

Optimal Methods for Shoulder Tendon Palpation: A Cadaver Study

Background and Purpose. Physical therapists often must either palpate tendons of the shoulder or, as part of treatment, apply forces to those tendons. Many methods have been suggested for minimizing the amount of soft tissue that overlies these tendons, but no data have been presented to justify the use of any approach. The purpose of this study was to evaluate methods described in the literature by use of cadaver models. **Subjects.** Twenty-four shoulders from 12 cadavers of individuals aged 55 to 92 years were dissected. **Methods.** Shoulders were placed in the positions described in the literature, and the positions in which the tendons were maximally exposed (ie, had the least overlying tissue) were noted. **Results.** Positions were found in which tendons were maximally exposed. **Conclusion and Discussion.** Positions described in the literature for optimizing the exposure of shoulder tendons are not always optimal, and palpation and treatment may be improved by using positions determined by research such as those suggested in this report. [Mattingly GE, Mackarey PJ. Optimal methods for shoulder tendon palpation: a cadaver study. *Phys Ther.* 1996;76:166-174.]

Key Words: *Anatomy, Biceps, Cadaver, Infraspinatus, Palpation, Shoulder, Subscapularis, Supraspinatus, Tendons, Teres minor.*

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Tendinitis associated with the shoulder joint is a common clinical problem in patients referred to physical therapy. Frequently affected tendons include the rotator cuff (supraspinatus, infraspinatus, teres minor, and subscapularis) and the tendon of the long head of the biceps brachii muscle. Physical therapy for tendinitis can include a variety of modalities, including ultrasound, phonophoresis, iontophoresis, and various massage techniques. The effectiveness of these procedures are dependent on the depth of penetration of the modalities and the accessibility of these tendons.¹ With the shoulder in the anatomical position, these tendons are not readily accessible because they reside deep to either the acromion (supraspinatus and infraspinatus) or the normally thick deltoid muscle (teres minor, subscapularis, and biceps brachii). Cyriax was one of the first clinicians to use an understanding of clinical anatomy gained from many years of patient treatment to develop specific clinical postures (James Cyriax, personal communication, 1981). Many authors have developed a variety of patient-specific postures for repositioning the shoulder tendons to make them more accessible for treatment.¹⁻¹⁵ Yet, these authors do not indicate how these treatment postures were established. In addition, these methods are often vaguely described, and positioning may be inconsistent due to a lack of goniometric measurements.

The purposes of our study were to review the literature on palpation methods for shoulder tendons, to evaluate these proposed methods by cadaver dissection, and to propose an optimal method of shoulder tendon palpation.

Supraspinatus Tendon

The supraspinatus tendon inserts on the superior facet of the greater tuberosity of the humerus.¹⁶ In addition, the tendon also attaches directly to the capsule of the glenohumeral joint. With the shoulder in the anatomical or neutral position, the supraspinatus tendon is deep to the acromion of the scapula. In this position, the tendon is inaccessible to palpation, massage, and most other forms of treatment. Four different positions that supposedly reposition the supraspinatus tendon from under the acromion to a more accessible area have been described.²⁻¹⁴ None of these cited positions include goniometric measurements.

The most widely reported shoulder position for accessing the supraspinatus tendon was first described by Cyriax^{2,3} and subsequently adopted by others.⁴⁻⁹ Cyriax described this position as full medial rotation with adduction and slight hyperextension. This position is readily obtained by placing the patient's forearm behind the lower back. These authors²⁻⁹ reported that this position allows the supraspinatus tendon to be palpated anterior to the acromion. Cyriax³ further stated and illustrated that with this position the tendon passes "near vertical," lateral, and parallel to the bicipital groove.

Another suggested position requires medial rotation, extension, and adduction of the shoulder. Hawkins and Bokor¹⁰ suggested obtaining the position by placing the patient's forearm on the patient's abdomen. With the patient's shoulder in this position, Hawkins and Bokor claimed that the insertion of the supraspinatus tendon can be palpated anterolateral to the acromion.

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A third proposed position is hyperextension of the shoulder. Hoppenfeld¹¹ and Boublik and Hawkins¹² reported that in this position the supraspinatus tendon is exposed anterior to the acromion.

A fourth proposed position for accessing the supraspinatus tendon is neutral or "slight" hyperextension of the shoulder. Nicholson and Clendaniel¹³ and Kessler¹⁴ suggested that the supraspinatus tendon insertion can be found anterior to the acromion in this position. Kessler further stated, "It is essential that the tendon be located by knowledge of anatomy; it cannot be distinguished by palpation."^{14(p199)}

Infraspinatus and Teres Minor Tendons

The tendons of the infraspinatus and teres minor muscles insert next to each other on the middle and lowest facets of the greater tuberosity. These tendons also make an attachment to the capsule of the shoulder joint. The tendons of the infraspinatus and teres minor muscles are inferior to the supraspinatus muscle and deep to the deltoid muscle. Three shoulder positions that supposedly allow better access to these two tendons have been proposed in the literature. No goniometric measurements, however, were cited by the authors.^{2-6,8,11,12}

One treatment position described initially by Cyriax^{2,3} and later by Magee⁵ has the patient lie prone on the elbows with the shoulder in flexion, slight lateral rotation, and slight adduction. With the patient in this position, the tendon of the infraspinatus muscle is reported to be located just below the lateral extent of the scapular spine (acromial angle). The tendon of the teres minor muscle is just inferior to the tendon of the infraspinatus muscle.

Hoppenfeld¹¹ and Boublik and Hawkins¹² proposed a position of shoulder hyperextension to allow better access to the infraspinatus and teres minor tendons. This is the same position proposed for exposing the supraspinatus tendon, as mentioned previously. The authors claimed that with the shoulder in this position, the tendons of the supraspinatus, infraspinatus, and teres minor muscles can be palpated as a unit anterior to the acromion.

A third proposed position places the shoulder in full medial rotation, with adduction and slight hyperextension.^{4,6,8} This is the same position as the forearm-behind-the-back position that was used to expose the supraspinatus tendon. The authors^{4,6,8} suggested that in this position the infraspinatus and the teres minor muscles can be palpated anterior to the acromion, immediately posterior to the supraspinatus tendon.

Subscapularis Tendon

The insertion of the subscapularis tendon is on the lesser tuberosity of the humerus and makes an attachment to the anterior capsule of the glenohumeral joint. In the anatomi-

cal or neutral position, the tendon is under the anterior aspect of the deltoid muscle. Two shoulder positions have been proposed to allow for better access to the subscapularis tendon. For these muscles, no goniometric measurements were cited by the authors.^{2-4,8}

Cyriax^{2,3} proposed a position of shoulder adduction and medial rotation for accessing the subscapularis tendon. This positioning allows the examiners to slip their fingers just medial to the upper medial border of the deltoid muscle to palpate directly over the insertion of this muscle. Cyriax argued that the tendon cannot be distinguished from the underlying bone. The second position, as proposed by Halbach and Tank⁴ and Yahara,⁸ is shoulder extension and lateral rotation. The authors suggested that in this position the lesser tuberosity of the humerus and the area of insertion of the subscapularis tendon can be readily identified. Hoppenfeld,¹¹ however, asserted that because of its anterior location the tendon of the subscapularis muscle cannot be palpated.

Tendon of the Long Head of the Biceps Brachii Muscle

The tendon of the long head of the biceps brachii muscle passes through the bicipital groove of the humerus, then through the capsule of the glenohumeral joint to make its ultimate attachment to the superior glenoid tubercle of the scapula. In the anatomical or neutral position, the tendon is deep to the anterior part of the deltoid muscle. The literature cites three proposed shoulder positions for identifying and gaining better access to the tendon of the long head of the biceps brachii muscle.^{2-4,10-12,15}

Cyriax,^{2,3} followed by Hawkins and Bokor¹⁰ and Burkhead,¹⁵ proposed a posture of shoulder adduction and medial rotation. Hawkins and Bokor and Burkhead suggested that 10 degrees of medial rotation is necessary to bring the bicipital groove to an anterior position. Cyriax stated that the patient should place his or her hand on his or her lap while adopting a "half-lying position on a couch" to draw the bicipital groove to the anterior position. Hawkins and Bokor further stated that in their proposed position the anterior edge of the deltoid muscle that overlies the bicipital groove can be confused with the biceps tendon and that the tendon cannot be palpated except in very thin individuals. Burkhead claimed that the tendon can be palpated in this position by palpating 7.6 cm (3 in) below the anterior acromion. Burkhead also stated that with additional rotation the tendon disappears under the short head of the biceps brachii muscle and the coracoid process.

Halbach and Tank⁴ advocated use of a position of lateral rotation of the shoulder. These authors suggested that in this position the bicipital groove can be identified between the greater and lesser tuberosities. They also suggested that in some people the tendon of the long head of the biceps

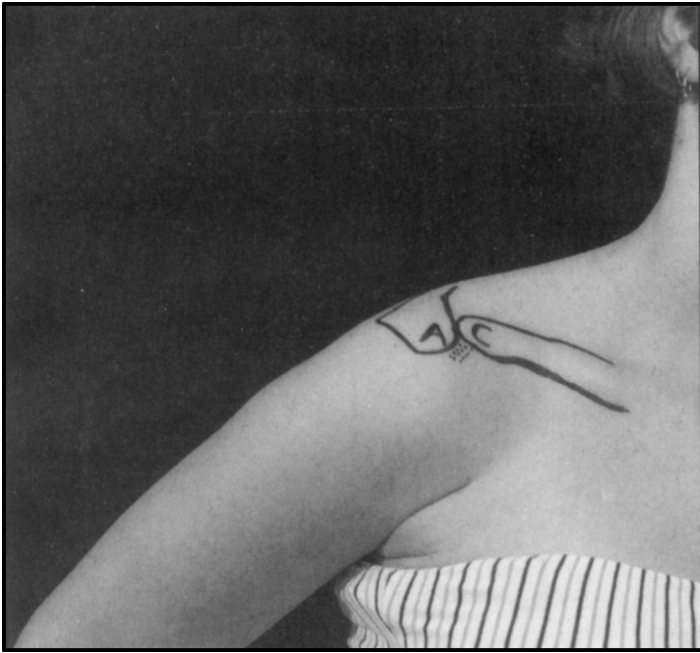


Figure 1. Model positioned sitting with shoulder position of maximal adduction, medial rotation, and hyperextension, producing maximal exposure of supraspinatus tendon. Stippling represents amount of exposure and location of supraspinatus tendon in relationship to anterior acromion (A) and lateral clavicle (C).

brachii muscle is impossible to discern because of the mass of the overlying deltoid muscle.

Hoppenfeld¹¹ and Boublik and Hawkins¹² proposed a position in which the shoulder is in the neutral position. Boublik and Hawkins stated that with this posture the biceps tendon can be palpated midway between the apex of the axilla and the lateral border of the deltoid muscle, approximately 2.5 cm (1 in) distal to the acromion. Hoppenfeld did not describe the position, but he used a figure demonstrating the palpation of the biceps brachii muscle with the shoulder in the neutral position.

Many authors have presented a wide variety of patient-specific positions for repositioning the shoulder tendons for the purpose of making them more accessible for treatment. Yet, these positions have often been described without reference to goniometric measurements of joint position, and their use is not supported by data.

Method

In our study, we used 24 shoulders from 12 embalmed cadavers. Six cadavers were male, and 6 cadavers were female. The ages at the time of death ranged from 55 to 92 years ($\bar{X}=79.6$, $SD=10.3$).

All shoulder specimens were dissected in the same manner. After the skin and subcutaneous fat were removed, the deltoid muscles were cut from their origin on the scapular

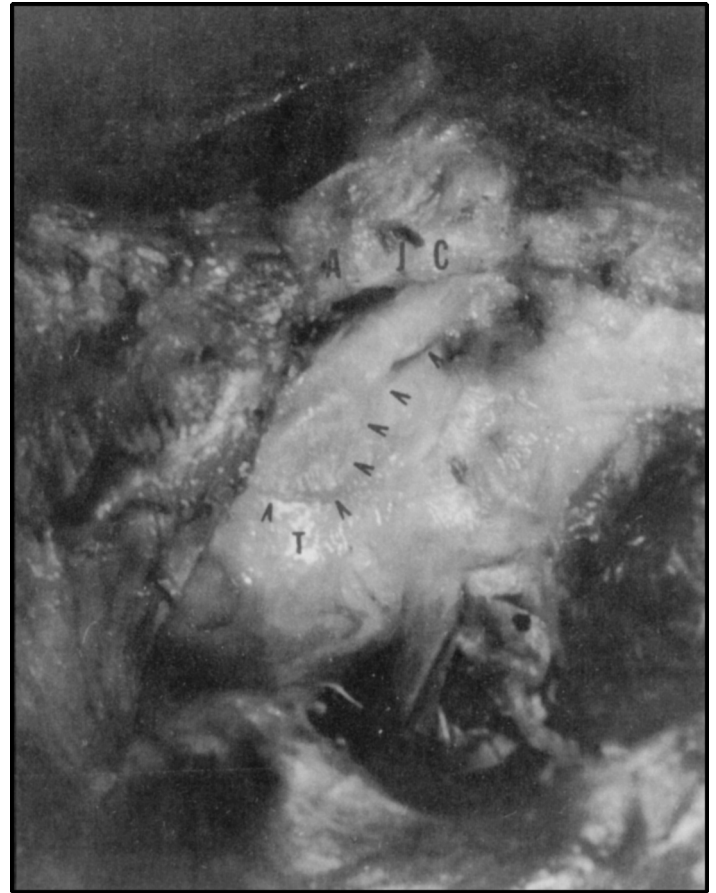


Figure 2. With cadaver in position depicted in Figure 1, dissection showing exposure of distal portion of supraspinatus tendon (outlined by arrows) in relationship to the anterior acromion (A), lateral clavicle (C), acromioclavicular joint (J), and greater tuberosity of humerus (T).

spine, acromion, and lateral clavicle. The deltoid muscles were then reflected to their insertion on the deltoid tuberosity. Surrounding fat and fascia were removed to allow a clearer view of the major tendons of the shoulder. All muscles and associated tendons of the shoulder were intact, with no evidence of pathological change. All shoulders were then placed in the positions proposed in the literature within the limitations of the inherent cadaver rigidity. For each position, tendon exposure was noted. The shoulders were then placed in the position that allowed the maximum visual exposure of the target tendon for treatment purposes. While in these selected positions, goniometric measurements were taken of the shoulders using the procedures described by Norkin and White.¹⁷

The supraspinatus tendons were observed in the following positions: (1) with the forearm behind the back and with the shoulder in full medial rotation, adduction, and slight hyperextension; (2) same position as with the forearm behind the back but with maximal hyperextension; (3) with the forearm on the abdomen and with the shoulder in medial rotation



Figure 3. Model positioned supine in forearm-behind-the-back shoulder position, producing minimal exposure of supraspinatus tendon. Stippling represents amount of exposure and location of supraspinatus tendon in relationship to anterior acromion (A) and lateral clavicle (C).

and extension; (4) hyperextension; and (5) neutral or slight hyperextension.

The infraspinatus and teres minor tendons were observed in the following positions: (1) with the cadaver positioned prone on the elbows with the shoulders in flexion, slight lateral rotation, and slight adduction; (2) with the cadaver positioned sitting with the shoulders in flexion, slight lateral rotation, and slight adduction; (3) hyperextension; and (4) with the forearm behind the back as mentioned previously.

The subscapularis tendons were observed with the shoulders in the following positions: (1) adduction and medial rotation, (2) extension and lateral rotation, and (3) simple adduction.

The tendons of the long head of the biceps brachii muscle were observed with the shoulders in the following positions: (1) adduction and medial rotation, (2) lateral rotation, and (3) neutral.

Results

All 24 shoulders displayed similar amounts of visual tendon exposure when placed in the various positions.

Supraspinatus Tendon

The shoulder position that produced the maximum visual exposure of the supraspinatus tendon with the least amount of overlying tissue was maximal shoulder adduction, maximal medial rotation, and maximal hyperextension (Fig. 1). In this position, the distal portion of the supraspinatus tendon is repositioned from under the acromion to a point



Figure 4. With cadaver in position depicted in Figure 3, dissection showing exposure of distal portion of supraspinatus tendon (outlined by arrows) in relationship to the anterior acromion (A), lateral clavicle (C), acromioclavicular joint (J), and greater tuberosity of humerus (T).

anterior to the acromioclavicular joint (Fig. 2). This position is similar to the forearm-behind-the-back position except for the maximal degree of hyperextension; that is, the forearm is held as far posterior from the lower back as the patient can tolerate. In this position, elbow flexion was maintained at approximately 90 degrees. Shoulder adduction was approximately 10 degrees and limited by contact with the thoracic wall. Medial rotation ranged from 80 to 90 degrees. Hyperextension ranged from 30 to 40 degrees. The amount of exposure of the tendon is predominately dependent on the amount of hyperextension. When the forearm-behind-the-back position was studied, less of the tendon was exposed (Figs. 3, 4) as compared with the previous position.

The next position studied was hyperextension alone. Hyperextension up to 40 degrees alone was less successful in exposing the supraspinatus tendon than were the prior two positions.

The last two positions of forearm on the abdomen and neutral or slight hyperextension did not expose the supraspi-

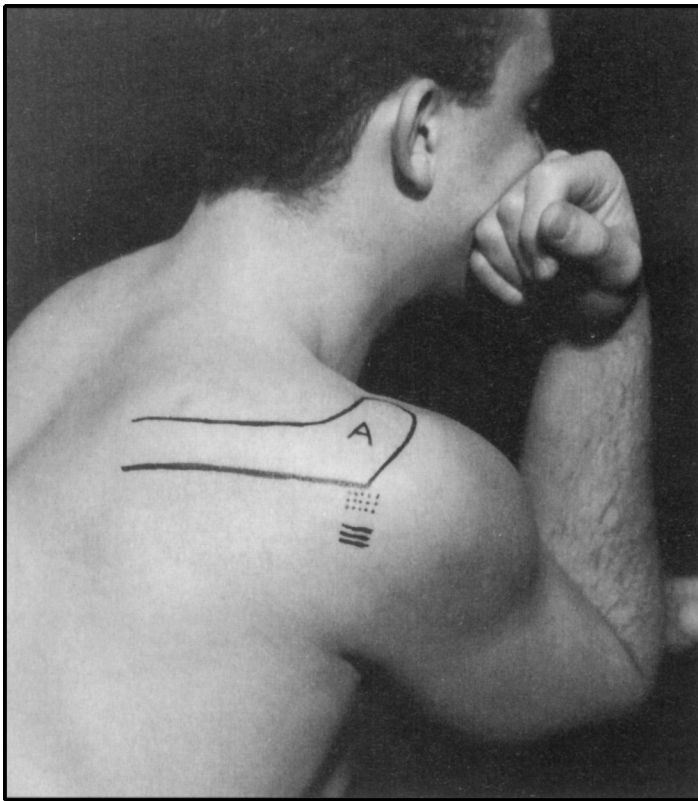


Figure 5. Model positioned sitting in shoulder position of flexion, adduction, and lateral rotation, producing maximal exposure of infraspinatus and teres minor tendons. Stippling represents distal portion of infraspinatus tendon, and parallel lines represent distal portion of teres minor tendon in relationship to posterior lateral acromion (A).

natus tendon. In these positions, the tendon of the muscle remained under the acromion.

Infraspinatus and Teres Minor Tendons

The position that produced maximum visual exposure of the infraspinatus and teres minor tendons with the least amount of overlying tissue was shoulder flexion to 90 degrees, 10 degrees of shoulder adduction, and 20 degrees of shoulder lateral rotation. In this position, the infraspinatus tendon is deep to the posterior deltoid muscle and inferior to the acromial angle. Cyriax^{2,3} advocated using this shoulder position with the patient lying prone. We found that this shoulder position exposes the tendons to the same degree as with the patient sitting (Fig. 5). The teres minor tendon is deep to the deltoid muscle and inferior to the tendon of the infraspinatus muscle.

The remaining two positions, hyperextension and forearm behind the back, did not place the tendons anterior to the acromion as reported.^{4,6,8,11,12} With the cadaver limbs in these positions, the infraspinatus tendon is repositioned under the acromion and the teres minor tendon is inferior to the angle of the acromion.



Figure 6. Model positioned supine in shoulder position of adduction, neutral flexion/extension, and neutral medial/lateral rotation, producing maximal exposure of subscapularis tendon in the deltopectoral triangle. Deltopectoral triangle bounded by medial deltoid muscle (D), inferior clavicle (C), and lateral pectoralis major (P) muscle.

Subscapularis Tendon

The position that allowed maximum visual exposure of the subscapularis tendon with the least amount of overlying tissue was with the shoulder adducted to the side of the thorax and neutral in terms of flexion/extension and medial/lateral rotation (Fig. 6). In this position, the tendon can be located deep in the deltopectoral triangle between the long and short heads of the biceps brachii muscle. By using the "doorway" of the deltopectoral triangle, the tendon of the subscapularis muscle can be palpated without the intervening deltoid muscle.

The proposed position of adduction and medial rotation of the shoulder also places the tendon in the deltopectoral triangle between long and short heads of the biceps brachii muscle. Yet, with this position, only the insertion of the subscapularis tendon can be palpated. Most of the tendon of the muscle is found deep to the short head of the biceps brachii muscle and the coracobrachialis muscle.

The position of shoulder extension and lateral rotation places the lesser tuberosity and the attached tendon of the subscapularis muscle deep to the deltoid muscle.

Tendon of the Long Head of the Biceps Brachii Muscle

The best shoulder position for maximum visual exposure of the tendon of the long head of the biceps brachii muscle with the least amount of overlying tissue was shoulder adduction (0°) with approximately 20 degrees of medial

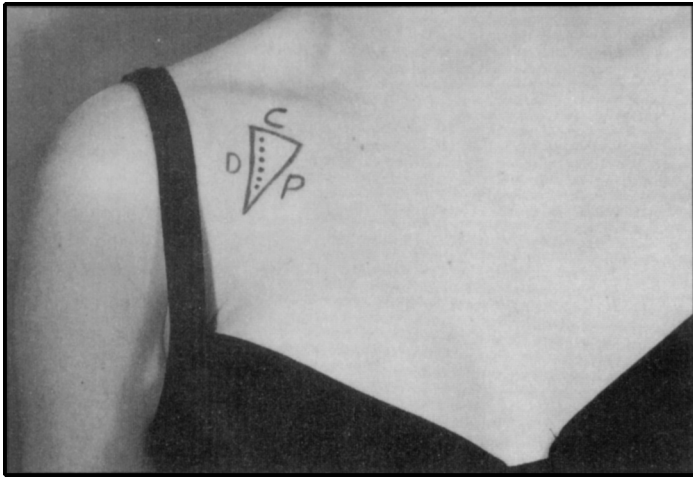


Figure 7. Model positioned supine in shoulder position of abduction and medial rotation ("hands-on-lap" position), producing maximal exposure of the tendon of the long head of the biceps brachii muscle in the deltopectoral triangle. Deltopectoral triangle bounded by medial deltoid muscle (D), inferior clavicle (C), and lateral pectoralis major muscle (P).

rotation (Fig. 7). In this position, the tendon is in the deltopectoral triangle. By using the triangle, the tendon can be accessed without the intervening deltoid muscle. This position is very similar to the "hand-on-lap" position proposed by Cyriax and others and results in a similar tendon exposure.

The proposed position of shoulder lateral rotation places the tendon under the lateral aspect of the deltoid muscle, whereas the proposed neutral position places the tendon under the anterior aspect of the deltoid muscle, making the tendon less accessible.

Discussion

The tendons of the rotator cuff and the long head of the biceps brachii muscle are commonly affected by tendinitis.^{18,19} For the physical therapist to treat this condition successfully, the tendons must be accurately located. Our study demonstrates that many of the methods proposed in the literature for locating shoulder tendons are inaccurate. Unfortunately, many of these methods are published in commonly used physical therapy textbooks^{1,5,7,9,11,13,14}; thus, these errors can be perpetuated when physical therapy students are learning these methods. Our study further demonstrates that there are optimal positions for maximally exposing these tendons with the least amount of overlying bone and soft tissue. The more accessible the tendons, the more effectively physical therapy modalities and manual techniques may be applied.

In general, anterior tendons are accessed best either anterior to the acromion (supraspinatus) or within the deltopectoral triangle (subscapularis and long head of the biceps brachii muscle). The posterior tendons (infraspinatus and teres

minor) are more accurately accessed inferior to the acromial angle.

Supraspinatus Tendon

For accessing the supraspinatus tendon, the four proposed positions did not begin to adequately reposition the distal tendon from under the acromion, except for the forearm-behind-the-back position. Although this position begins to expose the tendon, additional hyperextension will expose a greater amount of the tendon.

Cyriax stated and illustrated that with the forearm-behind-the-back position, "the supraspinatus tendon is bent through a right angle and lies in the sagittal plane, passing from the base of the coracoid process directly forwards over the head of the humerus to the greater tuberosity, emerging under the anterior edge of the acromion" (James Cyriax, personal communication, 1981). We were unable to reproduce this tendinous exposure when placing cadaver shoulders in this position. Cyriax's illustration appears to show more of the tendon than was found in our cadaver study.

When we positioned the cadavers' shoulders as described by Cyriax for the supraspinatus tendon, we found that the tendon of the long head of the biceps brachii muscle was readily exposed. Therefore, there is a possibility that the tendon of the long head of the biceps brachii muscle may be palpated in this position instead of the supraspinatus tendon.

Neer and Welsh¹⁸ suggested that there may be an anatomical reason the tendons of the supraspinatus muscle and the long head of the biceps brachii muscle may be confused. These authors described a close anatomical relationship between these two structures and stated that it is common to have a tenosynovitis of the long head of the biceps brachii muscle with impingement of the supraspinatus tendon. The relationship between the tendons of the supraspinatus muscle and the long head of the biceps brachii muscle is further supported by the detailed anatomical study of the rotator cuff by Clark and Harryman.¹⁹ These authors observed that the tendon of the long head of the biceps brachii muscle was "ensheathed by interwoven fibers derived from the subscapularis and supraspinatus tendons."^{19(p713)} This relationship also would explain why tenosynovitis of the long head of the biceps brachii muscle would occur with an impingement of the supraspinatus tendon. Although we found that the forearm-behind-the-back position with the addition of 30 to 40 degrees of hyperextension results in optimal exposure of the supraspinatus tendon, the amount of hyperextension is limited by patient tolerance.

Infraspinatus and Teres Minor Tendons

The position that produced maximum exposure of the infraspinatus and teres minor tendons was the position advocated by Cyriax^{2,3}: shoulder flexion (90°), adduction

(10°), and lateral rotation (20°). Although Cyriax advocates using this position with the patient lying prone, this position exposes the tendons with the same degree of accessibility when the patient is in a sitting position. We often find that our patients' tolerance is greater in a sitting position than in a prone position.

Other authors^{4,6,8,11} advocate using either the forearm-behind-the-back position or simple hyperextension to gain access to the infraspinatus and teres minor tendons. These authors state that the tendons are repositioned anterior to the acromion. This assertion is not supported by our observations.

Tendons of the Subscapularis Muscle and Long Head of the Biceps Brachii Muscle

We find that the deltopectoral triangle is a convenient "doorway" for accessing the subscapularis tendon and the tendon of the long head of the biceps brachii muscle. The subscapularis tendon is brought into the triangle by maintaining a neutral shoulder position. When accessing the tendon of the long head of the biceps brachii muscle, it is necessary to bring the bicipital groove into the triangle by slightly rotating the shoulder medially (20°) as described earlier. Positions with more lateral rotation will place these two tendons under the deltoid muscle, whereas positions with more medial rotation will place these two tendons under more medially located structures.

We acknowledge the limitations of a shoulder study using embalmed cadavers. The inherent stiffness of the anatomical structures presented some limitations regarding the positions used in this study and the anatomical structures' correlation to the natural movements of living tissues. We believe that further studies using fresh, unembalmed cadavers would be beneficial to further refine the results of our study.

Conclusion

There are many proposed methods for accessing shoulder tendons that are normally located deep to bone, ligament, and muscle. After cadaver dissection of 24 shoulders, we conclude that many of these proposed methods for locating these tendons are incorrect. We also conclude that there are optimal positions for maximal exposure of these tendons with the least amount of overlying tissue, rendering them more superficial for effective treatment techniques.

The distal tendon of the supraspinatus muscle was maximally exposed with the least amount of overlying tissue when the shoulder was at maximal adduction (10°), medial rotation (80°–90°), and hyperextension (30°–40°). Although Cyriax's forearm-behind-the-back position was effective, additional hyperextension further exposed the distal tendon.

The distal tendon of the infraspinatus muscle was maximally exposed with the least amount of overlying tissue in shoulder

flexion (90°), adduction (10°), and lateral rotation (20°), regardless of whether the cadavers were positioned prone or sitting. The subscapularis tendon was maximally exposed with the least amount of overlying tissue when the shoulder was adducted to the side of the thorax and neutral in terms of flexion/extension and medial/lateral rotation. The tendon of the long head of the biceps brachii tendon was maximally exposed with the least amount of overlying tissue in shoulder adduction (0°) and slight medial rotation (20°). We believe clinicians should optimally access shoulder tendons when initiating treatment. Our findings allow alternatives for patient comfort and effectiveness. Further studies using fresh, unembalmed cadavers would be beneficial to further refine the results of our study.

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