level of the fracture.2,5,7,8,10,12,13,15,18

The purpose of this study was to determine the value of the upper edge of the pectoralis major insertion as a landmark for establishing proper height and version of hemiarthroplasties implanted for proximal humeral fractures.

MATERIALS AND METHODS

All soft tissues, except the pectoralis major insertion, were removed from 20 cadaveric humeri. Of the cadavers, 12 were male and 8 female, with a mean age of 68 years (range, 54-96 years). There were 12 left and 8 right humeri. The upper edge of the pectoralis major insertion was marked with a metallic device, and another metallic device was placed one centimeter proximal to the first one and in line with the pectoralis major insertion. A computer tomographic (CT) study was performed on all the specimens. All the measurements were obtained from the CT scan images. Total humeral length was recorded for all specimens. The distance between the upper edge of the pectoralis major insertion to the tangent to the humeral head was also recorded (Figure 1).

The anatomic neck of the humerus was determined in the axial plane of the CT scan, and a perpendicular line was drawn to represent the posterior fin of a prosthesis. The CT scan slice, showing the upper insertion of the pectoralis major, was superimposed on that image, and the distance of the metallic marker to the posterior fin of the prosthesis was recorded as the angle formed by lines connecting the upper margin of the pectoralis major insertion to the center of the diameter of the anatomic neck and with the posterior fin of the prosthesis (a) (Figure 2). These measurements were also obtained for the metallic marker 1 cm, proximal to the upper edge of the pectoralis major insertion.
Qualitative variables are presented in absolute and percentage values. Quantitative variables are presented with mean values and standard deviation. Contrast among quantitative variables was done using the Student t test. \( P < .05 \) was considered statistically significant. Statistical analyses were performed with SPSS-Windows 12.0 (SPSS, Chicago, IL).

RESULTS

The mean total humeral length was 32.13 cm (31.01-33.26). The mean distance from the upper border of the pectoralis major insertion to the tangent to the humeral head was 5.64 cm (5.29-5.99). The distance was 1 cm less in 2 specimens (4.47 and 3.96) and 1 cm more (7.35) in 1 specimen. The mean distance from the upper border of the pectoralis major insertion to the tangent to the humeral head represents 17.55% (16.70-18.39) of the total humeral length. The mean distance from the upper margin of the pectoralis major insertion to the posterior fin of the prosthesis was 1.06 cm (0.88-1.25). The mean distance of the marker 1 cm proximal to the upper margin of the pectoralis major insertion to the posterior fin of the prosthesis was 1.17 cm (1.02-1.32). In 2 specimens, the distance was more than 0.5 cm less (0.55 and 0.51), and in 2, the distance was greater than 0.5 cm (1.68 and 2.01).

The angle between the upper border of the pectoralis major insertion and the posterior fin of the prosthesis was 24.65° (20.14°-29.16°). The angle between the 1-cm proximal reference marker to the upper margin of the pectoralis major insertion and the posterior fin of the prosthesis was 28.55° (24.26°-32.84°). In 3 specimens, the angle was decreased more than 10° (8°, 11°, and 13°) and was increased more than 10° (38°) in another.

No statistical differences were noted among the values obtained at the upper margin of the pectoralis insertion and those obtained at 1 cm, proximal to that insertion point (\( P = .692 \) and \( P = .626 \)).

No statistical differences were noted among right and left humeri for total humeral length (\( P = .063 \)); the mean distance from the upper edge of the pectoralis major insertion to the tangent to the humeral head (\( P = .622 \)); the mean distance of the upper border of the pectoralis major insertion to the posterior fin of the prosthesis, and the mean angle between the upper pectoralis major insertion and the posterior fin of the prosthesis (\( P = .915 \) and \( P = .680 \)).

DISCUSSION

Treating complex proximal humeral fractures with a hemiarthroplasty is challenging, because the displaced tuberosities provide no reference for where the prosthesis should be placed as far as height and retroversion is concerned. The poor and unpredictable functional results obtained when treating these fractures with hemiarthroplasty correlates with malposition of the tuberosities. To improve tuberosity
attachment, restoration of the anatomy of the proximal humerus is mandatory. It has also been demonstrated that lack of anatomic, geometric restoration leads to poor function.\textsuperscript{1,11}

No consensus exists about the best way to determine proper humeral height when implanting a hemiarthroplasty for proximal humeral fractures. Some authors use the tension of the long head of the biceps as a guide, while others use the distance of the humeral head to the undersurface of the acromion; however, as both of them rely on muscle relaxation by anesthesia, no reliable determination can be obtained. Others have suggested using specially designed jigs to reproduce predetermined humeral height; however, these jigs can be too bulky to use and interfere with testing of the reattachment of the tuberosities.\textsuperscript{2}

Anatomic studies have found a wide range of retroversion of the humeral head from -8° to +74°.\textsuperscript{6} Some authors suggest adjusting retroversion of the prosthesis to a fixed angle between 20° and 40°, despite the individual anatomic retroversion of each case. Others use the bicipital groove as a landmark for retroversion and suggest placing the posterior fin of the prosthesis 6.3-11.8 mm from the posterior edge of the bicipital groove.\textsuperscript{5,10,12,13,15,18} Detractors of the use of the bicipital groove as a landmark have shown how the bicipital groove shifts medially from proximal to distal, giving different humeral head retroversion values depending on the level of the fracture, with a mean change of 15.9° from the upper to the lower part of the bicipital groove.\textsuperscript{12}

Few studies comment on the advantages of using the upper edge of the pectoralis major insertion as a landmark for restoring humeral height, and none comments on its use for determining humeral head retroversion.\textsuperscript{16}

The results found in the present study agree with the results obtained by Murachovsky,\textsuperscript{16} with a mean distance from the upper part of the pectoralis major insertion to the top of the humeral head of 5.6 mm, with a 95% confidence interval. We have also found that the distance was decreased more than 1 cm (4.47 and 3.96) in 2 specimens and increased more than 1 cm (7.35) in 1 specimen. Therefore, if the prosthesis were implanted at 5.6 cm from the upper border of the pectoralis major insertion, the height error will be less than 1 cm in 85% of cases.

To be more accurate, we have shown that the distance from the upper margin of the pectoralis major insertion to restore the anatomy should be 17.55% of the total humeral length. Therefore, in clinical practice, when treating proximal humeral fractures with hemiarthroplasty, the anatomy can be restored by placing the prosthesis 5.6 cm above the upper insertion of the pectoralis major or by performing an x-ray of the contra lateral humerus. This is done to determine total humeral height and preoperatively calculate 17.55% of this value to determine where to place the prosthesis from the upper edge of the pectoralis major insertion.

Placement of the prosthesis in the proper retroversion can be achieved by placing the posterior fin 1.06 cm posterior to the upper border of the insertion of the pectoralis major or by placing the posterior fin at 24.65° with respect to the upper insertion line. With a 95% confidence interval, this position will reproduce the anatomy. We have also found a decreased distance of more than 0.5 cm difference (0.55 and 0.51) in 2 specimens and an increase of more than 0.5 cm (1.68 and 2.01) in 2.

If we consider the angle formed by the posterior prosthetic fin and the upper edge of the pectoralis, we have also found a decreased angle of more than 10° (8°, 11°, and 13°) in 3 specimens and an increase of more than 10° (38°) in 1. For clinical practice, to find the location of the upper pectoralis major in the fractured proximal humerus shaft,
a mark is drawn on the upper pectoralis major insertion. A second mark is placed 1 cm proximal to the first, following the pectoralis major insertion along the humeral shaft. The line connecting these 2 points is extended proximally along the humeral shaft until it connects with the fracture margin. The point where this line connects to the proximal fracture margin represents the superimposed pectoralis major insertion, and can be used as the landmark for measuring prosthetic retroversion in relation to the posterior prosthetic fin (Figure 3).

In conclusion, the upper border of the insertion of the pectoralis major constitutes a reliable reference point for reproducing anatomy in hemiarthroplasty for proximal humeral fracture.

REFERENCES