

Position of the Anterior Branch of the Axillary Nerve in Relation to the Humeral Bone Length

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Abstract

Many studies have attempted to define a safety zone for the axillary nerve in lateral approaches to the deltoid, but with varying results. The main objective of our study was to analyze the variations in the position of this nerve, especially in relation to the length of the humerus.

Overall, 16 cadaveric shoulders were dissected. The distances between both the anterolateral edge of the acromion (anterior distance) and the lateral edge of the acromion (posterior distance) to the axillary nerve were measured; the length of the humerus was also measured. Correlation analysis was performed between each distance and the length of the humerus.

The average anterior and posterior distance were 7.2 cm \pm 0.84 cm and 7.9 cm \pm 0.92 cm, respectively; the average length of the humerus was 30.7 cm \pm 3.2 cm. A significantly high positive correlation was found between the length of the humerus and both anterior distance ($P = .94$), and posterior distance ($P = .92$).

In shoulder surgery, prior measurement of the length of the humerus could predict the distance between the acromion and the axillary nerve, and determine its position.

The axillary nerve originates from the posterior cord of the brachial plexus and descends with an inferolateral route, passing in front of the subscapularis muscle. Then, it traverses the quadrilateral space at the lower edge of the subscapularis and divides into 2 branches: anterior and posterior. The anterior branch runs along the neck of the humerus deep

to the deltoid muscle in a subfascial plane and goes intramuscularly to give motor innervation to the middle and anterior portions of the deltoid.¹⁻⁴

The axillary nerve is mostly affected during various surgical procedures to the shoulder representing 6-10% of all lesions of the brachial plexus.^{5,6} All transdeltoid surgical exposures consist of splitting the fibers of the deltoid muscle, therefore presenting a potential risk of injury to the axillary nerve by either stretching or sectioning it.⁷

The location of the axillary nerve is usually described at 5 cm from the lateral edge of the acromion,^{7,8} but most studies are in agreement that there is significant anatomic variation from one person to another, with different results depending on the study.^{1,4,7,9-11} Therefore, the main objective of our study was to define the relationship between the length of the humerus and the position of the axillary nerve from the acromion, in order to define a security zone adapted to each individual preoperatively, and potentially reduce the risk of iatrogenic injuries to the anterior branch of the axillary nerve, while performing an anterolateral deltoid splitting surgery.

MATERIALS AND METHODS

We conducted an anatomical study on 16 cadaveric shoulders (ie, 8 shoulders embalmed in 10% formaldehyde and 8 fresh shoulders). All subjects were adult Caucasians of French origin; none of the individuals had previous shoulder surgery.

The landmarks we chose were the anterolateral and the lateral edges of the acromion, as they are conventionally used in surgical approaches. The dissection began following the deltopectoral groove. The deltoid muscle was then gradually dissected from the clavicle, acromion, and scapular spine. The interval between the anterior and middle deltoid was identified. The dissection of the axillary nerve deep to the deltoid was performed beginning from its emergence from the quadrangular space. The dissection was very meticulous and least aggressive possible to leave the nerve in its native atmosphere and not affect its position (Figure 1).

The position of the nerve and its branches were marked by transcutaneous pins to represent its course on the skin. Special attention was made to align the pins perpendicularly to the skin and deltoid. Then, the

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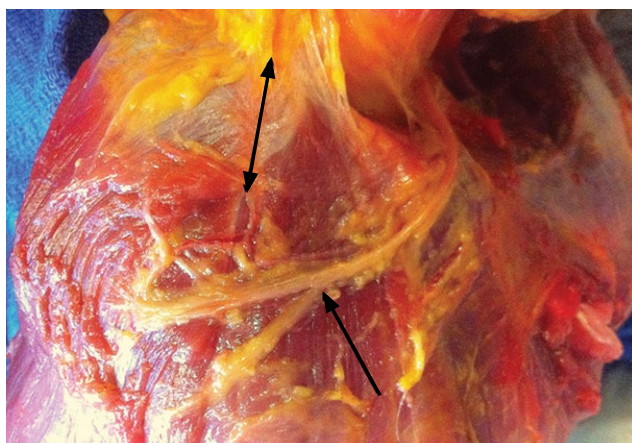


Figure 1. The inner surface of the deltoid muscle exposed showing the anterior branch of the axillary nerve. Interval between the middle and anterior fibers of the deltoid (double arrow); anterior branch of the axillary nerve with its terminal branches (single arrow).

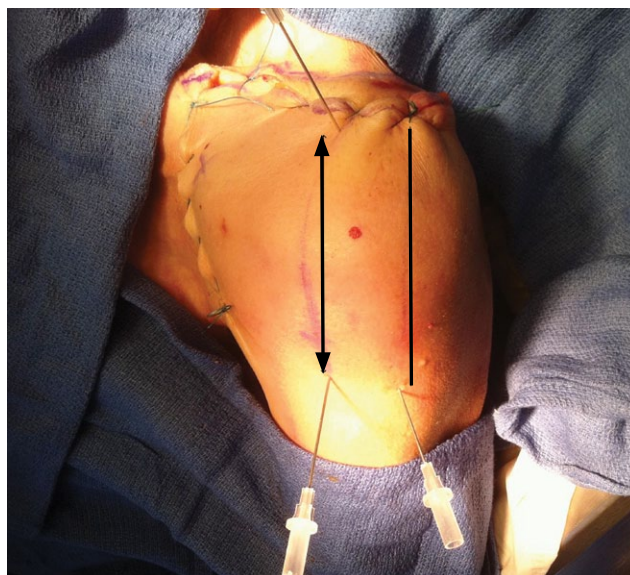


Figure 2. The deltoid muscle sutured back in its native original position. Transmuscular needles pointing to the position of the axillary nerve and showing anterior distance (double arrow) and posterior distance (line).

deltoid muscle was sutured back in its original anatomic position following specific needle landmarks (Figure 2). With the arms positioned along the body in neutral rotation, the following distances were measured in millimeters:

- Anterior distance (AD): the anterolateral edge of the acromion to the axillary nerve
- Posterior distance (PD): the lateral border of the acromion to the axillary nerve
- Length of the humerus (HL): the lateral epicondyle of the humerus to the top of the humeral head

The diameter of the axillary nerve and its length in the anterior deltoid were measured. The number of muscular branches and their distributions were also recorded. All dissections and measurements were made by the same operator. The ratios of the HL to the AD, and HL to PD, were calculated for each case and were recorded as an anterior index and a posterior index. The Kolmogorov-Smirnov test was used to verify the normal or Gaussian distribution of the variables. The correlation between the position of the axillary nerve in relation to the acromion and HL was evaluated using the Pearson correlation coefficient in a linear regression model. Variables were expressed by their means and their standard deviations.

RESULTS

The average AD was 72 mm \pm 8.4 mm (range, 60 to 85 mm), PD 79 mm \pm 9.2 mm (range, 65 to 90 mm), and HL 307 mm \pm 32 mm (range, 268 to 360 mm). The relationship between AD and HL were highly statistically significant ($r=0.94$; 95% Confidence Interval [CI], 0.82-0.98) (Figure 3). The relationship between PD and HL was also highly statistically significant ($r=0.92$; 95% CI, 0.78-0.97) (Figure 4). The mean values for anterior and posterior ratios were 0.23 \pm 0.02 and 0.25 \pm 0.02, respectively.

The axillary nerve was always located in the subfascial level, deep to the deltoid. In all the cases, there was only

one common trunk in the interval between the middle and anterior deltoid. The common trunk divided into 2 or more distal branches innervating the anterior portion of the muscle. Upon further dissection of the anterior branch of the axillary nerve at the anterior deltoid, we identified a subfascial portion with an average length of 13 mm (range, 5 to 25 mm), which continues following an intramuscular course with an average length of 18 mm (range, 10 to 25 mm).

DISCUSSION

The superolateral approach is increasingly used in shoulder surgery. It is conventionally used for acromioplasty, rotator cuff repair, reverse total shoulder arthroplasty, and anterograde intramedullary nailing of the humerus. Some surgeons prefer this approach to the deltopectoral approach for open reduction internal fixation of fractures of the proximal humerus and even arthroplasty. They attribute this to better visibility of the posterolateral portion of the humeral head and greater ease, while reducing tuberosity by lowering the risk of devascularization, and therefore, necrosis of the proximal end of the humerus.¹²⁻¹⁴

However, all transdeltoid surgical approaches hold a major risk of an axillary nerve lesion. The use of easily identifiable and reproducible anatomical landmarks pre- and intraoperatively, combined with anatomical knowledge of the operated area, is essential to reduce iatrogenic lesions to this nerve.

Numerous studies have shown significant anatomical variations in the position of the axillary nerve in relation to the acromion ranging from 3.5 cm to 7.5 cm on the lateral side of the shoulder,^{7,10} and 3.5 cm to 8.5 cm on the anterior side of the shoulder.^{4,7,9-11,15} These variations may be attributed to anatomical and morphologi-

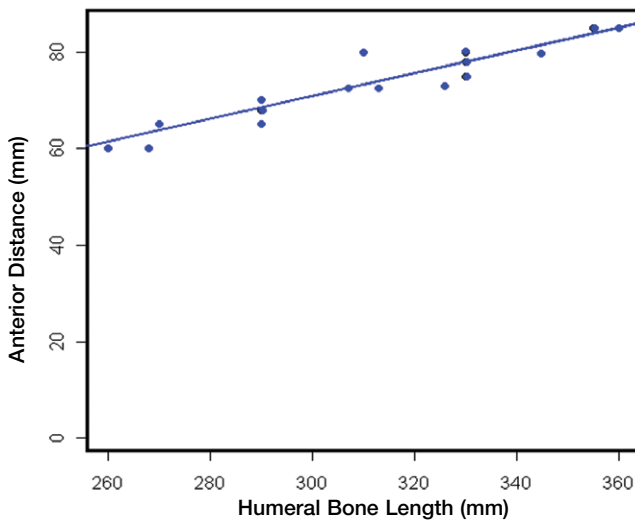


Figure 3. Graph showing the correlation between humeral bone length and anterior distance.

cal variability between individuals.

Duparc and colleagues¹ reported on 32 shoulders and found an average distance of 3.4 cm between the axillary nerve and the acromial insertion of the deltoid muscle. Kamineni and colleagues¹⁰ studied 40 shoulders and found that the axillary nerve was located at an average length of 5.7 cm away from the acromion on the lateral side of the shoulder, and approximately 5.1 cm on the anterior side. The reason that our study showed larger distances than what has been previously reported may be due to the fact that our measurements from the acromion were based on palpation, which we performed in order to simulate preoperative planning.

Variation by gender was described by Burkhart and colleagues,¹⁶ which placed the axillary nerve in men approximately 7.9 cm from the acromion at the anterior clavicular line and 6.9 cm in women. In a study of 102 shoulders, Burkhead and colleagues⁷ also found the distance between the middle edge of the lateral border of the acromion and the axillary nerve to be 5.4 cm in women and 6.2 cm in men, and the distance between the anterolateral corner of the acromion and the axillary nerve to be 5.2 cm in women and 6.1 cm in men.

These measurements may also vary depending on the position of the shoulder. According to Cheung and colleagues,¹⁷ 60° of abduction of the shoulder decreased the distance between the axillary nerve and the acromion from 7.57 cm to 6.16 cm (-19%) and it may decrease from 6.1 cm in to 4.5 cm in 90° of abduction (-27%).⁷

Other studies have shown a correlation between the position of the axillary nerve and deltoid muscle length.^{9,11} Nevertheless, we find it difficult to measure clinically the length of the deltoid muscle preoperatively.⁸

To the best of our knowledge, only one study, con-

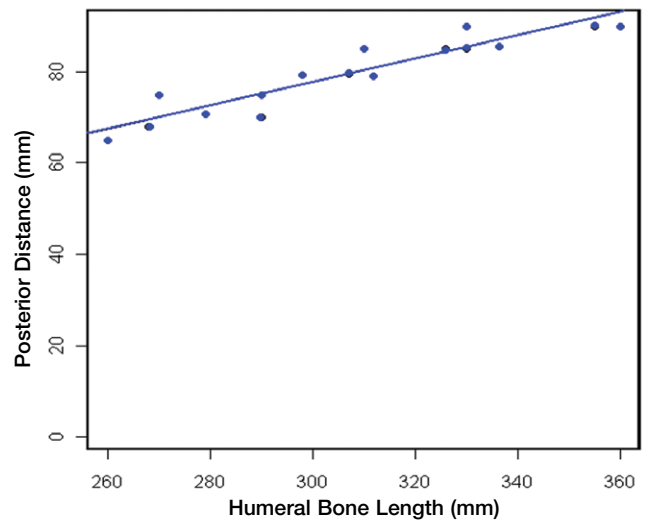


Figure 4. Graph showing the correlation between humeral bone length and posterior distance.

ducted by Cetik and colleagues,⁸ found a significant relationship between the position of the axillary nerve measured from the acromion and arm length, which they defined as the distance between the anterolateral edge of the acromion to the lateral epicondyle. The axillary nerve was identified using 2 landmarks: the anterolateral and posterolateral edges of the acromion. The average values of the corresponding ratios for anterolateral and posterolateral were 0.20 and 0.16, respectively. Similarly, we used easily identifiable and reproducible anatomical landmarks as the anterior edge of the acromion, which serves as a reference for most trans-deltoid approaches. In contrast to the study by Cetik and colleagues,⁸ we defined the true length of the humerus beginning from the top of the head to the lateral epicondyle. In addition, detachment of the distal insertion of the deltoid was done and special focus on the anterior branch was made in our study. We also identified the position of the axillary nerve on the skin to simulate preoperative templating. This was not done in the study by Cetik and colleagues,⁸ because in their cases, all the skin was removed and the nerve level was identified directly on the belly of deltoid, which may not give an accurate estimate and simulate preoperative prediction of the nerve's position. It should also be noted that all their cadavers were embalmed.

Our study had limitations, including the number of cadavers. A future study on living individuals using MRI or ultrasound may widen our knowledge on this nerve and confirm our results.

In conclusion, all surgical approaches on the shoulder hold some risk of axillary nerve lesion. Preoperatively, the position of this nerve may be approximated based on the length of the humerus, providing safe exposure to this area.

AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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