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Some anatomical characteristics of rotator cuff insertions into the greater tuberosity of the humerus in Vietnamese adults related to surgery

Manh Nguyen Huu[1], Dung Tran Trung[2*], Trinh Le Khanh[1], Toan Nguyen Minh[1], Tuyen Nguyen Trung[1]

[1] - *Department of Orthopedics Saint Paul General Hospital, Hanoi, Vietnam;*

[2] - *Faculty of Surgery, Hanoi Medical University, Vietnam;*

Corresponding author: *Dung Tran Trung, Associate Professor, Head of Orthopeadic Division, Faculty of Surgery, Hanoi Medical University, 1, Ton That Tung St., Dong Da District, Hanoi, Vietnam*

Abstract

Background: The anatomy of subscabpularis insertion is relatively clear. However, the other 3 rotator cuff muscles have the insertions into the greater tuberosity of the humerus, so the anatomy of these insertions so far not very clear. The research results of the authors are not consistent. The ***purpose*** of this study is to describe the anatomic characteristics of the insertion of 3 rotator cuff muscles (supraspinatus, infraspinatus, teres minor) on Vietnamese adults their application in surgery.

Materials and Methods: Descriptive study consisted of 20 shoulders of fresh cadavers with an average age of 63.2, not accompanied by rotator cuff lesions. These specimens were dissected and to reveal the rotator cuff tendons and their insertions in a consistent procedure. Anatomical features of cuff insertions were marked and scanned by a 3D scanner. Image data was extracted and analyzed by specialized 3D image processing software.

Results: The anterior edge of the 3 tendons tended to converge at one point. Distance from the superolateral point of the insertion sites of the supraspinatus (SSP), infraspinatus (ISP) and teres minor (TM) tendon to the cartilage margin and distance between these points were respectively BB_1 = 10.01 mm, GG_1 = 10.25 mm, KK_1 = 12.8 mm, ZZ_1 = 20.93 mm; BG = 8.05 mm, GK = 9.53 mm, ZK = 23.91 mm. The distance from the superolateral point of the supraspinatus insertion site to the bicipital groove was BB_2 =7.54 mm.

Conclusion: Some anatomical features of the rotator cuff insertions may help determine the locations of the anchors in rotator cuff repair surgery more accurately and nearly anatomically similar to the original insertions.

Keywords: anatomy, rotator cuff insertion, greater tuberosity, Vietnamese adults.

Introduction :

The surgical intervention number performed for total arthroplasty grows yer to yer. It means the increasingly greater patients' number is in need of rehabilitation therapy. And it is necessary to be high-quality and efficient. Shoulder dysfunction are the in case of rotator cuff disease incommon [1,2]. One of the basic things in rotator cuff repair surgery is a tendency to restore the tendon insertions similar to the original anatomy to restore the biomechanical function of the rotator cuff [3,4]. Anatomically, in order to properly repair the rotator cuff insertions, it is necessary to identify and clearly distinguish the insertion sites of each tendon and the distance from them to some clinically identifiable anatomical landmarks [2,5]. However, because the fibers of the rotator cuff tendons at the greater tuberosity insertions tend to intertwine and merge together into a rotator cable, it is difficult to distinguish the insertions of these tendons [6-10]. There are authors who have conducted cadaveric studies on the anatomy of the rotator cuff insertions. However, the research results are still variable in the morphology of each tendon insertion site. There has been no agreement on the boundary between the rotator cuff tendons at the attachment sites [5,7,9]. On the other hand, anatomically, the rotator cuff and shoulder joint capsular are different components. But in reality, there is a close association of the deep layer of the rotator cuff tendons with the fibers of the capsular from the glenoid rim to the humeral head. And in cases of

a full-thickness rotator cuff tear, there is always damage to both components [11-13]. So, the efficient arthroscopic repair needs more detailed information about joint anatomy and the detailed tendons attachment [13].

In the actual treatment of rotator cuff tear, we realize that understanding the anatomy of rotator cuff insertions will make the reparation more accurate. Therefore, we have conducted anatomical research on fresh cadavers to identify some anatomical characteristics of the rotator cuff insertions in Vietnamese adults related to cuff repair surgery.

MATERIALS AND METHODS :

The study consisted of 20 shoulders of 10 fresh cadavers, including 4 females and 6 males with an average age of 63.2 . These shoulder specimens were selected and excluded according to the following criteria:

Inclusion criteria :

- A fresh frozen adult cadaver with no lesions of the shoulder and have never been dissected.
- The cadavers were randomly selected.

Study methods :

This is a cross-sectional study of fresh cadaveric specimens.

Dissected techniques:

- The incision was made along the lateral edge of the spinatus and the acromion
- The deltoid origin at the acromion was released, the acromion was to expose the synovial bursae and rotator cuff tendons.
- The rotator cuff muscles were cut at a point 5 cm from the insertion.
- The humerus was cut at the position just above the deltoid insertion.
- The specimen was taken out, dissection was performed to remove the subacromial synovial bursae and expose the rotator cuff (Fig. 1).

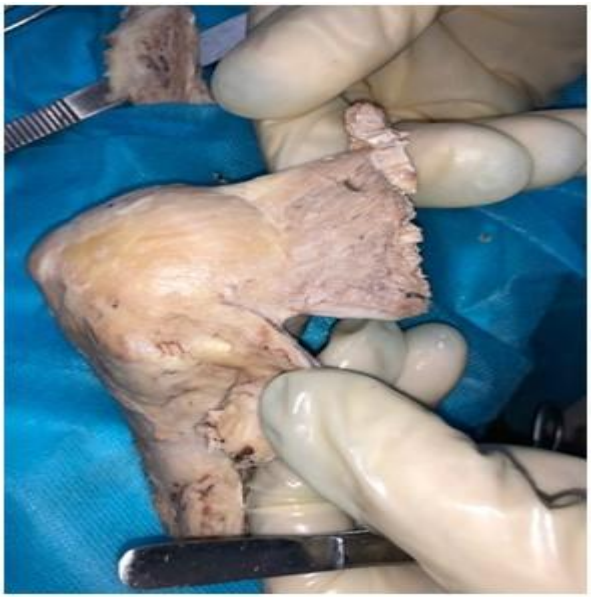

Fig. 1. Specimen is separated for analysis.

- Splitting along the anterior edge of the rotator cuff tendons to reveal the insertion site on the greater tuberosity. Mark the boundary between the tendons and lateral edge of the attachment site of each tendon (Fig. 2).

Fig. 2. Splitting along the anterior edge of the tendon.

- The tendon insertions were released and highlighted separately for each.
- The reference landmarks that can be observed and applied as landmarks during arthroscopic surgery were identified and marked: the articular cartilage margin, the lateral edge of the bicipital groove (Fig. 3).

Fig. 3. Marking the insertions of each tendon.

Measurement techniques :

The specimens were scanned by Go Scan 3D scanner (Creaform, 0.1mm accuracy) at to times:

- ✓ After revealing the subacromial synovial bursae.
- ✓ After revealing and marking the rotator cuff insertion sites.

Imported scanned and captured images into 3D scanning software, using Vxelementstm software to scan 3D images and Geomagic Studio software to measure and determine dimensions on 3D images (Fig. 4).

Fig. 4. 3D scanner and specialized processing software.

RESULTS:

It was interesting to note that the boundaries of the rotator cuff muscles tend to converge at a point on the lateral side of the greater tuberosity, which called the “rotator cuff convergence point” (Fig. 5).

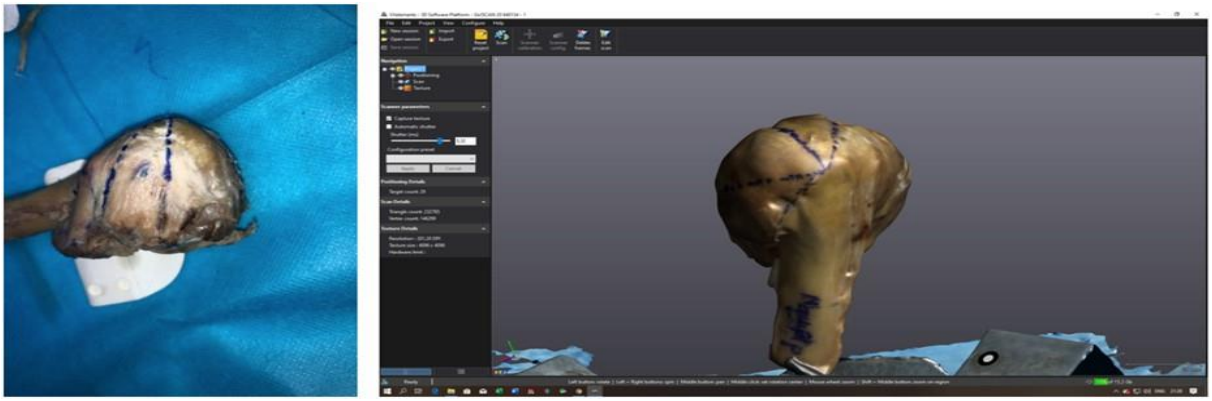

Fig. 5. Illustration of the rotator cuff convergence point on a photo and in 3D image.

The SSP and ISP tendons intertwine together at the insertions and cannot distinguish each tendon clearly. We see that the insertion site of the SSP and the ISP tendons has a trapezoid shape, and the insertion site of the TM tendon has a triangular shape. The SSP, ISP, and TM tendons attach to the superior, middle and inferior facet of the greater tuberosity, respectively.

Based on specialized software, we draw the landmarks on the 3D images of specimens and measure the distances related to the actual surgery of rotator cuff single-row repair.

- The most lateral point of the anterior edge of the SSP insertion site (point B): this is an important point as a milestone to determine the next locations. We determined this point based on two fixed landmarks that can be observed on the specimen and in surgery:

✓ Distance from this point to the lateral edge of the bicipital groove: BB2 = 7.54 mm (range 6.96-9.42 mm).

✓ Distance from this point to the cartilage margin: BB1 = 10.01 mm (range 8.03-14.46 mm).

- The most lateral point of the anterior edge of the ISP insertion site (point G): we determined this point based on:

✓ Distance from this point to point B: GB = 8.05 mm (range 5.78-10.75 mm).

✓ Distance from this point to the cartilage margin: GG_1 = 10.25 mm (range 8.48-12.2 mm).

- The most lateral point of the anterior edge of the TM insertion site (point K): we determined this point based on:

✓ Distance from this point to point G: KG = 9.53 mm (range 5.72-13.87 mm).

✓ Distance from this point to the cartilage margin: KK_1 = 12.8 mm (range 8.6-16.42 mm).

- The most inferior point of the lateral edge of the TM insertion site (point Z) (Fig. 6):

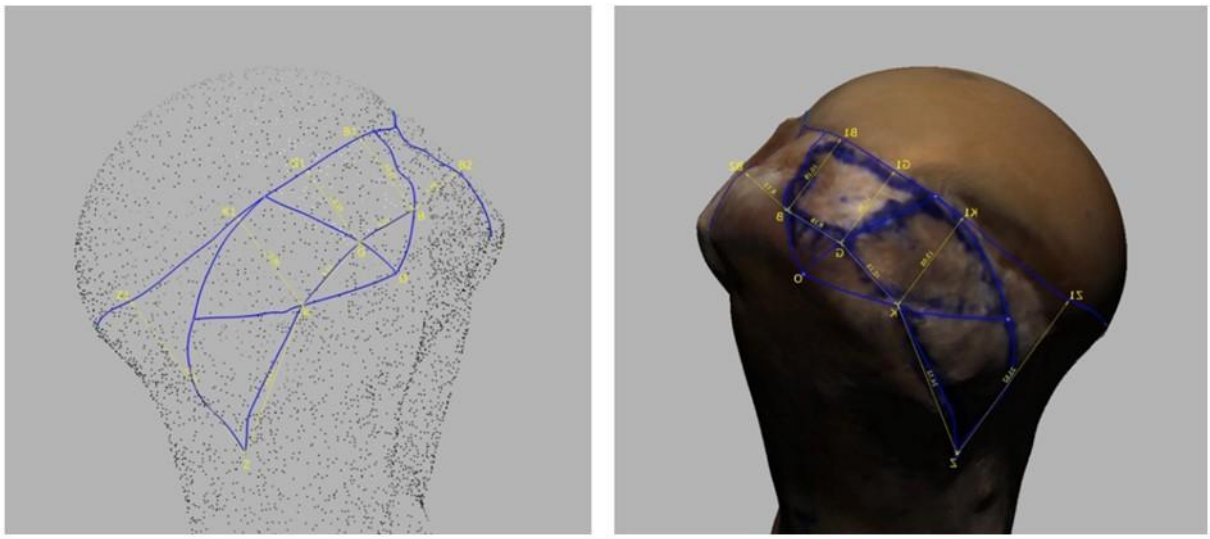

Fig. 6. Illustration of measuring landmarks.

we determined this point based on:

✓ Distance from this point to point K: ZK = 23.91 mm (range 19.3-31.64 mm).

✓ Distance from this point to the cartilage margin: ZZ_1 = 20.93 mm (range 15.5-26.83 mm).

DISCUSSION :

The surgical total arthroplasty is the way to get better life-quality for a large number of patients with joint pathology, especially in a not therapeutic case [14]. But practice surgeons have some difficulties because of not total detailed information on joint anatomy data. The authors of

anatomic studies of the rotator cuff insertions still have conflicting opinions. Some authors argue that the insertions of SSP and ISP tendon are interwoven, some then thought that these insertions are separate. This led to the morphology of the rotator cuff insertions that will vary according to the study authors [5,7,8,14]. Most previous studies suggested that most of the degenerative changes and tears of rotator cuff primarily began to occur in the SSP tendon and gradually spread to other sites [15,16]. In clinical practice, when observing the rotator cuff tear in arthroscopic surgery, we found that the rotator cuff tendons had no clear separation. Based on the reality of the rotator cuff anatomy, we have a different viewpoint on the application of the insertion site's anatomy during the surgery. Because the fibers of the rotator cuff tendons intertwine with each other at the location of rotator cable, close to the insertion sites on the greater tuberosity, so when the rotator cuff tendons were torn, they will be both injured. Most surgeons only need to be concerned about how the reparation can cover the tear area to match the original anatomy without the tear [13,16]. For small tears, this may seem simple. However, with the large or massive tears, this problem seems to be complicated and confusing for surgeons because they do not know what fixed landmarks to use to place the anchors so that after reparation the insertion site will return to be most similar to the original anatomy. Klein and Burkhart presented two easily recognizable landmarks: supinatus and coracoid process. However, they are only significant in distinguishing and interval slide technique [17].

Single-row is a long-standing method of rotator cuff repair techniques with the anchors were placed in a straight line from anterior to posterior of the greater tuberosity, corresponds to the lateral position of the tear [18,19]. Therefore, the characteristics of the rotator cuff insertion site on the lateral edge of the greater tuberosity will be paid more attention by the surgeons during the place the anchors. Because of this, and because we want to simplify the study, we only focus our research on the anatomical features that are much involved in the single-row rotator cuff repair technique.

In previous studies, most of the specimens were directly measured and photographed during perform dissection, which led to higher errors, the omission of data and difficulty in reusing when there are new ideas of researching [2,4,6,14,20]. With Creaform's 3D color scanner with an accuracy of 0.1mm, along with specialized 3D measurement and rendering software, we can save images with the actual size of the sample and ensure high accuracy. The discovery of the "rotator cuff convergence point" is very significant in determining the lateral boundary of the rotator cuff insertion sites on the greater tuberosity. According to our dissection technique, the SSP and ISP insertion sites were trapezoidal, the TM insertion site was triangular. The SSP, ISP, and TM insertion sites were on the superior facet, middle facet and inferior facet of the greater tuberosity, this is similar to that of Minagawa et al (6). Mochizuki also said that the SSP insertion site is located on the superior part of the greater tuberosity, the ISP insertion site is more inferior and posterior. However, the SSP insertion site is triangular, while the ISP insertion site is trapezoidal [8]. A.S. Curtis also has a similar opinion about the order of the location of the insertion sites on the greater tuberosity [5]. Although there is a similar judgment about the location of the insertion sites on the greater tuberosity, the characteristics of the insertion site size do not appear to be similar, and we found it difficult to apply these characteristics during arthroscopic surgery.

The average value of the distances from the most superior point of the lateral edge of the SSP, ISP and TM insertion sites to the cartilage margin in our study were BB_1 = 10.01 mm, GG_1 = 10.25 mm, KK_1 = 12.83 mm, respectively. Regarding the length of the insertion sites, we also only care about

the length of the lateral edge of these sites: GB = 8.05 mm, KG = 9.53 mm, ZK = 23.91 mm. This measure is different from the normal measurement of other authors is to calculate the average distance between the lateral and medial edge and the distance between the anterior and posterior edge of the insertion sites (5,7,9). Regarding the distance between the anterior edge of the SSP insertion site and the bicipital groove, we only measure the distance between the most lateral point of the anterior edge of the SSP insertion site and the lateral edge of the bicipital groove: BB_2 = 7.54 mm. The most medial point of the anterior edge of the SSP insertion site is generally located near the anterior edge of the greater tuberosity, which was also pointed out by H. Minagawa et al. in their study [7].

The identification of certain anatomical fixed landmarks is very important in distinguishing the tendons and in surgery. However, some landmarks are only meaningful when the tendon is intact, such as the superior margin of the “sulcus” (anatomic neck without cartilage) in H. Minagawa study. This landmark has a relative significance in determining which tendon is torn in cases of a small and non-spread tear. In cases of large tear or tear spread to the superior margin of the sulcus, it is difficult to identify this area. In the study of J. Liu et al., the authors showed that the deviation of the anchors placement can affect the biomechanics. Yamamoto et al. also found that the deviation of the anchors position (medially) also affected the shoulder range of motion [3,4].

During arthroscopic cuff repair the anchors are usually placed in order from anterior to posterior [21,22]. In cases of massive tear, it is difficult to determine the location of anchors on the greater tuberosity that is suitable for anatomy [22,23]. With the characteristics of the single-row repair technique mentioned above along with the determination of the distance from the most lateral point of the anterior edge of the SSP insertion to 2 fixed landmarks that can be observed and clearly identified during arthroscopy (the bicipital groove and the cartilage margin), we can determine the first reasonable anchor position. After obtaining the first anchor position, based on the distances between the most lateral points of the anterior edge of the SSP, ISP and TM insertion and the distances from them to the cartilage margin, we can determine the next anchor positions (Fig. 7). Restoring the rotator cuff insertions nearly identical to anatomy will limit the biomechanical effects.

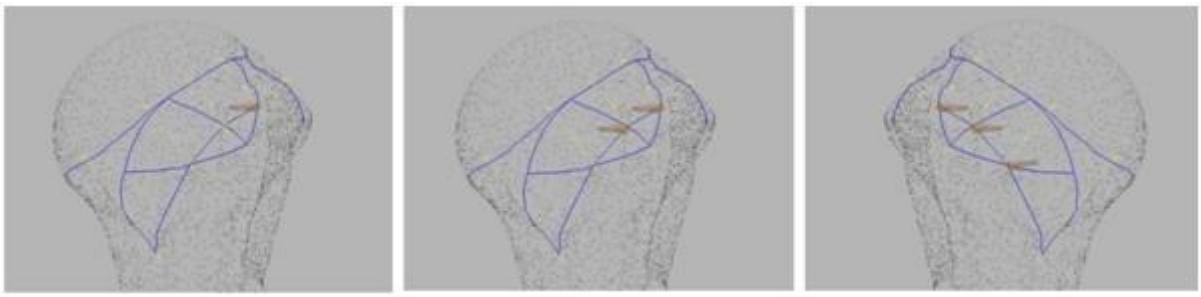

Fig. 7. Imaging of the Shoulder: Sonoanatomy and Sonopathology Atlas of the Shoulder Including Anatomy, Radiography and Arthroscopy. Illustration of the location of the anchors in the single-row rotator cuff repair technique.

CONCLUSION :

The supraspinatus, infraspinatus, and teres minor insertions covering the superior, middle, and inferior facet of the greater tuberosity. Some anatomical features of the lateral edge of rotator cuff insertions on the greater tuberosity along with the use of two observable fixed landmarks during arthroscopy (the cartilage margin and the bicipital groove) may help determine the

locations of the anchors in rotator cuff repair surgery more accurately and nearly anatomically similar to the original insertions.

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