

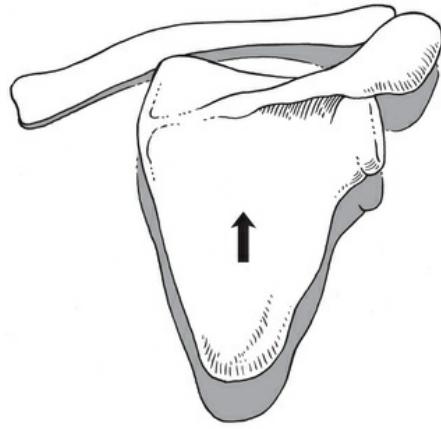
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## CHAPTER 5

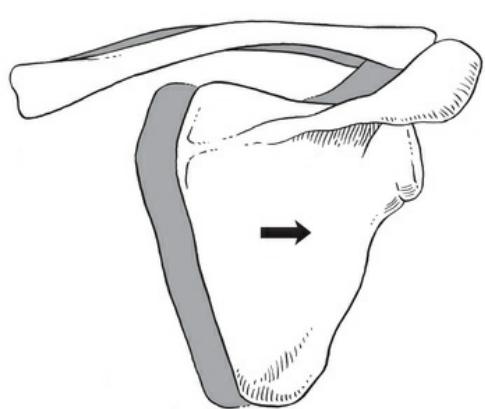
# Testing the Muscles of the Upper Extremity

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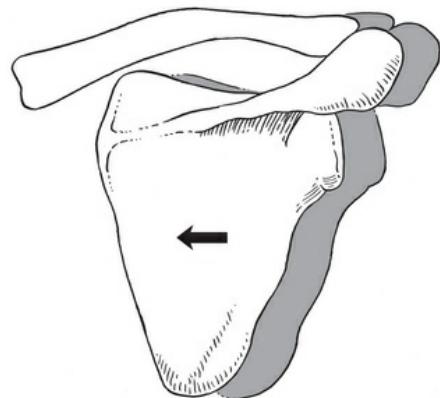
CARDINAL PLANES OF  
THE SCAPULA



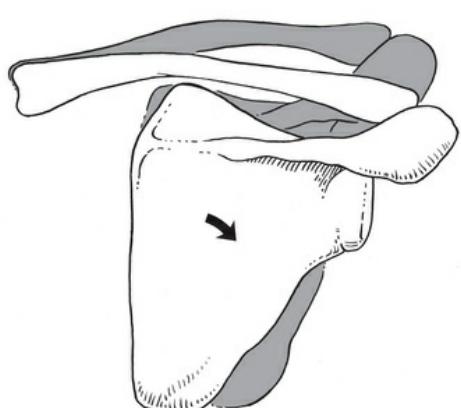
ELEVATION



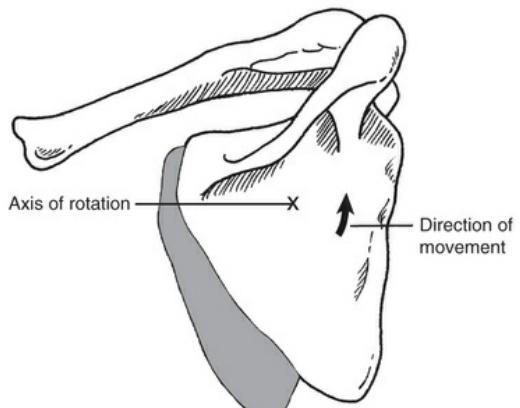
ABDUCTION



ADDITION



DEPRESSION AND  
DOWNWARD ROTATION



UPWARD ROTATION

**PLATE 2** Elevation (as in shrugging the shoulders). Abduction (protraction) forward movement occurring in pushing, thrusting, or reaching. Adduction (retraction) (as in bracing the shoulders). Depression and downward rotation (medial rotation)—returning scapula to rest position. Upward rotation (lateral rotation) occurs with shoulder elevation and with protraction of the scapula



## Introduction to Shoulder Girdle Strength Testing

The shoulder girdle is a complex system comprised of five distinct joints and at least 16 muscles, many of which have multiple parts and actions. The purpose of scapulohumeral motion is the appropriate positioning of the glenohumeral (G-H) joint in space, while the purpose of scapular stability is to provide a foundation for G-H motion.<sup>1</sup>

The chief muscles that act upon the G-H joint are the deltoid (three parts), the pectorales (two parts), the latissimus dorsi, teres major, and the four rotator cuff muscles (subscapularis, supraspinatus, infraspinatus and teres minor).<sup>2</sup> The primary muscles acting upon the scapula to properly position the humerus are the serratus anterior and upper and lower trapezius.<sup>3</sup>

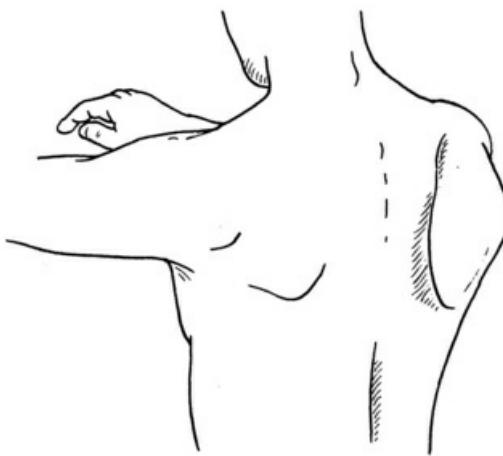
Shoulder elevation is the preferred term used in this text. Shoulder elevation is any combination of humeral abduction and flexion occurring at the glenohumeral joint. The most efficient shoulder elevators are the anterior and middle deltoid and the supraspinatus (initially).<sup>1</sup> Shoulder elevation is not to be confused with shoulder girdle elevation, the motion of shrugging the shoulders.

### Preliminary Examination

Observation of posture in sitting and standing is important prior to strength testing, noting the natural variability between sides and between individuals. First examine the sitting patient (with hands in the lap) from the back (posterior view), noting the position of the scapulae at rest, any asymmetry of shoulder height, muscular bulk, position of the G-H joint, and any scapular winging (Figs. 5.1 and 5.2). Some scapular asymmetry is common and has many causes. Handedness, habitual stretch weakness (e.g., rounded shoulders that can accompany the forward head posture (see Fig. 3.14), and carrying purses or briefcases habitually on one side can all contribute to normal scapular asymmetry.



FIGURE 5.1



**FIGURE 5.2**

#### Position and Symmetry of Scapulae:

The normal scapula lies close to the rib cage with the vertebral border nearly parallel to and from 1 to 3 inches lateral to the spinous processes. The inferior angle is on the chest wall.

The most prominent abnormal posture of the scapula is "winging," in which the vertebral border tilts away from the rib cage, a sign of probable serratus anterior weakness (see [Fig. 5.2](#)).

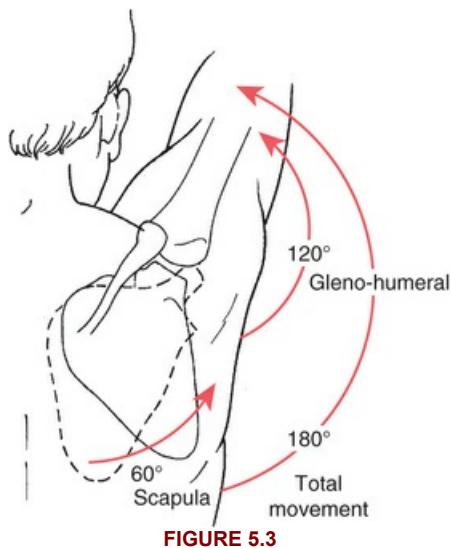
#### Scapulohumeral Rhythm:

Next, observe scapulohumeral rhythm. Scapulohumeral rhythm consists of integrated movements of the G-H, scapulothoracic, acromioclavicular, and sternoclavicular joints that occur simultaneously. It occurs in sequential fashion to allow full functional motion of the shoulder complex. Although there is normal variability in scapulohumeral rhythm, the overall ratio of G-H to scapulothoracic motion is approximately 2 : 1 to complete 180° of shoulder elevation, but varies throughout the range.<sup>3,4</sup> Thus, for 180° of shoulder elevation, approximately 120° comes from the G-H joint and the other 60° from upward rotation of the scapula.

#### Scapular Range of Motion:

Total scapular motion increases over the arc of shoulder elevation. G-H and scapular movements occur not as separate motions, but as synchronous motions throughout the range. Specifically:

- a. The scapula sits against the thorax (T) during the first phase of shoulder abduction and flexion to provide initial stability as the humerus (H) abducts and flexes to 30°. During this first 30°, the scapula's contribution to G-H movement is minimal.
- b. From 30° to 90° of elevation, the G-H joint contributes another 30° of motion, as the scapula upwardly rotates 30°. During this range, the scapulohumeral rhythm is typically greater than 2 : 1.<sup>4</sup> The upward rotation is accompanied by clavicular elevation through the sternoclavicular and acromioclavicular joints ([Fig. 5.3](#)).



**FIGURE 5.3**

- c. The second phase ( $90^\circ$  to  $120^\circ$ ) is made up of  $60^\circ$  of G-H abduction and flexion and an additional  $30^\circ$  of scapular upward rotation. During this portion of the range, scapulohumeral rhythm declines to approximately 1 : 1.<sup>4</sup> Scapular rotation is associated with  $5^\circ$  of elevation at the sternoclavicular joint and  $25^\circ$  of rotation at the acromioclavicular joint (see Fig. 5.3).
- d. After  $120^\circ$  of shoulder elevation, the scapula rotates approximately  $1^\circ$  for every  $1^\circ$  of shoulder elevation until maximal shoulder elevation is achieved for a total of approximately  $35\text{--}55^\circ$  of scapular upward rotation.<sup>5</sup>

Observe that the scapula basically remains in its rest position at ranges of less than  $30^\circ$  of shoulder elevation (the position is variable among subjects). To feel upward rotation, palpate the vertebral borders of both scapulae with the thumbs, placing the web of the thumb below the inferior angle and the extended fingers around the axillary borders (see Fig. 5.1), and ask the patient to lift the arm to  $180^\circ$  of shoulder elevation.

If the scapula moves a lot as the G-H joint moves through a range from  $0^\circ$  to  $60^\circ$ —that is, if in this range they move as a unit—there is limited G-H motion. Above  $30^\circ$  and to about  $150^\circ$  or  $160^\circ$  in both active and passive motions, the scapula moves in concert with the humerus in about a 2 : 1 ratio.

After assessing the scapular position at rest, ask the patient to raise the test arm above the head in the sagittal plane. If the arm can be raised well above  $90^\circ$  (G-H muscles must be at least Grade 3 to do this), observe the direction and amount of scapular motion that occurs. Normally, the scapula rotates upward in a motion that is controlled by the serratus, and if erratic or “uncoordinated” motion occurs, the serratus is most likely weak. The normal amount of motion from the vertebral border is about the breadth of two fingers (Fig. 5.4). If the patient can raise the arm with simultaneous rhythmical scapular upward rotation, proceed with the test sequence for Grades 5 and 4.



**FIGURE 5.4**

#### **Scapula Abnormal Position at Rest:**

If the scapula is positioned abnormally at rest (i.e., downwardly rotated, abducted, or winging), the patient will not be able to elevate the arm above 90°. Proceed to serratus muscle tests described for Grades 2, 1, and 0. The serratus anterior never can be graded higher than the grade given to shoulder flexion. If the patient has a weak deltoid, the lever for testing is gone, and the arm cannot be used to apply resistance.

#### **Helpful Hint**

Thoracic spine extension is necessary to achieve full shoulder elevation. If a person is kyphotic, shoulder elevation will be sacrificed and a 10° to 20° deficit of shoulder elevation will be noted.

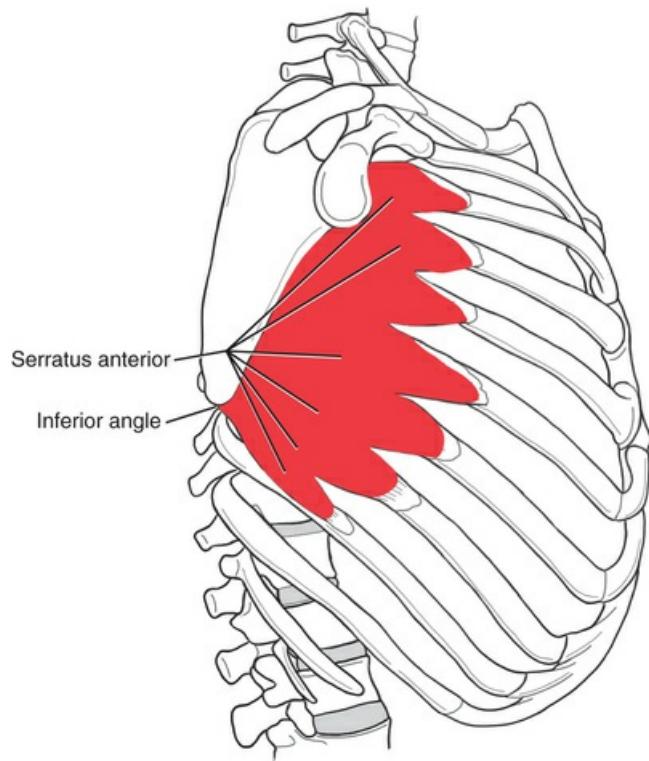


FIGURE 5.5

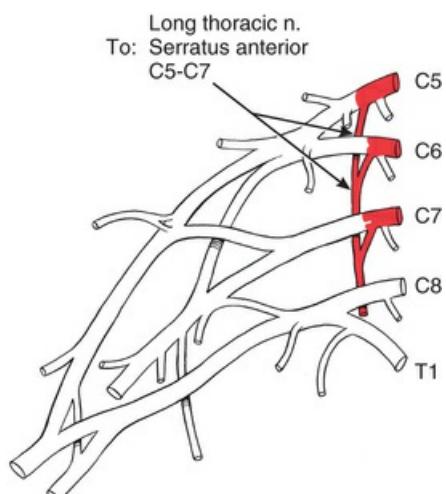
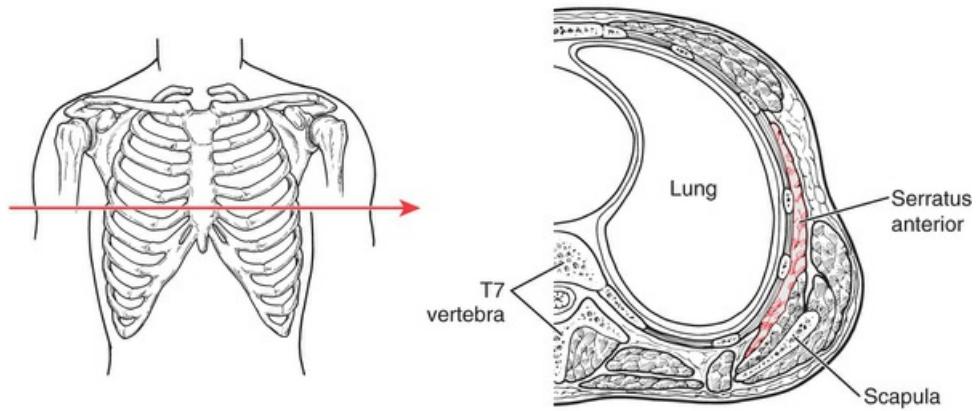


FIGURE 5.6



**FIGURE 5.7** Arrow indicates level of cross section.

# Scapular Abduction and Upward Rotation

(*Serratus anterior*)

## Range of Motion

Reliable values not available

**Table 5.1**  
**SCAPULAR ABDUCTION AND UPWARD ROTATION**

ID.	Muscle	Origin	Insertion	Function
128	Serratus anterior	Ribs 1–8 and often 9 and 10 (by digitations along a curved line) Intercostal fascia Aponeurosis of intercostals	Scapula (ventral surface of vertebral border) 1st digitation (superior angle) 2nd–4th digitations (costal surface of entire vertebral border) Lower 4th or 5th digitations (costal surface of inferior angle)	Upward rotation of the scapula (glenoid faces up) • Scapular abduction • Medial border of scapula drawn anteriorly close to the thoracic wall (preventing “winging”)
129	Pectoralis minor			• Scapular protraction (abduction): scapula moves forward around the chest wall. Works here with serratus anterior • Elevation of ribs in forced inspiration when scapula is fixed by the levator scapulae
Other	124	Upper and lower trapezius		• Works in conjunction with serratus to produce upward rotation

The serratus is a prime mover for scapular abduction (protraction), with the pectoralis minor also contributing. Their purpose is to maintain the continuous apposition of the scapula with the humerus. The rhomboids control the rate and range of motion of scapular abduction. As the arm is raised, the serratus helps other muscles to first fix the scapula, then rotate the scapula, allowing the arm to be raised to the vertical. The upper and lower fibers of the trapezius assist with the upward and medial pull of the lateral end of the clavicle and acromion.<sup>1</sup> This simultaneous action of the trapezius has focused attention on the development of exercises that focus on the serratus without simultaneously firing the trapezius. The serratus also works eccentrically in controlling gravity-assisted downward rotation of the scapula, especially if the arm is loaded (weight in hand).

Testing the serratus in the supine position is not recommended at any grade level. The supine position allows too much substitution that may not be noticeable. Lying supine on the table gives added stabilization to the scapula so that it does not “wing” and protraction of the arm may be performed by the clavicular portion of the pectoralis minor. The serratus should always be tested in shoulder elevation to minimize the synergy with the trapezius.

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Short sitting with arm forward flexed to about 130° and then protracted in that plane as far as it can move.

### Instructions to Therapist:

Stand at test side of patient. Ask patient to protract arm, to assess available range and the patient's ability to achieve the test position. If successful, position arm as noted above. Hand used for resistance grasps the upper arm just above the elbow and gives resistance in a backward direction. The other hand stabilizes the trunk just below the scapula on the same side, thus preventing trunk rotation (Fig. 5.8).



**FIGURE 5.8**

The therapist should select a spot on the wall or ceiling that can serve as a target for the patient to reach toward when the shoulder is at 130° of elevation.

**Test:**

Therapist resists protraction and elevation the arm at about 130° of flexion. The patient holds against maximal resistance.

**Instructions to Patient:**

"Hold your arm here. Don't let me move it."

**Grading**

**Grade 5:**

Scapula maintains its abducted and rotated position against maximal resistance (see [Fig. 5.8](#)).

**Grade 4:**

Scapular muscles "give" or "yield" against maximal resistance. The G-H joint is normally held rigid in the presence of a strong deltoid, but if the serratus yields, the scapula moves in the direction of adduction and downward rotation.

**Grade 3:**

Scapula moves through full range of motion without winging, and without resistance other than the weight of the arm ([Fig. 5.9](#)).

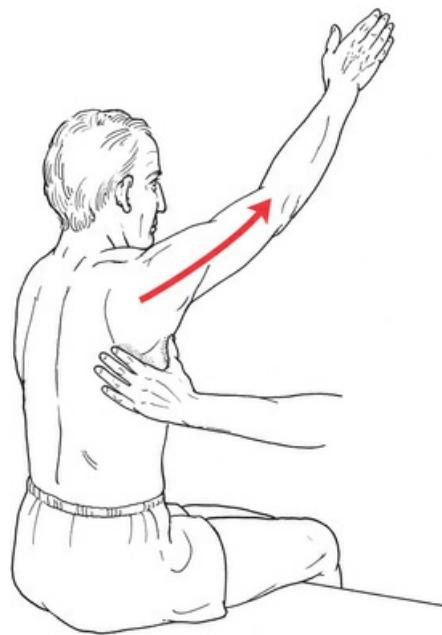


FIGURE 5.9

## Grade 2

### Position of Patient:

Short sitting with arm flexed above 90° and supported by therapist.

### Instructions to Therapist:

Stand at test side of patient. One hand supports the patient's arm at the elbow, maintaining it above the horizontal (Fig. 5.10). The other hand is placed at the inferior angle of the scapula with the thumb positioned along the axillary border and the fingers along the vertebral border (see Fig. 5.10).



FIGURE 5.10

### Test:

Therapist monitors scapular motion by using a light grasp on the scapula at the inferior angle. Therapist must be sure not to restrict or resist motion. The scapula is observed to detect winging.

**Instructions to Patient:**

"Hold your arm in this position" (i.e., above 90°). "Let it relax. Now hold your arm up again. Let it relax."

**Grading**

**Grade 2:**

If the scapula abducts and rotates upward as the patient attempts to hold the arm in the elevated position, the weakness is in the G-H muscles. If the scapula does not smoothly abduct and upwardly rotate without the weight of the arm or if the scapula moves toward the vertebral spine, the weakness is in the serratus and should be graded a 2.

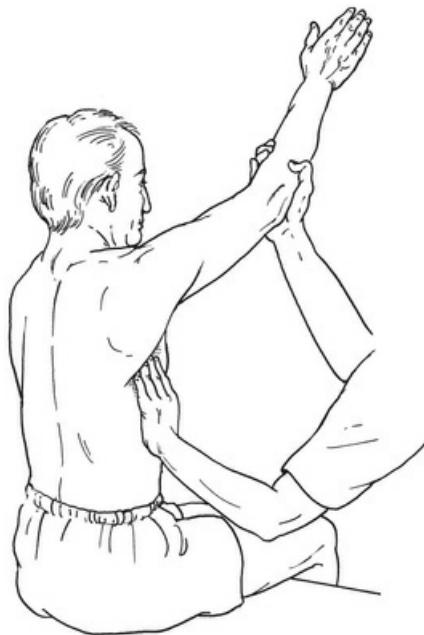
**Grade 1 and Grade 0**

**Position of Patient:**

Short sitting with arm forward flexed to above 90° (supported by therapist).

**Instructions to Therapist:**

Stand in front of and slightly to one side of patient. Support the patient's arm at the elbow, maintaining it above 90° ([Fig. 5.11](#)). Use the other hand to palpate the serratus with the tips of the fingers just in front of the inferior angle along the axillary border (see [Fig. 5.11](#)).



**FIGURE 5.11**

**Test:**

Patient attempts to hold the arm in the test position.

**Instructions to Patient:**

"Try to hold your arm in this position."

**Grading**

**Grade 1:**

Muscle contraction is palpable.

#### **Grade 0:**

No discernable palpable contraction.

### **Helpful Hints**

- The highest level of serratus anterior electromyography (EMG) activity is achieved below 90° of humeral elevation.<sup>6</sup>
- If a patient has a painful elbow (e.g., tennis elbow or epicondylitis) resistance may be applied above the painful joint, on the proximal arm.

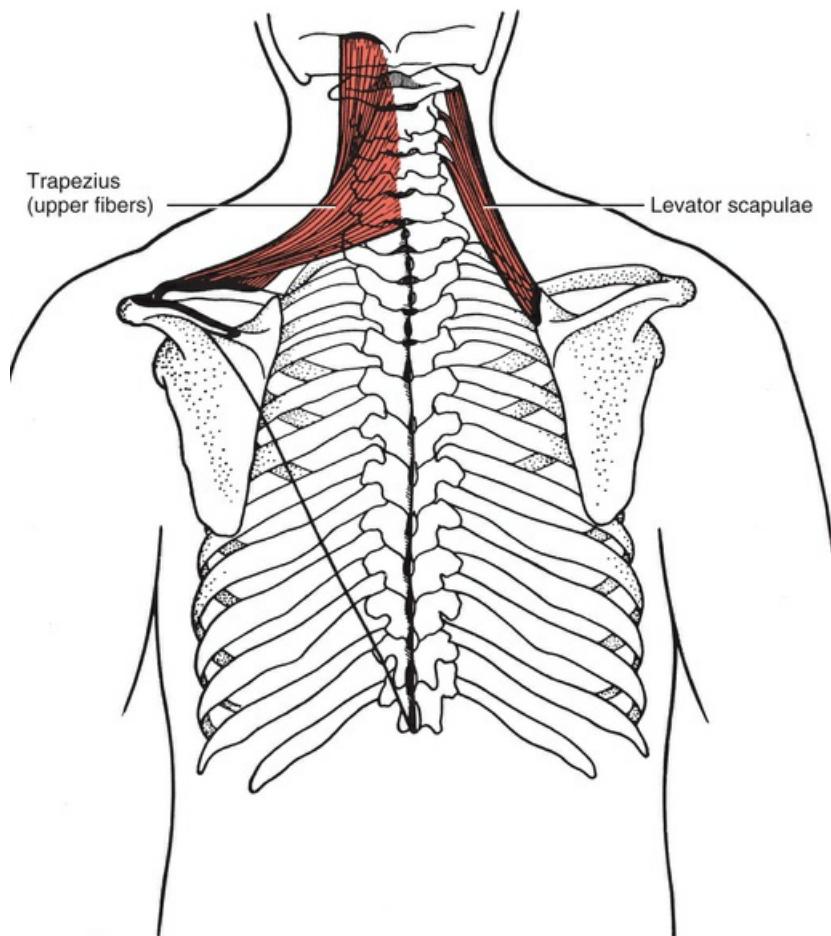
### **Suggested Exercises for Serratus Anterior**

- Push up progression
  - Least muscle demand: wall push up
  - Moderate muscle demand: pushup on knees
  - Highest muscle demand: pushup with feet elevated.<sup>7</sup>
- Push up plus<sup>\*8</sup> (produces minimal upper trapezius activation and maximum activation of the serratus)
- Dynamic hug<sup>8</sup>
- Diagonal exercise flexion (D1<sup>7,9</sup> and D2<sup>7</sup>, D2 diagonal pattern extension)<sup>7</sup>
- Bench press, seated (using a weight machine) with upper trapezius<sup>9</sup>
- Isometric low row (with lower trapezius)<sup>8</sup>
- Lawnmower rows (with lower trapezius)<sup>8</sup>

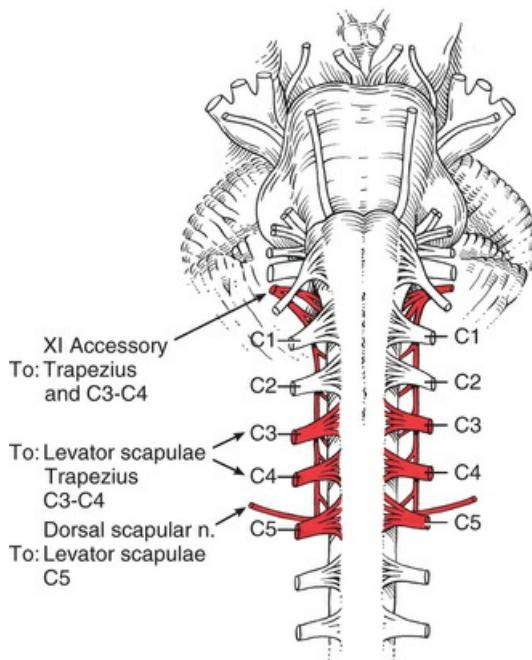
\*Push up plus is a classic pushup with extended arms and a narrow hand width. On fully extended arms, lift the back toward the ceiling. Then drop the trunk down, bending elbows 30°, then raising trunk again, lifting the back toward the ceiling at the end of the movement (it is a small movement, just a couple of inches).

## Scapular Elevation

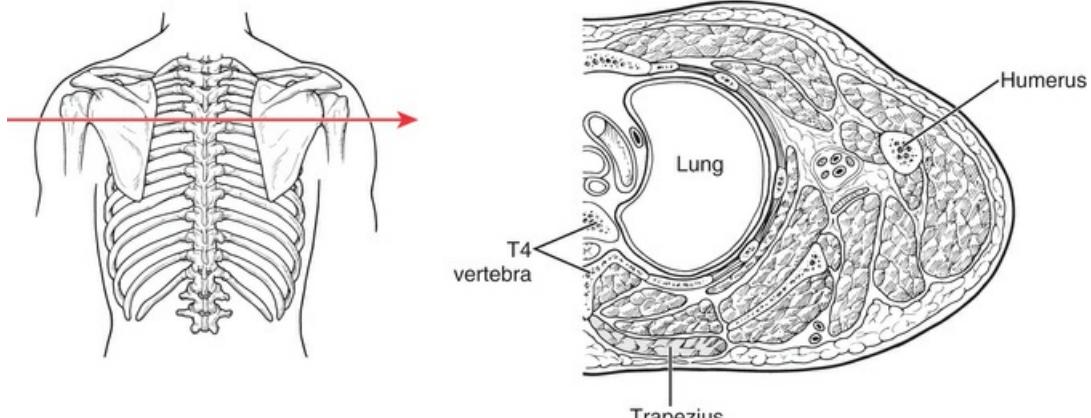
(Trapezius, upper fibers and Levator scapulae)<sup>10</sup>



POSTERIOR  
**FIGURE 5.12**



**FIGURE 5.13**



**FIGURE 5.14** Arrow indicates level of cross section.

## Range of Motion

Reliable data not available

**Table 5.2**  
**SCAPULAR ELEVATION**

I.D.	Muscle	Origin	Insertion	Function
124	Trapezius (upper fibers)	Occiput (external protuberance and superior nuchal line, medial Ligamentum nuchae C7 vertebra (spinous process))	Clavicle (posterior border of lateral $\chi_3$ )	Upper: • Elevation of shoulder girdle ("shrugging") (with levator scapulae) • Rotation of head to opposite side (one) • Capital extension (both) Upper and Lower: • Rotation of the scapula so glenoid faces up (inferior angle moves laterally and forward); occurs only if contracting in conjunction with serratus anterior • Cervical extension (both)
127	Levator	C1-C4 vertebrae (transverse processes)	Scapula (vertebral border between	• Elevates and adducts scapula

	scapulae		superior angle and root of scapular spine)	• Scapular downward rotation (glenoid faces down) • Lateral bending of cervical spine to same side (one) • Cervical rotation to same side (one) • Cervical extension (both assist)
<b>Others</b>				
125	Rhomboid major	See <a href="#">Table 5.3</a>		
126	Rhomboid minor	See <a href="#">Table 5.5</a>		

Elevation of the scapula and point of the shoulder, as in shrugging the shoulders, is generated by the trapezius acting on the lateral clavicle, acromion and spine of the scapula, with some assistance from the levator scapula. If the trapezius is weak the therapist may see some scapular downward rotation due to the action of the levator. If the levator is weak, elevation may be accompanied by some scapular upward rotation.<sup>1</sup> In the intact muscle, elevation should be a straight "up" movement.

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

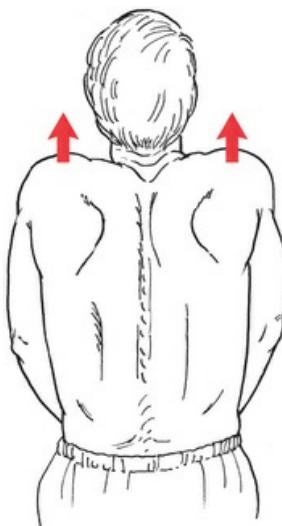
Short sitting over end or side of table in erect posture. Hands relaxed in lap.

#### Instructions to Therapist:

Stand behind patient. Ask the patient to elevate (shrug) the shoulders (Grade 3). If range is full and symmetrical, apply resistance. Contour hands over top of both shoulders to give resistance in a downward direction. This muscle is quite strong, so the therapist's arms should be nearly straight, transferring the therapist's body weight through the arms to provide enough resistance. If unilateral weakness is suspected (rare), testing each side separately may be indicated.

#### Test:

Patient elevates (shrugs) shoulders. The test is almost always performed on both sides simultaneously ([Fig. 5.15](#)).



**FIGURE 5.15**

#### Instructions to Patient:

"Shrug your shoulders." OR "Raise your shoulders toward your ears. Hold it. Don't let me push them down."

### Grading

#### Grade 5:

Holds test position against maximal resistance ([Fig. 5.16](#)).

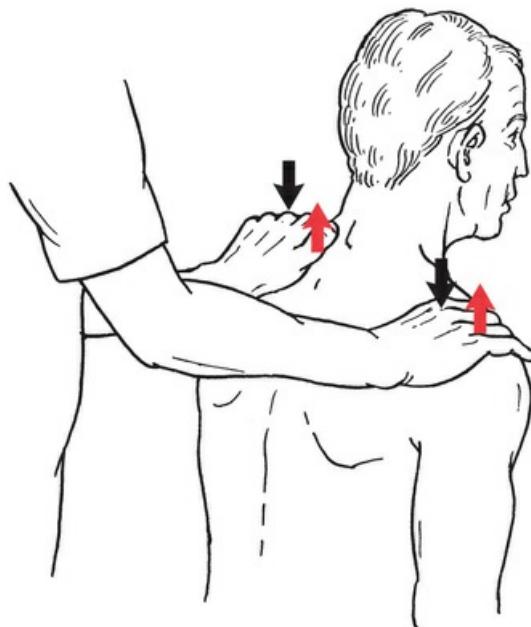


FIGURE 5.16

**Grade 4:**

Patient holds test position against strong to moderate resistance. The shoulder muscles may "give" at the end point.

**Grade 3:**

Elevates shoulders through full available range without resistance.

**Grade 2, Grade 1, and Grade 0**

**Position of Patient:**

Prone, fully supported on table. Head may be turned away from test side for patient comfort and to reduce the potential contribution of the levator scapulae (Fig. 5.17).



FIGURE 5.17

**Instructions to Therapist:**

Stand at test side of patient. Support test shoulder in palm of one hand. The other hand palpates the

upper trapezius near its insertion above the clavicle. A second site for palpation is the upper trapezius just adjacent to the cervical vertebrae.

**Test:**

With the therapist supporting the shoulder, the patient elevates the shoulder (usually done unilaterally) toward the ear.

**Instructions to Patient:**

"Raise your shoulder toward your ear (shrug)."

**Grading**

**Grade 2:**

Patient completes full range of motion in gravity-minimized position.

**Grade 1:**

Upper trapezius fibers can be palpated at clavicle or neck. The levator muscle lies deep and is more difficult to palpate in the neck (between the sternocleidomastoid and the trapezius). It can be felt at its insertion on the vertebral border of the scapula superior to the scapular spine when the head is turned towards the side being tested.

## Helpful Hints

- If the patient cannot assume the sitting position for testing for any reason, the tests for Grade 5 and Grade 4 in the supine position will be quite inaccurate. If the Grade 3 test is done in the supine position, it will require manual resistance because gravity is neutralized.
- If the prone position is not comfortable, the tests for Grades 2, 1, and 0 may be performed with the patient supine, but palpation in such cases will be less than optimal.

## Suggested Exercises for Upper Trapezius

- Shoulder shrug<sup>7</sup>
- Abduction to 45°, 90° and 120° (decreases middle trapezius activity)
- Low row (decreases serratus anterior activity)
- Prone horizontal abduction at 135° with ER (thumb up) (optimizes upper trapezius and decreases serratus anterior activity)<sup>7</sup>

## Scapular Adduction (Retraction)

(Trapezius, middle fibers and Rhomboid major and minor)

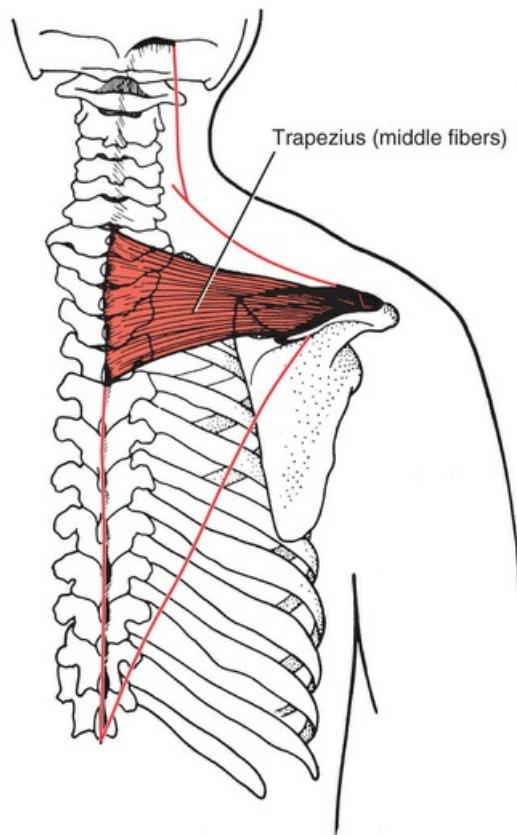
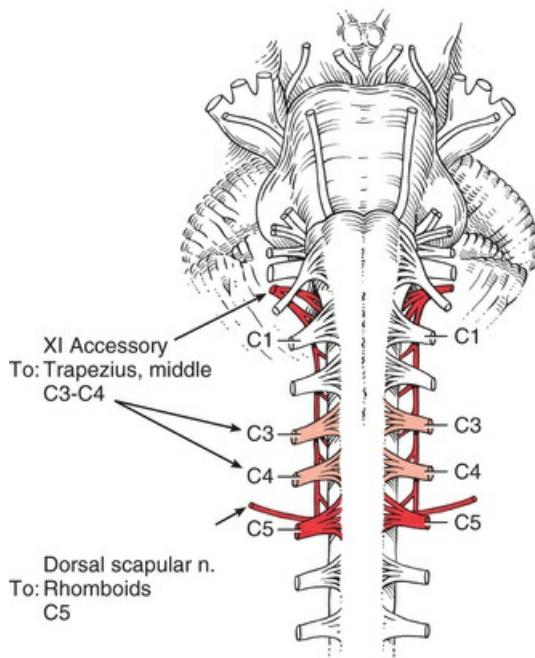
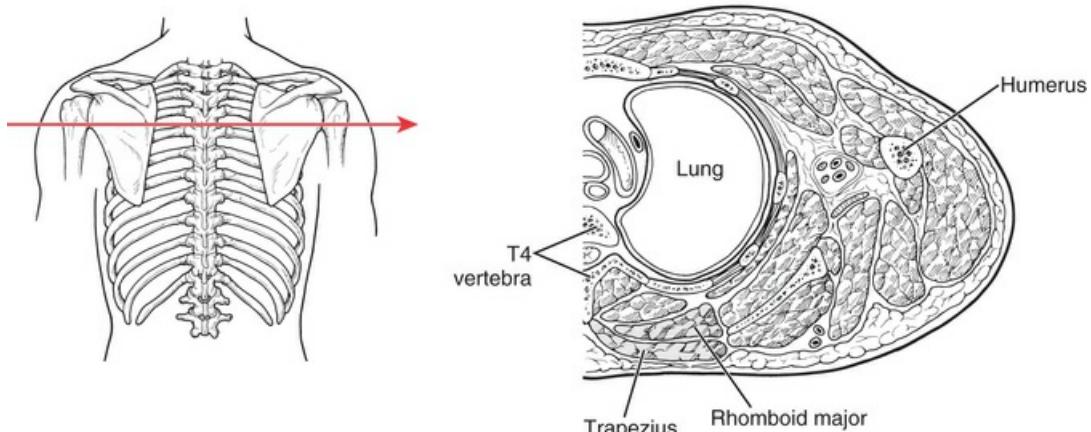


FIGURE 5.18



**FIGURE 5.19**



**FIGURE 5.20** Arrow indicates level of cross section.

## Range of Motion

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**Table 5.3**  
**SCAPULAR ADDUCTION (RETRACTION)**

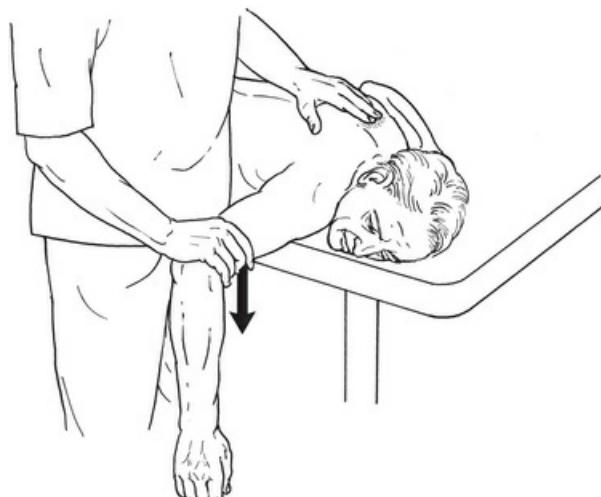
L.D.	Muscle	Origin	Insertion	Function
124	Trapezius (middle fibers)	T1-T5 vertebrae (spinous processes) Supraspinous ligaments	Scapula (medial acromial margin and superior lip of crest on scapular spine)	Scapular adduction (retraction) (with rhomboids)
125	Rhomboideus major	T2-T5 vertebrae (spinous processes) Supraspinous ligaments	Scapula (vertebral border between root of spine and inferior angle)	Scapular adduction Downward rotation of scapula (glenoid faces down) Scapular elevation
<b>Others</b>				
126	Rhomboideus minor	See Table 5.5	See Table 5.5	

124	Trapezius (upper and lower)	See <a href="#">Tables 5.3 and 5.4</a>	
127	Levator scapulae	See <a href="#">Table 5.2</a>	See <a href="#">Plate 3</a>

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Prone with shoulder at edge of table. Shoulder is abducted to 90°. Elbow is flexed to a right angle with forearm and hand hanging off table ([Fig. 5.21](#)). Head may be turned to either side for comfort.



**FIGURE 5.21**

### Instructions to Therapist:

Stand at test side close to patient's arm. Stabilize the contralateral scapular area to prevent trunk rotation. Ask the patient to lift elbow toward the ceiling (Grade 3). If able to complete full range, proceed to apply resistance in the test position in a downward direction ([Fig. 5.22](#)). Palpate the middle fibers of the trapezius at the spine of the scapula from the acromion to the vertebral column with the fingers of the other hand, as necessary.



**FIGURE 5.22**

**Test:**

Patient horizontally abducts arm and adducts scapula.

**Instructions to Patient:**

"Lift your elbow toward the ceiling. Hold it. Don't let me push it down."

**Grading**

**Grade 5:**

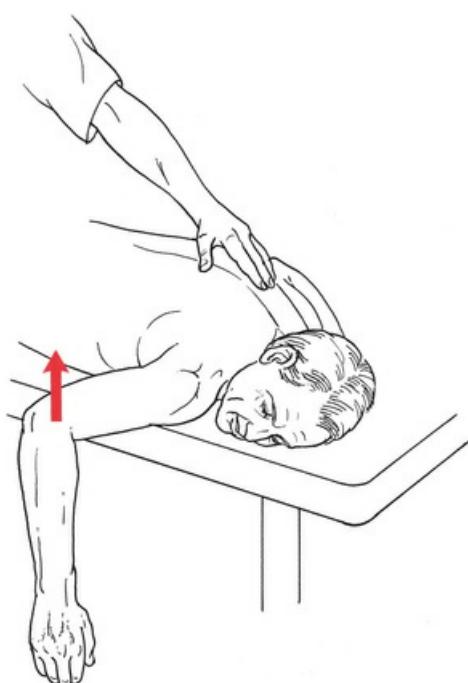
Holds test position against maximal resistance.

**Grade 4:**

Holds test position against strong to moderate resistance.

**Grade 3:**

Completes available range without manual resistance ([Fig. 5.23](#)).



**FIGURE 5.23**

**Grade 2, Grade 1, and Grade 0**

**Position of Patient and Therapist:**

Same as for Grade 5 test except that the therapist uses one hand to cradle the patient's shoulder and arm, thus supporting the arm's weight ([Fig. 5.24](#)), and the other hand for palpation.



FIGURE 5.24

**Test:**

Same as that for Grades 5 to 3.

**Instructions to Patient:**

"Try to lift your elbow toward the ceiling."

**Grading**

**Grade 2:**

Completes full range of motion without the weight of the arm.

**Grade 1 and Grade 0:**

A Grade 1 muscle exhibits contractile activity or slight movement. There will be neither motion nor discernable palpable contractile activity in the Grade 0 muscle.

**Substitutions**

By the rhomboids: The rhomboids can partially substitute for the middle trapezius in adduction of the scapula but if that should happen, adduction occurs simultaneously with scapular downward rotation.

**Helpful Hint**

When the posterior deltoid muscle is weak, support the patient's shoulder with the palm of one hand and allow the patient's elbow to flex. Passively move the scapula into adduction via horizontal abduction of the arm (see Fig. 5.24). Have the patient hold the scapula in adduction as the therapist slowly releases the shoulder support. Observe whether the scapula maintains its adducted position. If it does, it is Grade 3.

**Suggested Exercises for Middle Trapezius**

- Prone external rotation (ER)<sup>9</sup>
- Side-lying ER<sup>9</sup>
- Row with elbows extended

## Scapular Depression and Adduction

(Trapezius, lower and middle fibers)

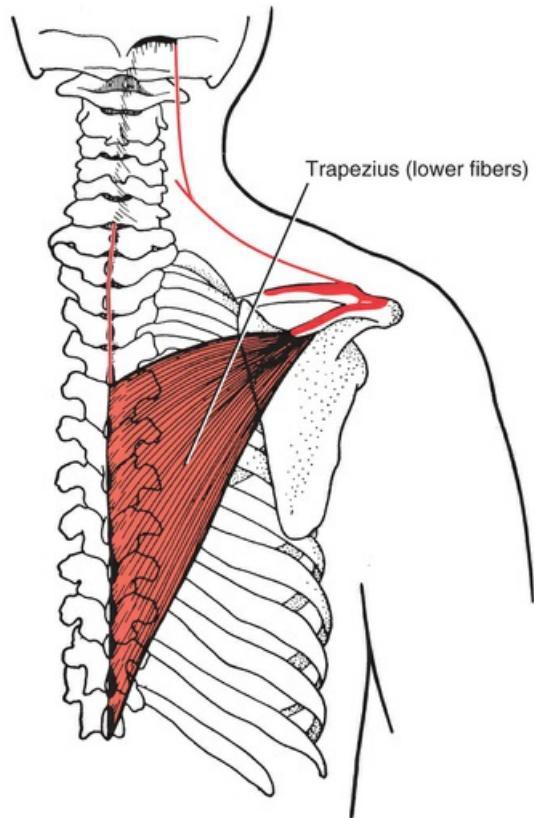
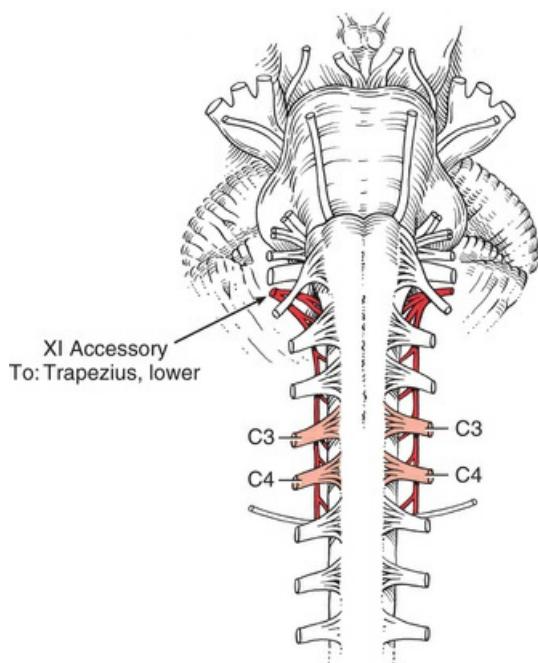
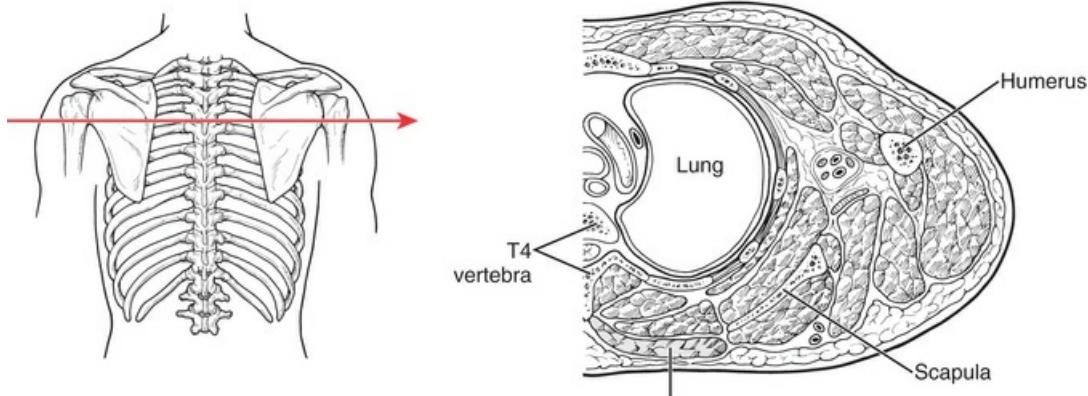


FIGURE 5.25



**FIGURE 5.26**



**FIGURE 5.27** Arrow indicates level of cross section.

## Range of Motion

Reliable data not available

**Table 5.4**  
**SCAPULAR DEPRESSION AND ADDUCTION**

I.D.	Muscle	Origin	Insertion	Function
124	Trapezius (middle and lower fibers)	T1-T5 vertebrae (spinous processes) Supraspinous ligaments T6-T12 vertebrae (spinous processes)	Scapula (spine, medial end, and tubercle at lateral apex via aponeurosis)	<p><i>Middle:</i></p> <ul style="list-style-type: none"> <li>• Scapular adduction (retraction) (with rhomboids)</li> <li>• Scapular adduction and depression</li> </ul> <p><i>Lower:</i></p> <ul style="list-style-type: none"> <li>• Scapular depression if the arms are fixed</li> <li>• Extension, adduction, and internal rotation of shoulder</li> <li>• Hyperextension of spine (muscles on both sides), as in lifting</li> <li>• The muscle is most powerful in overhead activities (such as swimming [downstroke] and climbing), crutch walking, elevation of trunk to arms, i.e., shoulder depression, or swinging<sup>11</sup></li> </ul>
130	Latissimus dorsi	Spines of the 6 lower thoracic vertebrae, thoracolumbar fascia, crest of the ilium, lowest 4 ribs	Anterior humerus, lower margin of the intertubercular sulcus	
<b>Others</b>				
131	Pectoralis major	Sternal half of clavicle, entire anterior surface of the sternum	Lateral lip of the intertubercular sulcus of anterior humerus	
129	Pectoralis minor	Ribs 3–5, intercostal cartilage	Coracoid process	

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Prone with test arm over head to about 145° of shoulder elevation and abduction (in line with the fibers of the lower trapezius). Forearm is in mid position (neutral rotation) with the thumb pointing toward the ceiling. Head should be turned to the test side.

### Instructions to Therapist:

Stand at test side. Ask patient to raise the arm from the table as high as possible (Grade 3) (Fig. 5.28). If full range is present, provide resistance. Hand giving resistance is contoured over the distal forearm, just above wrist (Fig. 5.29). Resistance will be given straight downward (toward the floor). Fingertips of the opposite hand palpate below the spine of the scapula and across to the thoracic vertebrae, following the muscle as it curves down to the lower thoracic vertebrae. If patient cannot hold the test position with resistance given on the forearm, apply resistance over distal humerus, above elbow (Grade 4).



FIGURE 5.28



FIGURE 5.29

**Instructions to Patient:**

"Hold your arm. Don't let me push it down."

**Grading**

**Grade 5:**

Holds test position against strong resistance applied over the forearm.

**Grade 4:**

Holds test position against strong resistance applied over the distal humerus or light resistance over the forearm.

**Grade 3:**

Patient raises arm from the table in test position against gravity, but patient cannot tolerate manual resistance (see Fig. 5.28).

**Grade 2, Grade 1, and Grade 0**

**Position of Patient:**

Same as for Grade 5.

**Instructions to Therapist:**

Stand at test side. Support patient's arm under the elbow (Fig. 5.30).



**FIGURE 5.30**

**Test:**

Patient attempts to lift the arm from the table. If the patient is unable to lift the arm because of a weak posterior and middle deltoid, the examiner should lift and support the weight of the arm. In the presence of a weak lower trapezius, the patient may substitute the middle trapezius and rhomboids, causing a lowering of the arm into an abducted position.

**Instructions to Patient:**

"Try to lift your arm from the table past your ear."

**Grading**

**Grade 2:**

Completes full scapular range of motion without the weight of the arm.

**Grade 1:**

Contractile activity can be palpated in the triangular area between the root of the spine of the scapula and the lower thoracic vertebra (T7-T12), that is, the course of the fibers of the lower trapezius.

**Grade 0:**

No discernable palpable contractile activity.

## Helpful Hints

- The lower trapezius will not be active with shoulder elevation of less than 120°, so if the patient does not have sufficient G-H range to assume the test position, the lower trapezius is nearly impossible to test as the scapulae adduct and the rhomboids take over. If the patient cannot isolate this test or substitutes away from test position, the grade is 0 (zero) or therapist should document, "unable to assume test position."

- Examiners are reminded of the test principle that the same lever arm must be used in sequential testing (over time) for valid comparison of results.

## Suggested Exercises for Lower Trapezius

- Prone rowing<sup>7</sup>
- Prone flexion with thumb up<sup>9</sup>
- Modified prone cobra<sup>12</sup>
- D2 diagonal pattern flexion with elastic tubing<sup>7</sup>
- Prone horizontal abduction at 90° and 125°<sup>7</sup>

## Scapular Adduction (Retraction) and Downward Rotation

(Rhomboids)

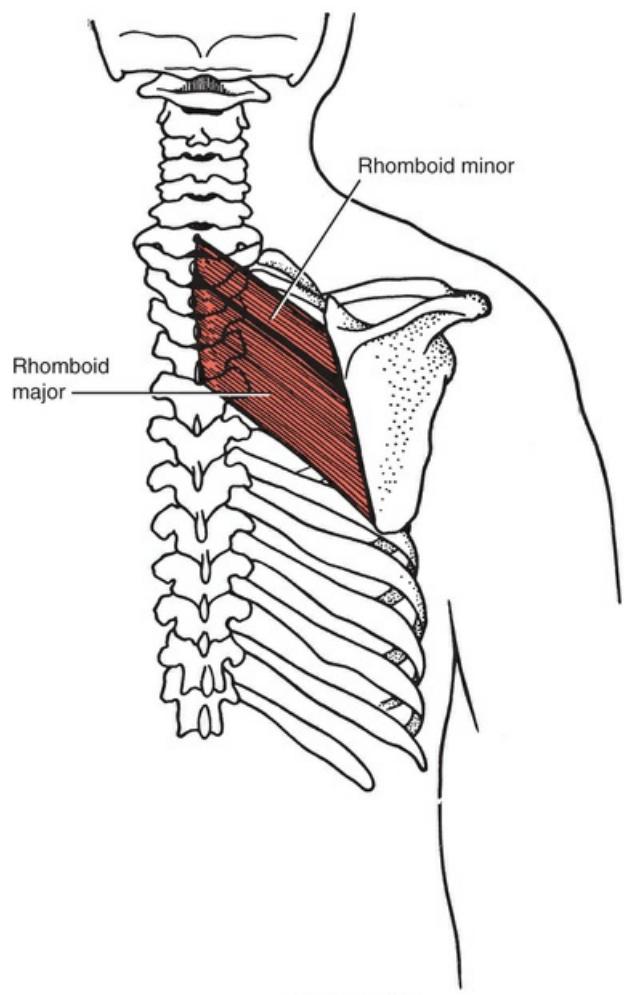
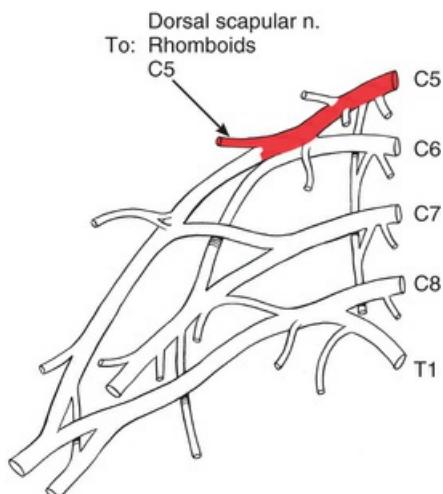
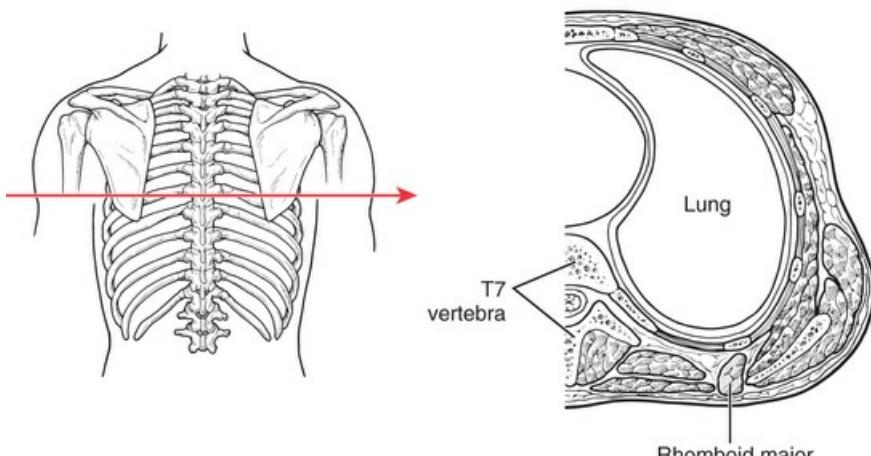


FIGURE 5.31



**FIGURE 5.32**



**FIGURE 5.33** Arrow indicates level of cross section.

## Range of Motion

Reliable data not available

**Table 5.5**  
**SCAPULAR RETRACTION AND DOWNWARD ROTATION**

I.D.	Muscle	Origin	Insertion	Function
125	Rhomboid major	T2-T5 vertebrae (spinous processes) Supraspinous ligaments	Scapula (upper vertebral border)	• Scapular adduction • Downward rotation of scapula (glenoid faces down)
126	Rhomboid minor	C7-T1 vertebrae (spinous processes) Ligamentum nuchae (lower)	Scapula (lower vertebral margin)	Scapular adduction Scapular downward rotation (glenoid faces down)
Other				
127	Levator scapulae	See Table 5.2		

The test for the rhomboid muscles has become the focus of some clinical debate. Kendall and co-workers claim, with good evidence, that these muscles frequently are underrated; that is, they are too often graded at a level less than their available performance.<sup>13</sup> At issue also is the confusion that can occur in separating the function of the rhomboids from those of other scapular or shoulder muscles, particularly the trapezius and the pectoralis minor. Because the rhomboids are innervated

only by one nerve root (C5), a test for the rhomboids, correctly conducted, can confirm or rule out a nerve root lesion at this level. With these issues in mind, the authors present first their method and then, with the generous permission of Mrs. Kendall, her rhomboid test as another method of assessment.

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Prone. Head may be turned to either side for comfort. Shoulder is internally rotated and the arm is adducted across the back with the elbow flexed and hand resting on the back ([Fig. 5.34](#)).



**FIGURE 5.34**

#### Instructions to Therapist:

Stand at test side. Ask patient to place hand at the small of the back and lift it several inches away from the back (Grade 3). If patient can successfully place the hand in this position, apply resistance in the test position. When the patient's shoulder extensor muscles are Grade 3 or higher, the hand used for resistance is placed on the humerus just above the elbow, and resistance is given in an outward and downward direction ([Fig. 5.35](#)).



**FIGURE 5.35**

When the shoulder extensors are weak, place the hand for resistance along the axillary border of the scapula (Fig. 5.36). Resistance is applied in a downward and outward direction.



FIGURE 5.36

The fingers of the hand used for palpation are placed deep under the vertebral border of the scapula.

**Test:**

Patient lifts the hand off the back, maintaining the arm position across the back. At the same time the examiner is applying resistance above the elbow in an outward direction. With strong muscle activity, the therapist's fingers will "pop" out from under the edge of the scapular vertebral border (see Fig. 5.34.)

**Instructions to Patient:**

"Lift your hand. Hold it. Don't let me push it down."

**Grading**

**Grade 5:**

Completes available range and holds against maximal resistance (Fig. 5.37). The fingers will "pop out" from under the scapula when strong rhomboids contract.

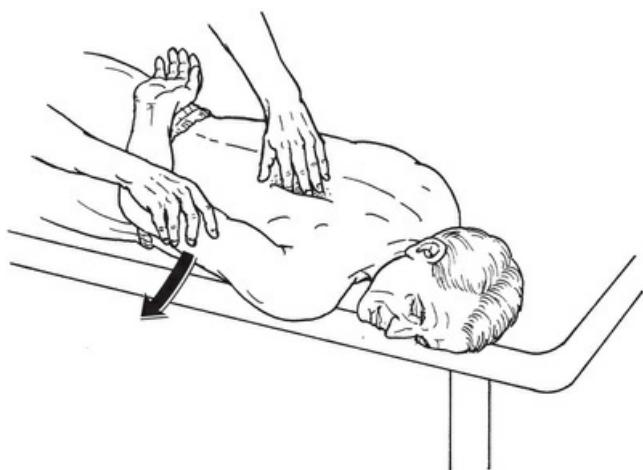


FIGURE 5.37

**Grade 4:**

Completes range and holds against strong to moderate resistance. Fingers usually will "pop out."

**Grade 3:**

Completes range but tolerates no manual resistance at either the humerus or scapula ([Fig. 5.38](#)).

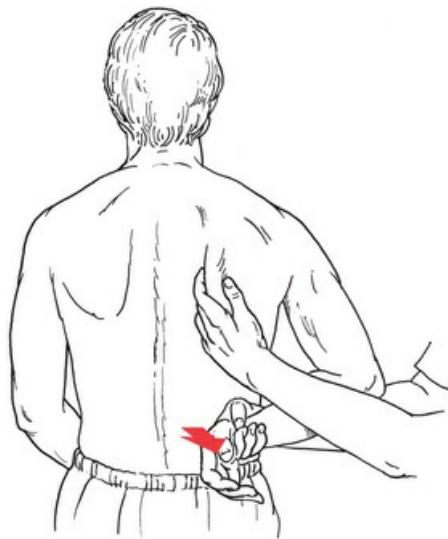


**FIGURE 5.38**

**Grade 2, Grade 1, and Grade 0**

**Position of Patient:**

Short sitting with shoulder internally rotated and arm extended and adducted behind back ([Fig. 5.39](#)).



**FIGURE 5.39**

**Instructions to Therapist:**

Stand at test side; support arm by grasping the wrist. The fingertips of one hand palpate the muscle under the vertebral border of the scapula.

**Test:**

Patient attempts to move hand away from back.

**Instructions to Patient:**

"Try to move your hand away from your back."

**Grading**

**Grade 2:**

Completes range of scapular motion.

**Grade 1 and Grade 0:**

A Grade 1 muscle has palpable contractile activity. A Grade 0 muscle shows no discernable palpable contractile activity.

**Alternate Rhomboid Test After Kendall<sup>13</sup>**

As a preliminary to this rhomboid test, the shoulder adductors should be tested and found sufficiently strong to allow the arm to be used as a lever.

**Position of Patient:**

Prone with head turned to side of test. Non-test arm is abducted with elbow flexed. Test arm is near the edge of the table. Arm (humerus) is fully adducted and held firm to the side of the trunk in external rotation (ER) and some extension with elbow fully flexed. In this position, the scapula is in adduction, elevation, and downward rotation (glenoid down).

**Instructions to Therapist:**

Stand at test side. Hand used for resistance is cupped around the flexed elbow. The resistance applied by this hand will be in the direction of scapular abduction and upward rotation (out and up; Fig. 5.40). The other hand is used to give resistance simultaneously. It is contoured over the shoulder joint and gives resistance caudally in the direction of shoulder depression.

**Test:**

Examiner tests the ability of the patient to hold the scapula in its position of adduction, elevation, and downward rotation (glenoid down).

**Instructions to Patient:**

"Hold your arm as I have placed it. Do not let me pull your arm out and forward." OR "Hold the position you are in; keep your shoulder blade against your spine as I try to pull it away."



**FIGURE 5.40**

## Helpful Hints

- The rhomboid test, where the resistance is applied to the humerus in an outward motion, should not be confused with the lift-off test, a diagnostic for a subscapular muscle tear.
- When the rhomboid test is performed with the hand behind the back, never allow the patient to lead the lifting motion with the elbow because this will activate the humeral extensors.
- Using needle electromyography (EMG) on 11 male subjects, Smith and colleagues<sup>10</sup> found the posterior deltoid manual muscle test produced more rhomboid EMG activity (30%) than the muscle test shown in Fig. 5.37. The manual muscle test described in Fig. 5.37 produced very high EMG activity in the latissimus dorsi and levator scapula muscles and equal activation in the middle trapezius, posterior deltoid, and rhomboids.
- The sitting position used in the posterior deltoid muscle test position described by Smith and colleagues<sup>10</sup> requires the rhomboids to function as a scapular rotator and scapular retractor as opposed to the prone position, which only requires the rhomboids to act as a scapular retractor.<sup>14,15</sup>
- The Kendall test (see Fig. 5.40) demonstrated greater rhomboid EMG activity (78% maximum voluntary contraction (MVC) than the rhomboid test shown in Fig. 5.37 (52% MVC), although the differences were not statistically significant.<sup>14</sup>

## Suggested Exercises for Rhomboids

- D2 diagonal pattern flexion and extension<sup>7</sup>
- Lat pull down with pronated wide grip in front of body<sup>15,16</sup>
- Prone row<sup>7,12</sup>
- Modified prone cobra (prone, arms extended at sides, lift trunk up, retracting scapulas and pulling hands towards feet).<sup>12</sup>

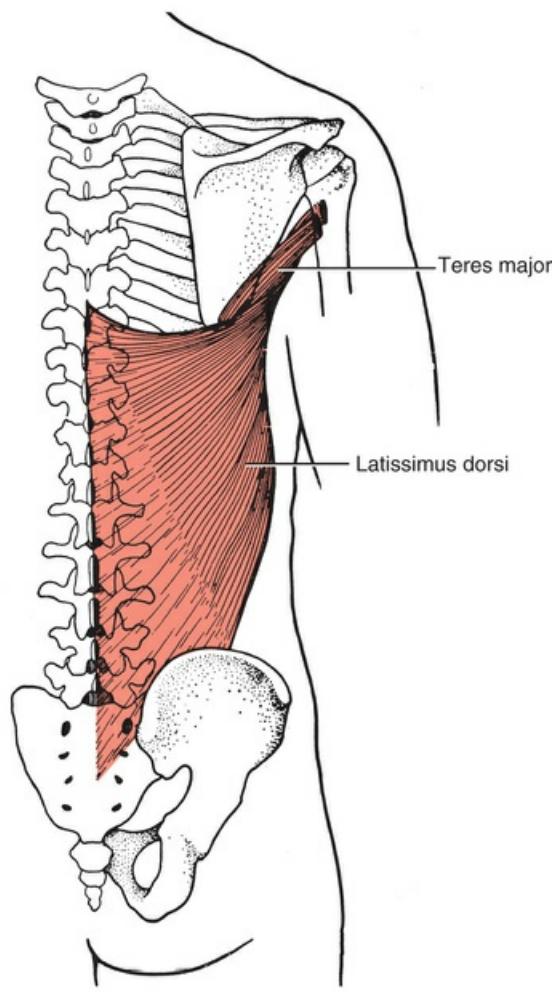
## Latissimus Dorsi

This large, broad muscle is anatomically complex, contributing to many movements at the humerus, scapula, and pelvis. It is the only muscle connecting the arms to the spine. Literally, it was our “swinging from the trees” muscle. It does not have a singular prime action. Rather its actions are dependent on the fixation of the humerus or pelvis. For example, when the humerus is fixed, the latissimus dorsi can lift the pelvis, which occurs during pressure relief in a wheelchair and during a sliding transfer (see Fig. 5.45). It is the main muscle used when we participate in the chin up/pull up exercise. When the pelvis is fixed, the latissimus dorsi acts on the arm in three ways:

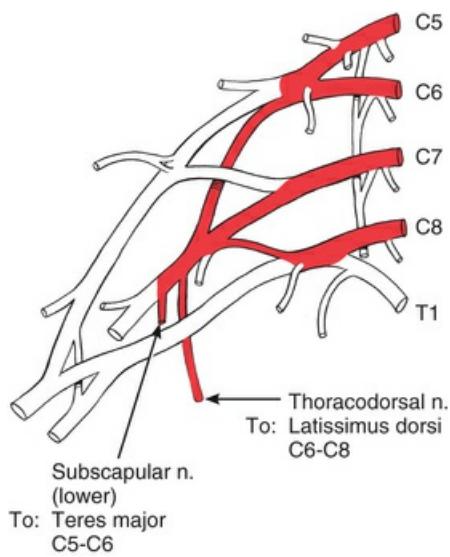
1. Shoulder extension
2. Shoulder adduction
3. Shoulder medial rotation

The latissimus can also depress the humerus and internally rotate, adduct, and extend the shoulder, particularly from a position of flexion. The student will find the latissimus dorsi mentioned in other parts of this chapter as a participant in multiple muscle actions, further supporting the importance and complexity of this muscle.

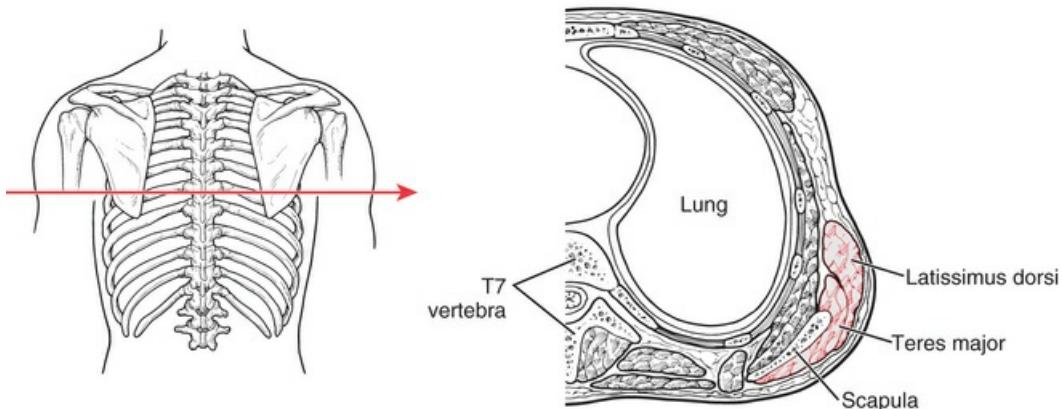
The latissimus dorsi also assists with breathing with the forced expiration as well as deep inspiration of breath from the lungs.



POSTERIOR  
FIGURE 5.41



**FIGURE 5.42**



**FIGURE 5.43**

**Table 5.6**  
**LATISSIMUS DORSI**

ID.	Muscle	Origin	Insertion	Function
130	Latissimus dorsi	Spines of the 6 lower thoracic vertebrae, thoracolumbar fascia, crest of the ilium, lowest 4 ribs	Anterior humerus, lower margin of the intertubercular sulcus	Shoulder extension, adduction and internal (medial) rotation Hyperextension of the spine Strong expiration and deep inspiration Elevation of the pelvis with arms fixed

### Grade 5, Grade 4, Grade 3, Grade 2, and Grade 1

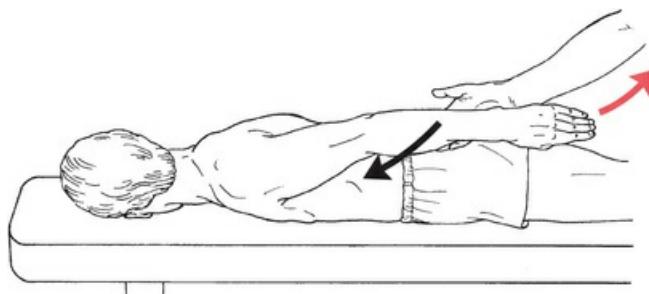
#### Position of Patient:

Prone with head turned to test side; arms are at sides and shoulder is internally rotated (palm up).

#### Instructions to Therapist:

Stand at test side. Ask patient to lift arm into shoulder extension and adduction (keeping arm close to trunk) (Grade 3). If full range is present, apply appropriate resistance. With shoulder in extension

and adduction and elbow extended, apply resistance with hand over medial forearm above patient's wrist in direction of abduction and slight flexion (outwards and down) ([Fig. 5.44](#)). No stabilization is needed because of prone position.



**FIGURE 5.44**

**Test:**

Patient lifts arm into extension and adduction (close to trunk).

**Instructions to Patient:**

"Hold your arm. Don't let me move it."

**Grading**

**Grade 5:**

Patient holds test position against maximal resistance (see [Fig. 5.44](#)).

**Grade 4:**

Patient holds test position against moderate resistance.

**Grade 3:**

Completes range but tolerates no resistance.

**Grade 2:**

Movement observable but range is limited.

**Grade 1:**

Muscle activity is palpable.

**Grade 0:**

No movement and no discernable muscle contraction is occurring.

**Alternate Test for Latissimus Dorsi**

As explained above, with the upper limb fixed, elevation of the trunk and pelvis are possible through the action of the latissimus dorsi, such as in crutch walking or buttock pressure releases in sitting.

**Position of Patient:**

Short sitting, arms adducted to trunk with hands flat on table adjacent to hips ([Fig. 5.45](#)).

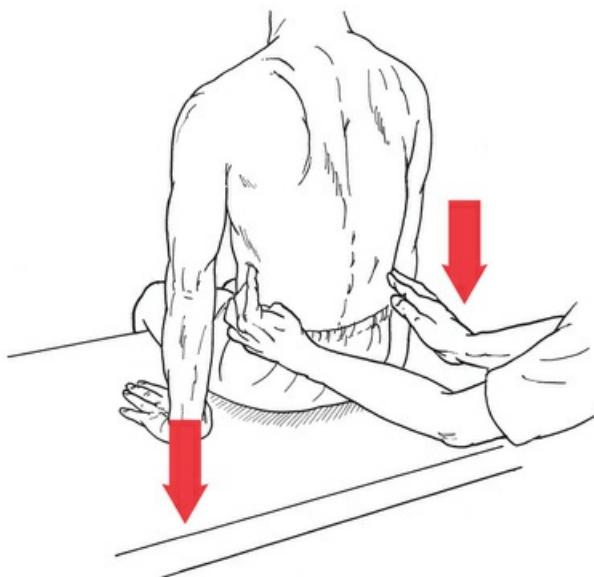


FIGURE 5.45

If the patient's arms are too short to assume this position, provide a push-up block for each hand.

**Instructions to Therapist:**

Stand behind patient. Fingers are used to palpate fibers of the latissimus dorsi on the lateral aspect of the thoracic wall (bilaterally) just above the waist (see Fig. 5.45).

**Test:**

Patient pushes down on hands (or blocks) and lifts buttocks from table (see Fig. 5.45).

**Instructions to Patient:**

"Lift your bottom off the table. Keep your arms into your sides."

**Grading**

**Grade 3, Grade 4 and Grade 5:**

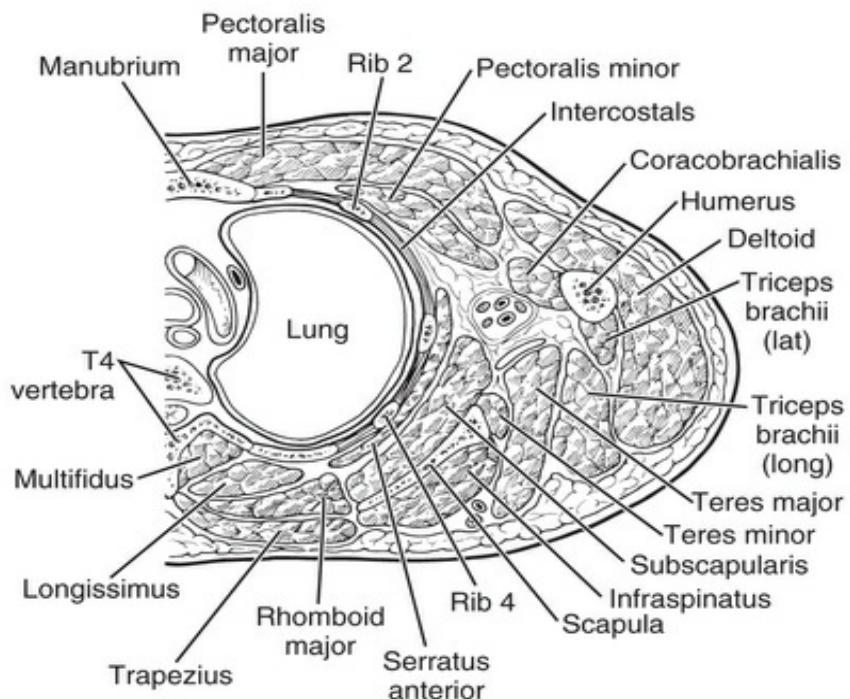
Patient can lift buttocks clear of table.

## Suggested Exercises for the Latissimus Dorsi

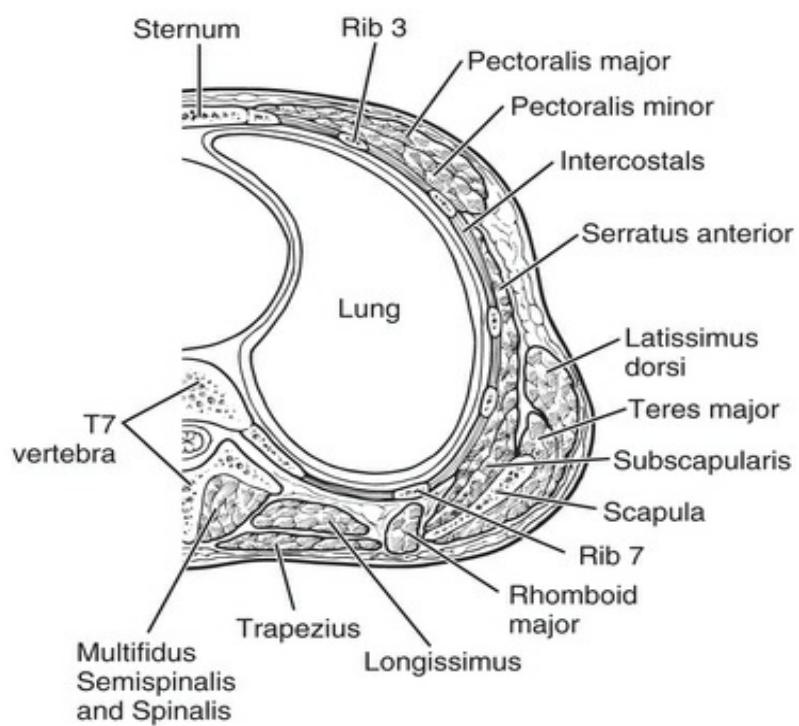
- Pull ups<sup>17</sup>
- Latissimus pull downs<sup>17</sup>
- Inverted row<sup>17</sup>
- Press up<sup>7</sup>
- Standing extension from 90°-0° with elastic tubing<sup>7</sup>

## CROSS SECTIONS OF THE ARM MUSCLES IN CHEST

### VENTRAL



### DORSAL



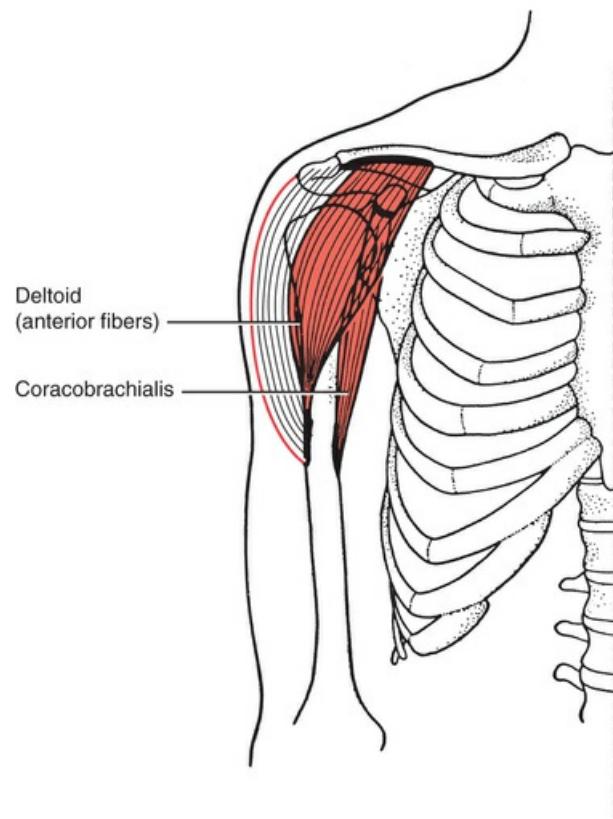
**PLATE 3** Cross Sections of the arm muscles in chest.

## Introduction to Testing the Deltoid

The deltoid muscle, made of three parts (anterior, middle and posterior), has multiple functions of mobility and stabilization of the head of the humerus into the glenoid fossa. The deltoid can act in part or as a whole. Together, the three parts allow swinging of the arm, and preventing downward dislocation of the humeral head when carrying an object in the hanging hand.<sup>18</sup> The three parts work together to produce abduction of the shoulder joint. The anterior part has a flexion and internal rotation (IR) function and the posterior part has an extension and ER function.<sup>1</sup> The anterior part acts with the rotator cuff to raise the arm in both flexion and abduction. The middle part is a strong shoulder abductor while the posterior part is a strong extensor (with the latissimus dorsi and teres major) and to a lesser degree, a horizontal abductor. The deltoid is capable of extending the humerus beyond the midline whereas the latissimus dorsi is not.

## Shoulder Flexion

(Anterior deltoid, Rotator cuff, Clavicular portion of pectoralis major, and Coracobrachialis\*)



ANTERIOR  
FIGURE 5.46

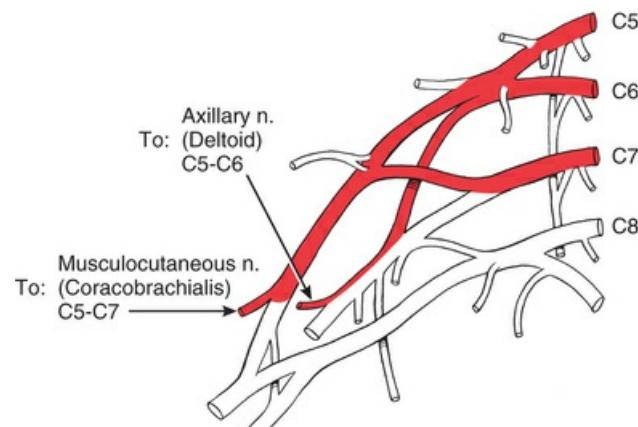
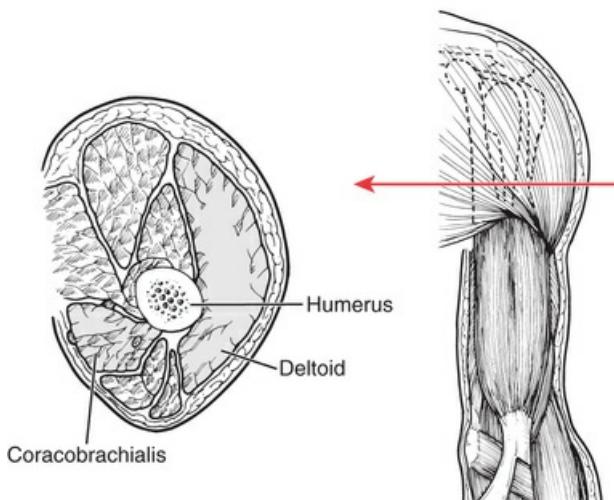


FIGURE 5.47



**FIGURE 5.48**

## Range of Motion

0°–180°

**Table 5.7**  
**SHOULDER FLEXION**

ID.	Muscle	Origin	Insertion	Function
133	Deltoid (anterior)	Clavicle (anterior superior border of lateral $\frac{1}{3}$ of shaft)	Humerus (deltoid tuberosity on shaft)	Flexion and internal rotation of shoulder (anterior fibers) The deltoid tends to displace the humeral head upward Shoulder horizontal adduction (anterior fibers)
139	Coracobrachialis	Scapula (coracoid process at apex)	Humerus (shaft, medial surface at middle $\frac{1}{3}$ )	Flexion of arm Adduction of shoulder
131	Pectoralis major (clavicular fibers)	See Table 5.4		<i>Clavicular fibers:</i> Flexion of shoulder Horizontal shoulder adduction Internal rotation of shoulder
<b>Others</b>				
135	Supraspinatus	Scapula (supraspinous fossa, medial $\frac{2}{3}$ ) Supraspinatus fascia	Humerus (greater tubercle, highest facet) Articular capsule of glenohumeral (G-H) joint	Maintains humeral head in glenoid fossa (with other rotator cuff muscles) Shoulder flexor Abduction of shoulder External rotation of shoulder
	Long and short head of biceps	See table 5.13		

Due to increasing moment arm with abduction, the anterior deltoid is more effective as a shoulder abductor in higher abduction angles (120°), with its greatest force production above the horizontal,<sup>19</sup> in contrast to the supraspinatus, which is a more effective shoulder abductor at lower abduction ranges. The supraspinatus has a role as a humeral head depressor during shoulder flexion.<sup>20</sup> The middle deltoid also provides G-H stabilization with greater amounts of shoulder flexion.

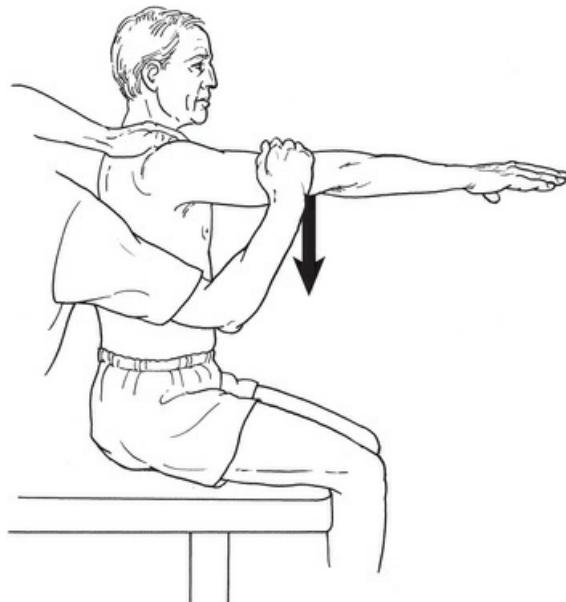
## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Short sitting with arms at sides, elbow slightly flexed, forearm pronated.

### Instructions to Therapist:

Stand at test side. Ask patient to raise arm forward to shoulder height (90°), keeping elbow straight. If full range is present (Grade 3), position arm in test position (90°) and apply appropriate resistance. Therapist's hand giving resistance is contoured over the distal humerus just above the elbow. The other hand may stabilize the shoulder (Fig. 5.49).



**FIGURE 5.49**

**Test:**

Patient flexes shoulder to 90° with elbow straight without rotation or horizontal movement (see Fig. 5.49). The scapula should be allowed to abduct and upwardly rotate.

**Instructions to Patient:**

"Hold your arm. Don't let me push it down."

**Grading**

**Grade 5:**

Holds test position (90°) against maximal resistance.

**Grade 4:**

Holds test position against strong to moderate resistance.

**Grade 3:**

Completes test range (90°) without resistance (Fig. 5.50)

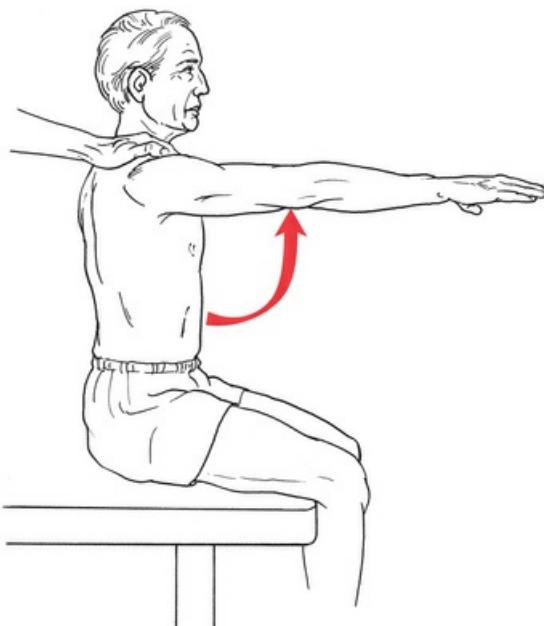


FIGURE 5.50

## Grade 2, Grade 1, and Grade 0

### Position of Patient:

Side-lying position (test side up).

### Instructions to Therapist:

With patient side-lying to minimize gravity, stand behind patient and cradle the test arm at the elbow. Then ask patient to flex the shoulder. (A powder board may also be used.)

### Test:

Patient attempts to flex shoulder.

### Instructions to Patient:

"Try to raise your arm."

## Grade 1 and Grade 0

### Instructions to Therapist:

Stand behind patient. Fingers used for palpation are placed over the superior and anterior surfaces of the deltoid over the shoulder joint ([Fig. 5.51](#)).

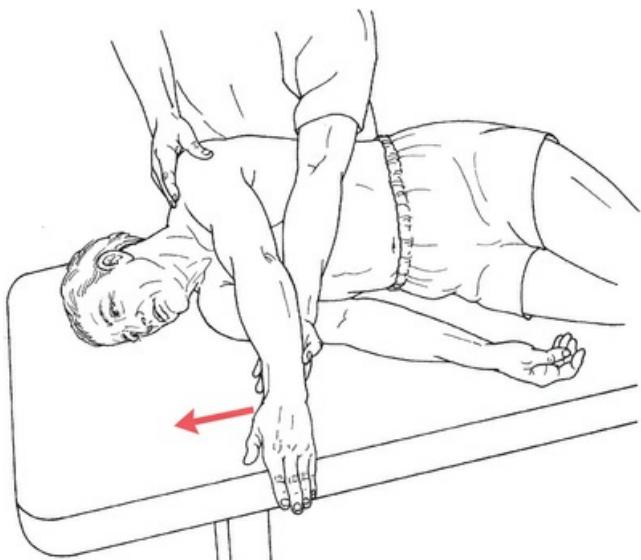


FIGURE 5.51

## Grading

Test for Grade 2, Grade 1, and Grade 0:

### Grade 2:

Completes full range of motion in gravity-minimized position.

### Grade 1:

Therapist feels or sees contractile activity in the anterior deltoid, but no motion occurs.

### Grade 0:

No discernable palpable contractile activity.

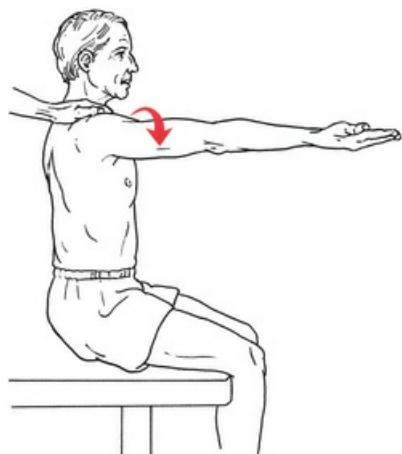


FIGURE 5.52

## Substitutions

- In the absence of a deltoid, the patient may attempt to flex the shoulder with the biceps brachii

by first externally rotating the shoulder (Fig. 5.52). To avoid this, the arm should be kept in the mid position between internal and external rotation.

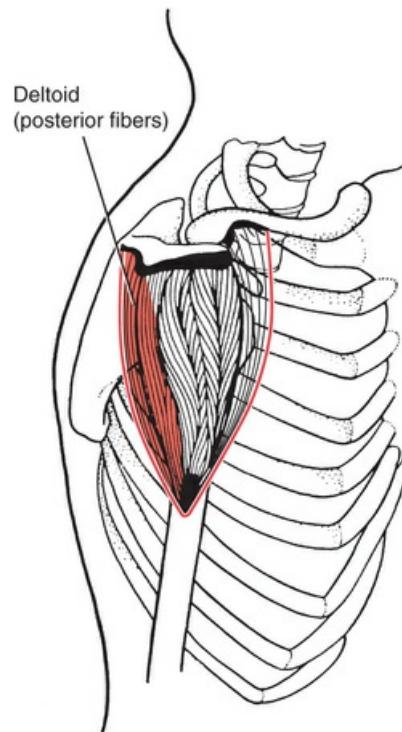
- Attempted substitution by the upper trapezius results in shoulder elevation.
- Attempted substitution by the pectoralis major results in horizontal adduction. It should be noted that substitution by the pectoralis major as a shoulder flexor can only occur up to about 70°.
- The patient may lean backward or try to elevate the shoulder girdle to assist in flexion.

## Suggested Exercises for Anterior Deltoid and Supraspinatus

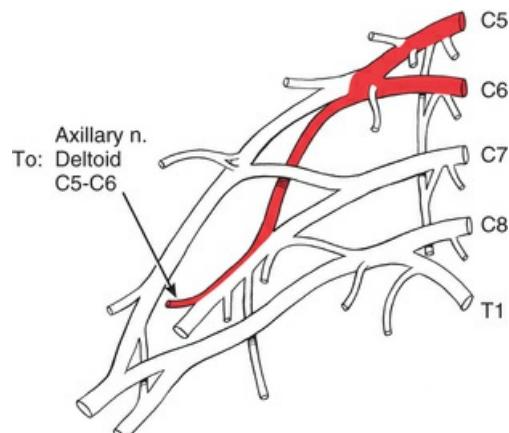
- Push up (40%–50% MVC)<sup>21</sup>
- Pressing incline activities between 28° and 90°<sup>22,23</sup> such as dumbbell press
- Plyometric push-up (clapping) (60%–70% MVC)<sup>21</sup>
- Full and empty can.<sup>8,24,25</sup> Full can produces less deltoid activity.
- Slow, controlled shoulder flexion at 90° and 125°<sup>24</sup>
- Prone horizontal abduction at 100° with external rotation<sup>8</sup>
- Upright row<sup>26</sup>

## Shoulder Extension

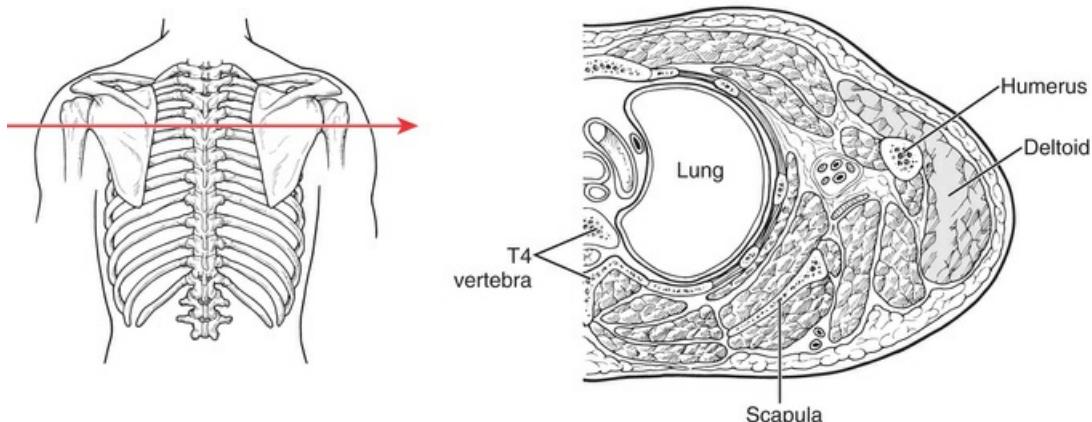
(Posterior deltoid, Latissimus dorsi, Teres major, and Long head of triceps)



LATERAL  
**FIGURE 5.53**



**FIGURE 5.54**



**FIGURE 5.55** Arrow indicates level of cross section.

## Range of Motion

0°–45° (up to 60°)

**Table 5.8**  
**SHOULDER EXTENSION**

I.D.	Muscle	Origin	Insertion	Function
133	Deltoid (posterior)	Scapula (spine on lower lip of lateral and posterior borders)	Humerus (deltoid tuberosity on mid shaft via humeral tendon)	Extension and external rotation. The posterior fibers of the deltoid tends to displace the humeral head upward Shoulder horizontal abduction
130	Latissimus dorsi	T6-T12, L1-L5, and sacral vertebrae (spinous processes) Supraspinous ligaments Ribs 9–12 (by slips interdigitating with obliquus abdominis externus) Ilium (crest, posterior) Thoracolumbar fascia	Humerus (intertubercular sulcus, floor) Deep fascia of arm	Shoulder extension (from a position of flexion) adduction, and internal rotation
138	Teres major	Scapula (dorsal surface of inferior angle)	Humerus (intertubercular sulcus, medial lip)	Extension of shoulder from a flexed position Internal rotation of shoulder Adduction and extension of shoulder
<b>Other</b>				
142	Triceps brachii (long head)			

The posterior deltoid is a stronger extensor throughout the range with the greatest contribution with the arms below horizontal. Its peak moment arm is at 30° of flexion (arm pointing down). The posterior deltoid is the primary shoulder hyper-extensor because neither the pectoralis major nor the latissimus dorsi extends the shoulder beyond anatomical neutral. This hyper-extension function allows the patient to reach behind the body to the gluteal area and beyond.<sup>18</sup> The posterior deltoid opposes the anterior deltoid in the sagittal (flexion) plane and acts as a strong external rotator (up to 80% when elevated into the plane of the scapula).<sup>1</sup>

## Grade 5, Grade 4, Grade 3, and Grade 2

### Position of Patient:

Prone with arms at sides and shoulder internally rotated (palm up) (Fig. 5.56).

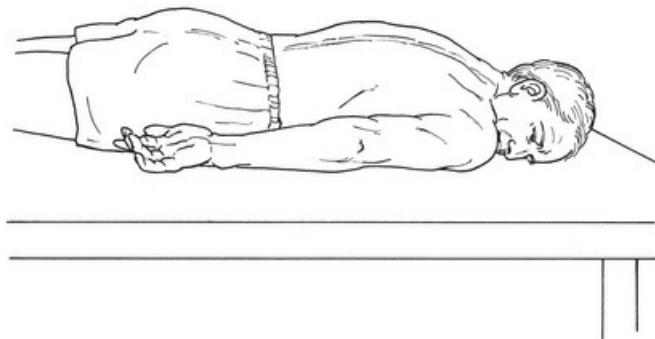


FIGURE 5.56

**Instructions to Therapist:**

Stand at test side. Ask patient to lift arm as high as possible. If full range is available (Grade 3), position arm in test position near end range and apply appropriate resistance. The hand used for resistance is contoured over the posterior arm just above the elbow ([Fig. 5.57](#)).

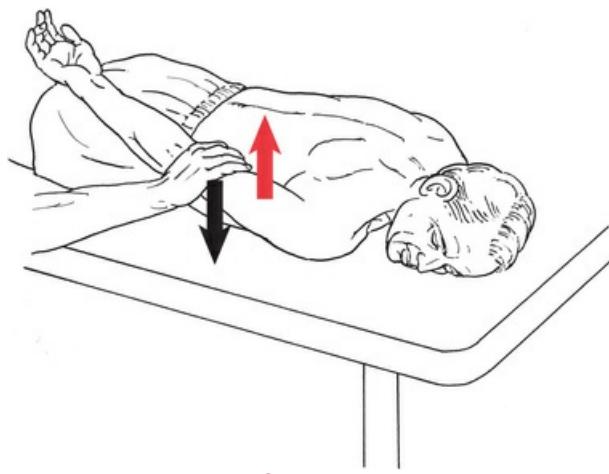


FIGURE 5.57

**Test:**

Patient raises arm off the table, keeping the elbow straight ([Fig. 5.58](#)).

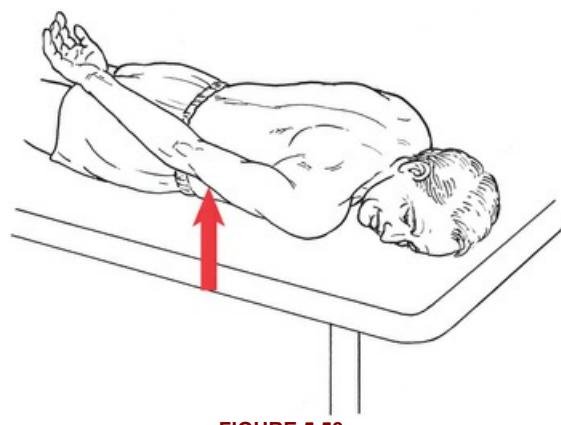


FIGURE 5.58

**Instructions to Patient:**

"Lift your arm as high as you can. Hold it. Don't let me push it down."

**Grading**

**Grade 5:**

Holds test position against maximal resistance.

**Grade 4:**

Holds test position against strong resistance.

**Grade 3:**

Completes available range of motion with no manual resistance (see [Fig. 5.58](#)).

**Grade 2:**

Completes partial range of motion.

**Grade 1 and Grade 0**

**Position of Patient:**

Prone with arms at sides and shoulder internally rotated (palm up).

**Instructions to Therapist:**

Stand at test side. Fingers for palpation are placed on the posterior aspect of the upper arm (posterior deltoid) ([Fig. 5.59](#)).



**FIGURE 5.59**

Palpate over the posterior shoulder just superior to the axilla for posterior deltoid fibers. Palpate the teres major on the lateral border of the scapula just below the axilla. The teres major is the lower of the two muscles that enter the axilla at this point; it forms the lower posterior rim of the axilla.

**Test and Instructions to Patient:**

Patient attempts to lift arm from table.

**Grading**

**Grade 1:**

Palpable contractile activity in any of the participating muscles but no movement of the shoulder.

**Grade 0:**

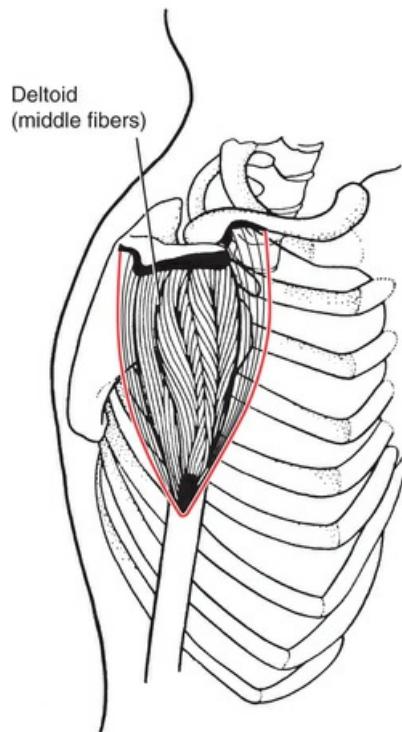
No palpable contractile response in participating muscles.

### Suggested Exercises for the Middle and Posterior Deltoid

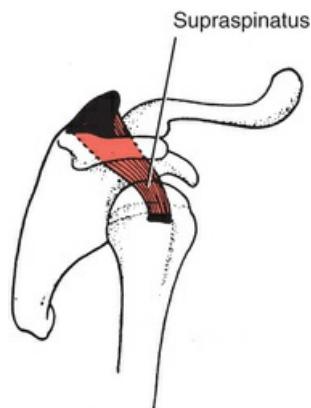
- D1 diagonal pattern extension<sup>7</sup>
- D2 diagonal pattern flexion<sup>7</sup>
- Push up exercises<sup>7</sup>
- Prone shoulder elevation (arm raised overhead in line with lower trapezius fibers)<sup>7,24</sup>
- Extension with internal rotation<sup>24</sup> shoulder abduction 30° with elbow extended. Arm extended and IR
- Side-lying ER at 0° abduction<sup>7</sup>
- Empty can<sup>24</sup>
- 45° incline row

## Shoulder Abduction

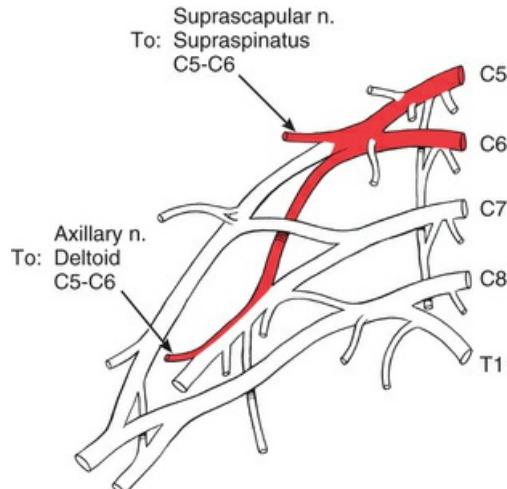
(Middle deltoid and Supraspinatus)



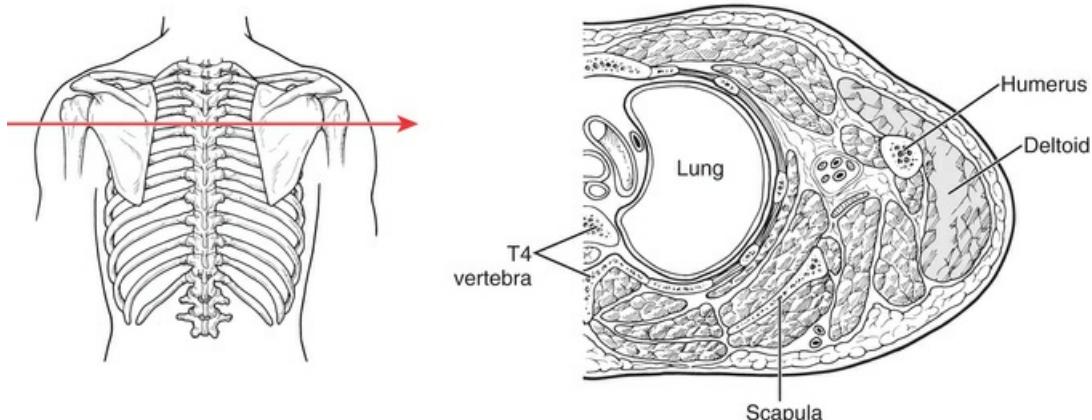
LATERAL  
FIGURE 5.60



LATERAL  
FIGURE 5.61



**FIGURE 5.62**



**FIGURE 5.63** Arrow indicates level of cross section.

## Range of Motion

0°–180°

**Table 5.9**  
**SHOULDER ABDUCTION**

I.D.	Muscle	Origin	Insertion	Function
133	Deltoid (middle fibers)	Scapula (acromion, lateral margin, superior surface, and crest of spine)	Humerus (deltoid tuberosity on shaft via humeral tendon)	Abduction of shoulder (glenohumeral [G-H] joint); primarily the acromial middle fibers. The anterior and posterior fibers in this motion stabilize the limb in its cantilever position
135	Supraspinatus	Scapula (supraspinous fossa, medial $\frac{2}{3}$ ) Supraspinatus fascia	Humerus (greater tubercle, highest facet) Articular capsule of glenohumeral (G-H) joint	Maintains humeral head in glenoid fossa (with other rotator cuff muscles) Abduction of shoulder External rotation of shoulder
	Long head of biceps (if humerus externally rotated)			
Other	Remaining cuff muscles: Infraspinatus, teres minor, subscapularis			Depresses head of humerus

In the frontal plane, the middle deltoid performs shoulder abduction. It also performs horizontal abduction with the posterior deltoid. It has the largest cross-sectional area of the three deltoids. The

supraspinatus and other rotator cuff muscles stabilize the humeral head against the elevating effect of the middle deltoid.<sup>27</sup>

## Testing the Supraspinatus

Much controversy exists regarding the diagnosis of supraspinatus pathology. Two tests used to examine the supraspinatus muscle are the empty can test (also known as the Jobe test) and the full can test. In the full can test, the arm is externally rotated (thumb pointed up); in the empty can test the arm is internally rotated (thumb pointed down). In both tests the shoulder is in abduction but with 30° of flexion included. In a meta-analysis of the full and empty can tests,<sup>28</sup> the empty can or Jobe test had insufficient sensitivity and specificity to be clinically useful in diagnosing supraspinatus tendonitis or impingement but performed better in identifying a full-thickness or massive tear, especially in the presence of weakness (sensitivity = 41%; specificity = 70%).<sup>29</sup> Furthermore, the empty can (thumb pointed down) and full can (thumb pointed up) positions were not statistically different in their performance of identifying pathology, probably because the supraspinatus generates abduction torque in neutral rotation.<sup>30</sup>

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Short sitting with arm at side and elbow slightly flexed.

#### Instructions to Therapist:

Stand behind patient. Ask patient to lift arm out to the side to shoulder level (test position) with arm in neutral rotation and elbow straight. If sufficient range is present, proceed to test Grade 5. Therapist's hand giving resistance is contoured over arm just above elbow (Fig. 5.64). Resistance is given in a downward direction.

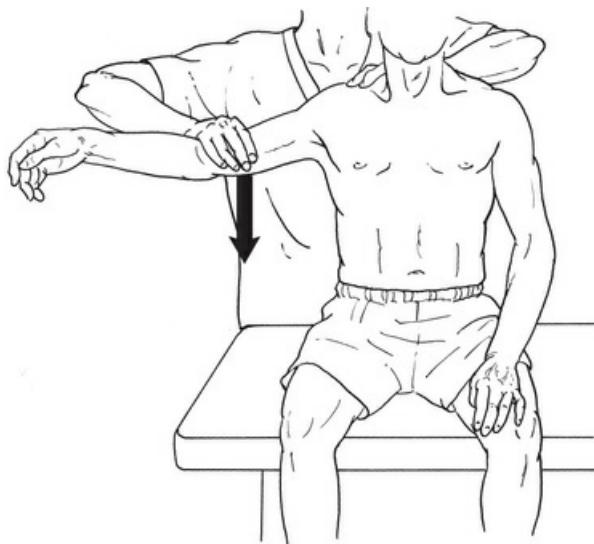


FIGURE 5.64

#### Test:

Patient abducts arm to 90°.

#### Instructions to Patient:

"Lift your arm out to the side to shoulder level. Hold it. Don't let me push it down."

## Grading

### Grade 5:

Holds test position against maximal resistance.

### Grade 4:

Holds test position against strong resistance.

### Grade 3:

Completes range of motion to 90° without resistance ([Fig. 5.65](#)).

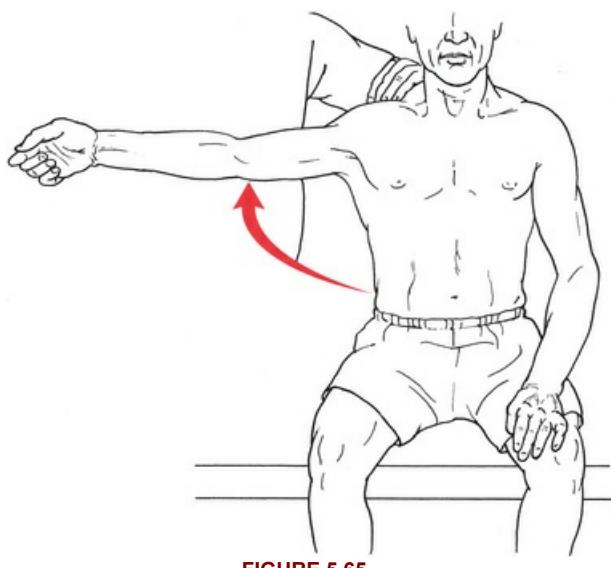


FIGURE 5.65

## Grade 2

### Position of Patient:

Supine. Arm at side supported on table in neutral rotation (thumb pointed outward) ([Fig. 5.66](#)).

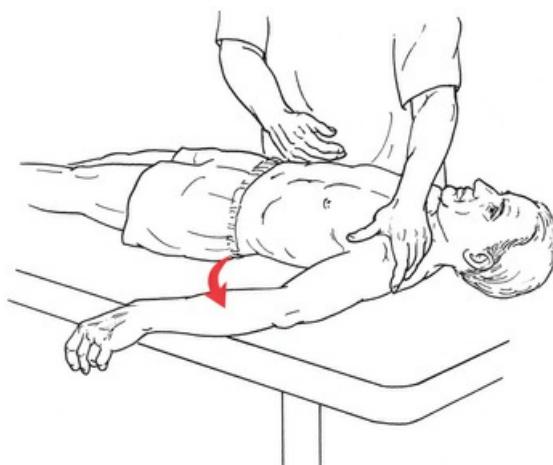


FIGURE 5.66

### Instructions to Therapist:

Stand at test side of patient (therapist is shown on opposite side of test in figure to clearly illustrate test procedure). Hand used for palpation is positioned over the middle deltoid, lateral to acromial process on the superior aspect of the shoulder.

**Test:**

Patient attempts to abduct shoulder by sliding arm on table without rotating it (see Fig. 5.66). A powder board or towel under the arm may be used to decrease friction.

**Instructions to Patient:**

"Take your arm out to the side."

**Grading**

**Grade 2:**

Completes full range of motion in this gravity-minimized position or cannot raise shoulder to 90° with elbow straight (cannot lift the weight of the extended arm)

**Grade 1 and Grade 0**

**Position of Patient:**

Supine with arm at side and elbow slightly flexed.

**Therapist Instructions:**

Stand at side of table at a place where the deltoid can be reached. Palpate the deltoid on the lateral surface of the upper one third of the arm (Fig. 5.67).



**FIGURE 5.67**

**Grade 1:**

Palpable or visible contraction of deltoid with no movement.

**Grade 0:**

No discernable palpable contractile activity.

## **Substitution by Biceps Brachii**

When a patient uses the biceps to substitute, the shoulder will externally rotate and the elbow will flex. The arm will be raised but not by the action of the abductor muscles. To avoid this substitution begin the test with the arm in a few degrees of elbow flexion, but do not allow active contraction of the biceps during the test.

## Helpful Hints

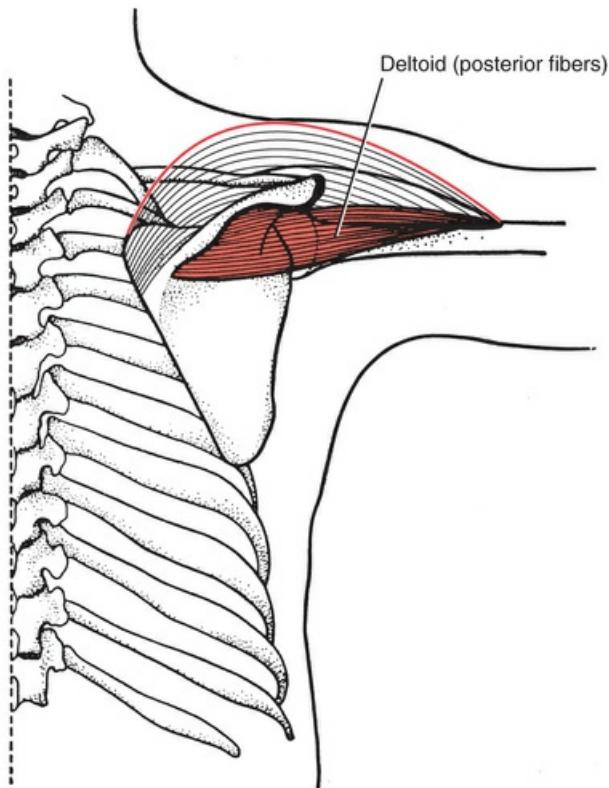
- Turning the face to the opposite side and extending the neck will put the trapezius on slack and make the supraspinatus more accessible for palpation.
- The deltoid and supraspinatus work in tandem; when one is active in abduction, the other also will be active. Only when supraspinatus weakness is suspected is it necessary to palpate.
- Do not allow shoulder elevation or lateral flexion of the trunk to the opposite side because these movements can create an illusion of abduction.
- The tendon of the supraspinatus is the most frequently injured of all the rotator cuff muscles because of its vulnerable position between the humeral head and acromion.<sup>29</sup>
- The supraspinatus is activated first when the patient abducts the arm from a neutral position of hanging at the side.<sup>20</sup> It functions to prevent the deltoid from superiorly translating the humeral head during abduction.<sup>31</sup>
- Peak activation of the supraspinatus is at 90° of abduction which corresponds with the largest shoulder joint compressive loads, when the forces of gravity and weight of the upper extremity are the greatest.<sup>20,32</sup>
- The predicted supraspinatus force during maximum effort isometric plane abduction (scaption) at the 90° position was 175N.<sup>32</sup>

## Suggested Exercises for Middle Deltoid and Supraspinatus (Combined)

- Flexion at 125°<sup>24</sup>
- Prone horizontal abduction at 100° with full external rotation<sup>8,25</sup>
- Standing external rotation<sup>25</sup>

## Shoulder Horizontal Abduction

(Posterior deltoid)



POSTERIOR  
FIGURE 5.68

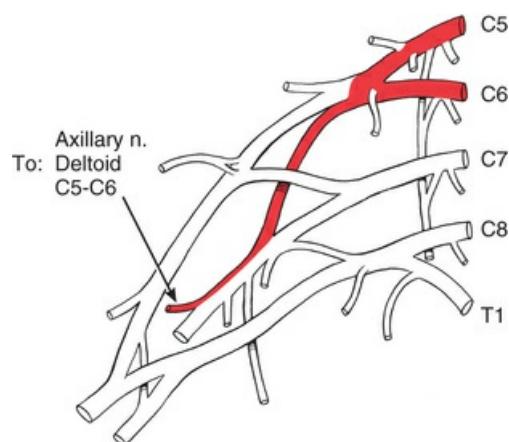


FIGURE 5.69

## Range of Motion

$0^\circ$ – $90^\circ$  (range,  $90^\circ$ ) when starting from a position of  $90^\circ$  of forward flexion  
 $-40^\circ$  to  $90^\circ$  (range,  $130^\circ$ ) when starting with the arm in full horizontal adduction

**Table 5.10**  
**SHOULDER HORIZONTAL ABDUCTION**

I.D.	Muscle	Origin	Insertion	Function
133	Deltoid (posterior fibers)	Scapula (spine on lower lip of crest)	Humerus (deltoid tuberosity via humeral tendon)	Shoulder horizontal abduction Extension and external rotation: posterior fibers
	Deltoid (middle fibers)	See <a href="#">Table 5.9</a>		
<b>Others</b>				
136	Infraspinatus			
137	Teres minor			
125	Rhomboideus major			
124	Trapezius (middle)			

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Prone. Shoulder abducted to  $90^\circ$  and forearm off edge of table with elbow straight.

#### Instructions to Therapist:

Stand at test side. Ask patient to lift elbow up toward the ceiling. If full range is present (Grade 3), apply appropriate resistance. Therapist's hand giving resistance is contoured over posterior arm just above the elbow ([Fig. 5.70](#)).



**FIGURE 5.70**

#### Test:

Patient horizontally abducts shoulder. Care should be provided to not allow the humerus to drop (lower), allowing substitution of the rhomboids.

#### Instructions to Patient:

"Lift your arm up toward the ceiling. Hold it. Don't let me push it down."

### Grading

#### Grade 5:

Holds test position against maximal resistance.

#### Grade 4:

Holds test position against strong to moderate resistance.

#### Grade 3:

Completes range of motion without manual resistance ([Fig. 5.71](#)). Note the elbow can be flexed for a

Grade 3.

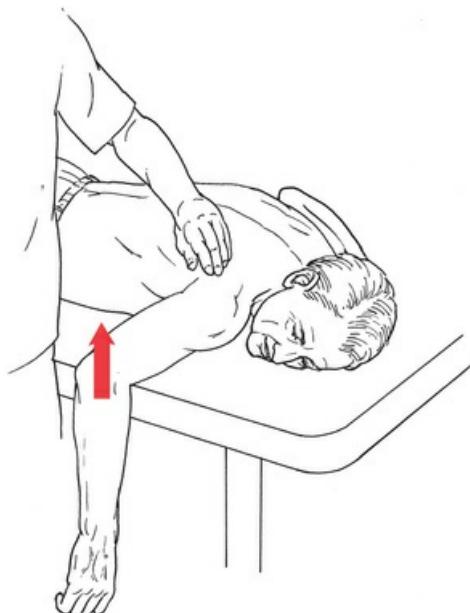


FIGURE 5.71

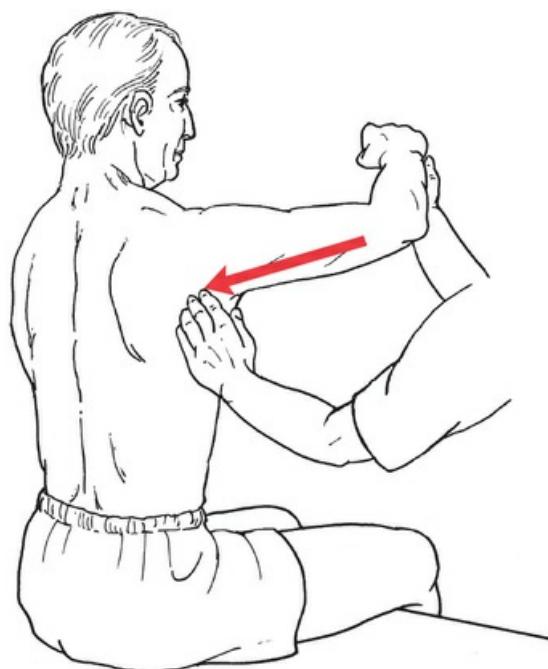
### Grade 2, Grade 1, and Grade 0

**Position of Patient:**

Short sitting.

**Instructions to Therapist:**

Stand at test side. Support forearm under volar aspect ([Fig. 5.72](#)) and palpate over the posterior surface of the shoulder just superior to the axilla.



**FIGURE 5.72**

**Test:**

Patient attempts to horizontally abduct the shoulder. Be careful not to allow the patient to drop the arm, substituting the rhomboids.

**Instructions to Patient:**

"Try to move your arm backward."

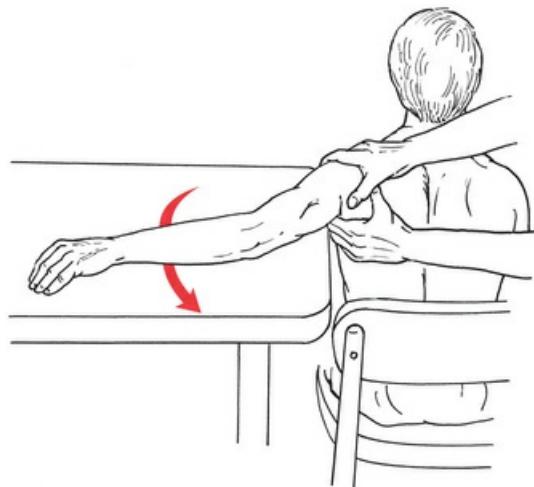
**Alternate Test for Grade 2, Grade 1, and Grade 0**

**Position of Patient:**

Short sitting with arm supported on table (smooth surface) in 90° of abduction; elbow partially flexed. A powder board can be used.

**Instructions to Therapist:**

Stand behind patient. Stabilize by contouring one hand over the superior aspect of the shoulder and the other over the scapula (Fig. 5.73). Palpate the fibers of the posterior deltoid below and lateral to the spine of the scapula and on the posterior aspect of the proximal arm adjacent to the axilla.



**FIGURE 5.73**

**Test:**

Patient slides (or tries to move) the arm across the table in horizontal abduction.

**Instructions to Patient:**

"Slide your arm backward."

**Grading**

**Grade 2:**

Moves through full range of motion.

**Grade 1:**

Palpable contraction; no motion.

**Grade 0:**

No discernable palpable contractile activity.

### **Helpful Hint**

If the scapular muscles are weak, the therapist must manually stabilize the scapula to avoid scapular abduction.

### **Substitution by Triceps Brachii (Long Head)**

Maintain the elbow in flexion to avoid substitution by the long head of the triceps.

### **Suggested Exercises for Posterior Deltoid**

- Bent over rear deltoid raise
- Prone rear deltoid raise
- Prone horizontal abduction at 100° with full external rotation<sup>25</sup>
- Prone external rotation at 90° of abduction<sup>25</sup>

## Shoulder Horizontal Adduction

(*Pectoralis major*)

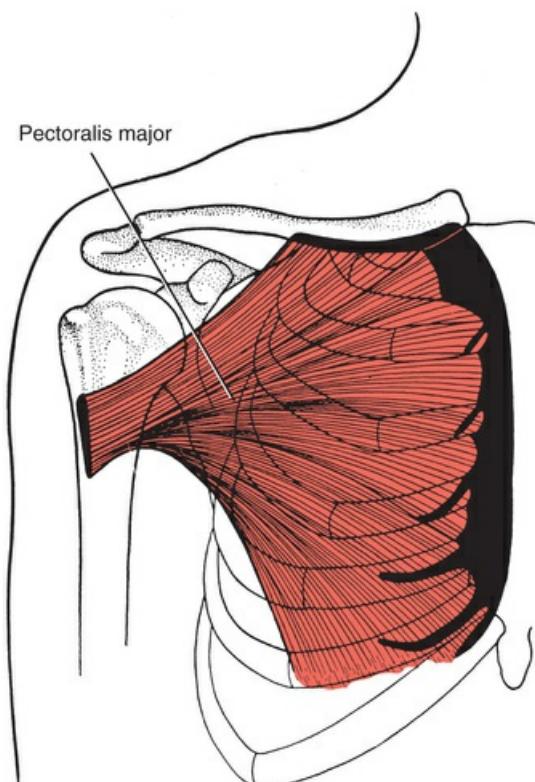


FIGURE 5.74

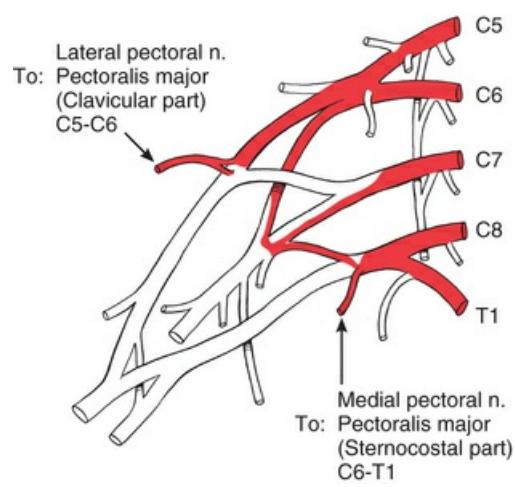
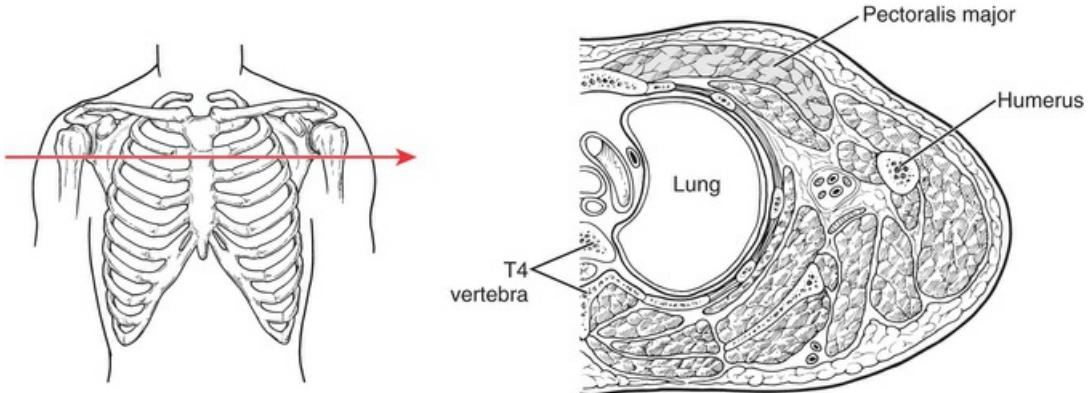


FIGURE 5.75



**FIGURE 5.76** Arrow indicates level of cross section.

## Range of Motion

0°–130°

When starting from a position of 90° of forward flexion: 0° to –40° (range, 40°)

When starting with the arm in full horizontal abduction: 0° passing across the midline to –40° (range, 130°)

**Table 5.11**  
**SHOULDER HORIZONTAL ADDUCTION**

I.D.	Muscle	Origin	Insertion	Function
131	Pectoralis major	Clavicular part Clavicle (sternal half of anterior surface)	Humerus (intertubercular sulcus, lateral lip)	Internal rotation of shoulder Flexion of shoulder Horizontal shoulder adduction
	Sternal part Sternum (anterior surface down to rib 6) Ribs 2–7 (costal cartilages) Aponeurosis of obliquus externus abdominis		Both parts converge on a bilaminar common tendon	Horizontal shoulder adduction Extension of shoulder Draws trunk upward and forward in climbing
Other	Deltoid (anterior fibers)	See Table 5.7		
133				

The two parts of the pectoralis major muscle can work separately or together. Together they adduct the arm across the body and medially rotate the shoulder. It swings the extended arm forwards and medially.<sup>1</sup> If the arm is fixed, such as gripping a branch overhead, the pectoralis major draws the trunk up and forwards.<sup>1</sup>

## Grade 5 and Grade 4

### Position of Patient:

#### Whole Muscle:

Supine. Shoulder abducted to 90°; elbow flexed to 90°.

#### Clavicular Head:

Patient begins test with shoulder in 60° of abduction with elbow flexed. Patient then is asked to horizontally adduct the shoulder in a slightly upward diagonal direction.

#### Sternal Head:

Patient begins test with shoulder in about 120° of abduction with elbow flexed. Patient is asked to horizontally adduct the shoulder in a slightly downward diagonal direction.

#### Instructions to Therapist:

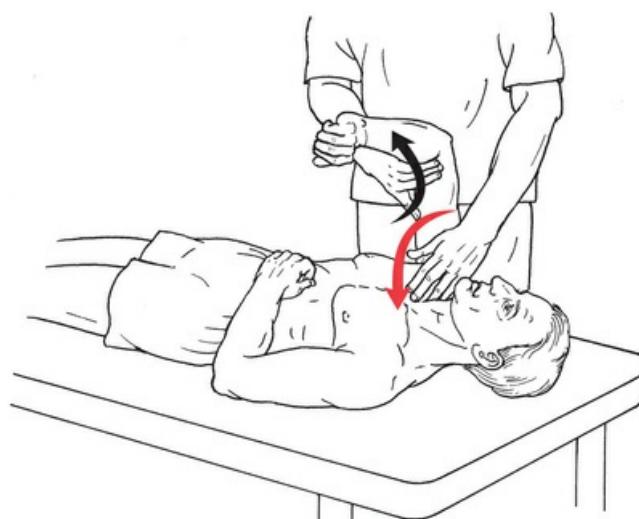
Stand at side of shoulder to be tested. Ask the patient to move the arm with elbow flexed in

horizontal adduction, keeping it parallel to the floor without rotation, checking the range of motion. If the arm moves across the body in a diagonal motion, test the sternal and clavicular heads of the muscle separately. If full range is present in a horizontal adducted direction (Grade 3), test the whole muscle together.

Therapist's hand used for resistance is contoured around upper arm, just proximal to elbow, allowing the forearm to hang free. Resistance is applied in the direction opposite the trunk in the transverse plane.

#### **Clavicular Head:**

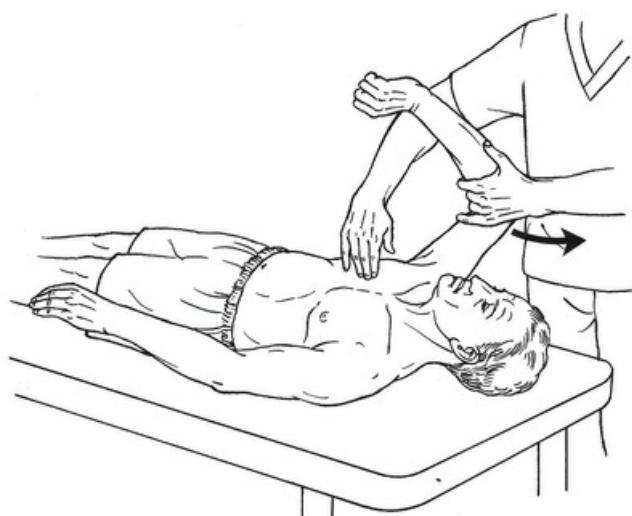
Resistance is applied above the elbow in a downward direction (toward floor) and outward (i.e., opposite to the direction of the fibers of the clavicular head, which moves the arm diagonally up and inward) ([Fig. 5.77](#)).



**FIGURE 5.77**

#### **Sternal Head:**

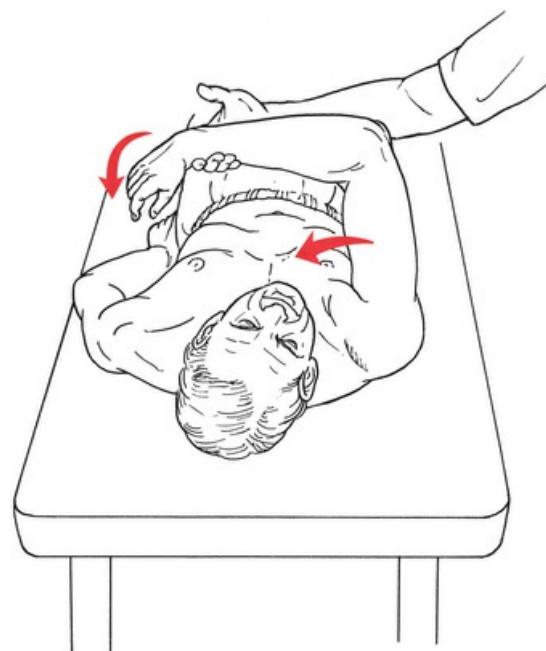
Resistance is applied above the elbow in an up and outward direction ([Fig. 5.78](#)) (i.e., opposite to the motion of the sternal head, which is diagonally down and inward).



**FIGURE 5.78**

**Test:**

When the *whole muscle* is tested, the patient horizontally adducts the shoulder in the transverse plane through the available range of motion (Fig. 5.79).



**FIGURE 5.79**

When the *clavicular head* is tested, the patient's motion begins at 60° of abduction and moves up and in across the body.

When the *sternal head* is tested, the motion begins at 120° of shoulder abduction and moves diagonally down and in toward the patient's opposite hip.

**Instructions to Patient:**

**Both Heads:**

"Move your arm across your chest. Hold it. Don't let me pull it back."

**Clavicular Head:**

"Move your arm up and in."

**Sternal Head:**

"Move your arm down and in."

**Grading**

**Grade 5:**

Holds test position against maximal resistance.

**Grade 4:**

Holds test position with strong to moderate resistance, but muscle exhibits some "give" at end of range.

**Grade 3:**

Completes available range of motion in all three tests (if appropriate) with no resistance other than the weight of the extremity.

## Grade 2, Grade 1, and Grade 0

### Position of Patient:

Supine. Arm is supported in 90° of abduction with elbow flexed to 90°.

### Alternate Position:

Patient is seated with test arm supported on table (at level of axilla) with arm in 90° of abduction midway between flexion and extension and elbow slightly flexed ([Fig. 5.80](#)). Friction of the table surface should be minimized (as with a powder board).



**FIGURE 5.80**

### Instructions to Therapist:

Stand at side of shoulder to be tested or behind the seated patient. If the patient is supine, support the full length of the forearm and hold the limb at the wrist (see [Fig. 5.77](#)).

For both tests palpate the pectoralis major muscle on the anterior aspect of the chest medial to the shoulder joint ([Fig. 5.81](#).)



**FIGURE 5.81**

**Test:**

Patient attempts to horizontally adduct the shoulder. The use of the alternate test position, in which the arm moves across the table, precludes individual testing for the two heads.

**Instructions to Patient:**

"Try to move your arm across your chest." In seated position: "Move your arm in towards your body."

**Grading****Grade 2:**

Patient horizontally adducts shoulder through available range of motion with the weight of the arm supported by the therapist or the table.

**Grade 1:**

Palpable contractile activity.

**Grade 0:**

No discernable palpable contractile activity.

**Helpful Hint**

Testing both heads of the pectoralis major separately should be routine in any patient with cervical spinal cord injury because of their different nerve root innervation.

**Suggested Exercises for Pectoralis Major, Pectoralis Major and Teres Major**

- Push up with narrow hand placement<sup>33</sup>
- Push up plus<sup>34</sup>
- D2 diagonal<sup>34</sup>

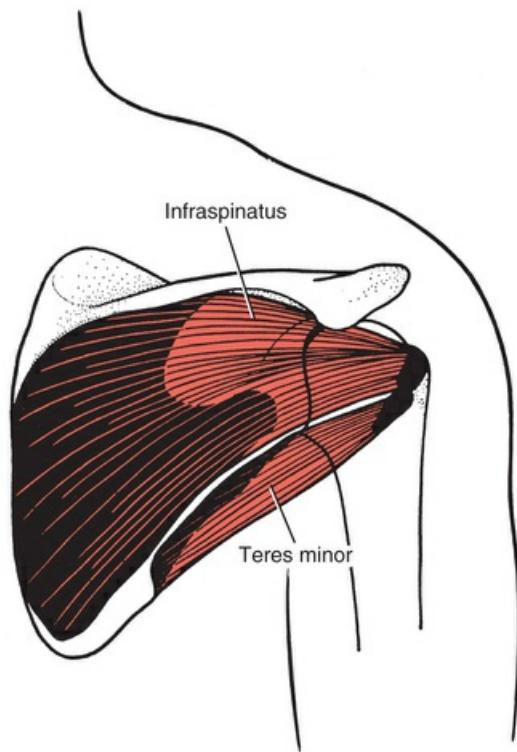
## Introduction to the Rotator Cuff

The rotator cuff is made up of the four tendons of the subscapularis, supraspinatus, infraspinatus, and teres minor muscles. However the teres minor, parts of the infraspinatus, and most of the subscapularis do not have tendons, so rotator cuff is a misnomer.<sup>1</sup> However, it is a familiar term and will be used in this discussion. The teres major has an important role in stabilizing the head of the humerus into the glenoid when the arm is elevated over 90° and is often considered a part of the rotator cuff.<sup>1</sup> The rotator cuff functions to provide a compressive force in all positions of the arm at the shoulder. The infraspinatus and teres minor act as an external rotator and the subscapularis and teres major act as an internal rotator. The supraspinatus initiates and assists with abduction. The supraspinatus assists with external rotation when the shoulder is abducted. The shoulder with a poorly performing rotator cuff is quite impaired because of the importance of humeral stabilization.<sup>1</sup>

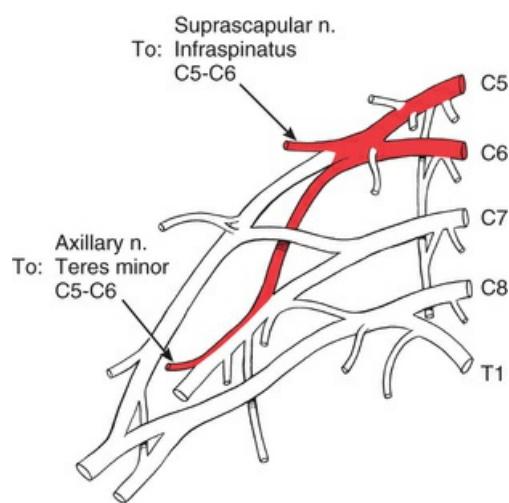
Resistance applied in tests of shoulder rotation should be administered gradually and carefully because of the inherent instability of the shoulder and in the presence of pain, muscle tears, or instability.<sup>1</sup>

## Shoulder External Rotation

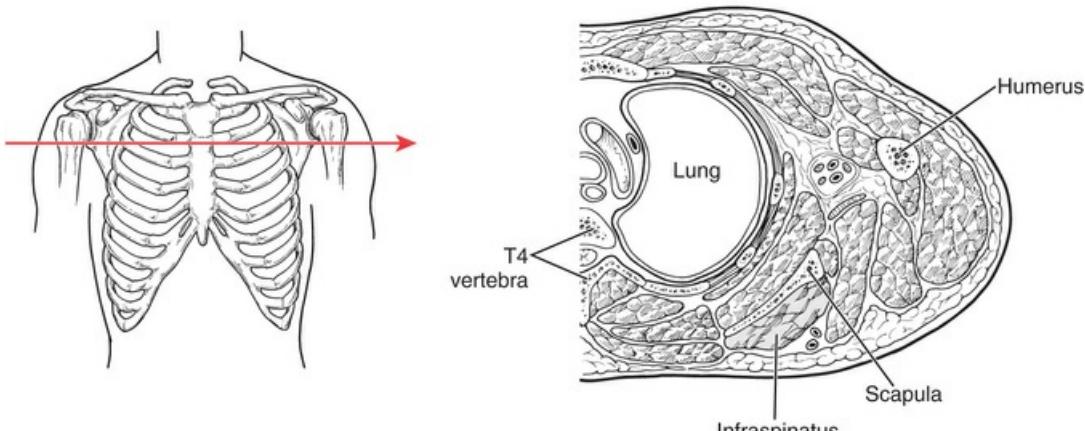
(Infraspinatus and Teres minor)



DORSAL  
**FIGURE 5.82**



**FIGURE 5.83**



**FIGURE 5.84** Arrow indicates level of cross section.

## Range of Motion

0°–80°

**Table 5.12**  
**SHOULDER EXTERNAL ROTATION**

I.D.	Muscle	Origin	Insertion	Function
136	Infraspinatus	Scapula (infraspinous fossa, medial Infraspinous fascia)	Humerus (greater tubercle, middle facet)	External rotation of shoulder Stabilizes shoulder joint by depressing humeral head in glenoid fossa
137	Teres minor	Scapula (lateral border, superior Infraspinous fascia)	Humerus (greater tubercle, lowest facet) Humerus (shaft, distal to lowest facet) Capsule of glenohumeral (G-H) joint	External rotation of shoulder Maintains humeral head in glenoid fossa, thus stabilizing the shoulder joint
<b>Other</b>				
135	Supraspinatus	See <a href="#">Table 5.9</a>		
133	Deltoid (posterior)	See <a href="#">Table 5.10</a>		

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Short sitting, with elbow flexed to 90° and forearm in neutral rotation, perpendicular with the patient's trunk.

### Instructions to Therapist:

Stand in front of patient. Ask patient to move the forearm away from the trunk. If full range is available (Grade 3), apply appropriate resistance. One hand stabilizes the medial aspect of the elbow and the other hand provides resistance at the dorsal (extensor) surface of the forearm, just proximal to the wrist to avoid eliciting the wrist extensors (Fig. 5.85). Resistance is given on the outside of the forearm towards the trunk. Because this is not an anti-gravity position, maximal resistance should be used, if appropriate.



**FIGURE 5.85**

**Test:**

Patient externally rotates arm, pushing forearm away from trunk.

**Instructions to Patient:**

"Push your forearm away. Hold it. Don't let me move it."

**Grade 3 Instructions to Patient:**

"Move your forearm away from your stomach" ([Fig. 5.86](#)).

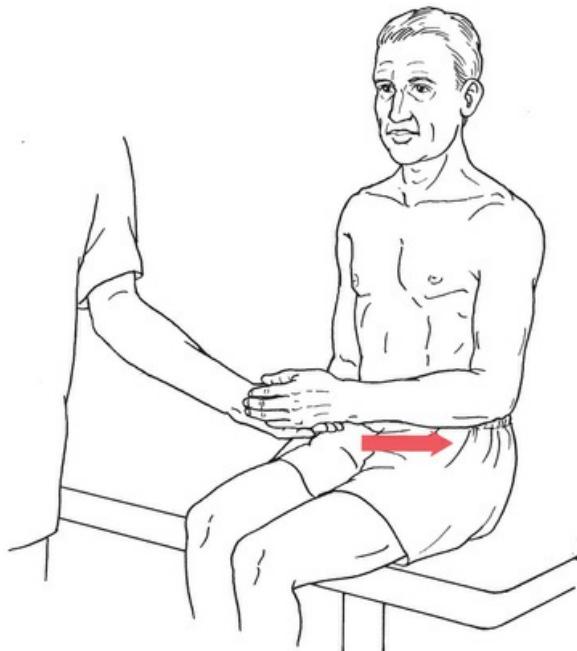


FIGURE 5.86

## Grading

### Grade 5:

Holds test position against maximal resistance.

### Grade 4:

Holds test position against strong resistance with some yield.

### Grade 3:

Completes available range of motion without manual resistance.

## Grade 2, Grade 1, and Grade 0

### Position of Patient:

Short sitting with elbow flexed to 90° and forearm in neutral rotation with hand facing forward, supported on table with friction minimized by therapist (Figs. 5.87 and 5.88), powder board or other means (see Fig. 5.87).



FIGURE 5.87

**Instructions to Therapist:**

Sit or stand on a low stool at test side of patient at shoulder level (picture shows therapist on opposite side to avoid obstructing view). One hand stabilizes the outside of the flexed elbow while the other hand palpates for the tendon of the infraspinatus over the body of the scapula below the spine in the infraspinous fossa. Palpate the teres minor on the inferior margin of the axilla and along the axillary border of the scapula (see Fig. 5.88). Supination may occur instead of the requested external rotation during the testing of Grades 2 and 1. This motion can be mistaken for external rotation.

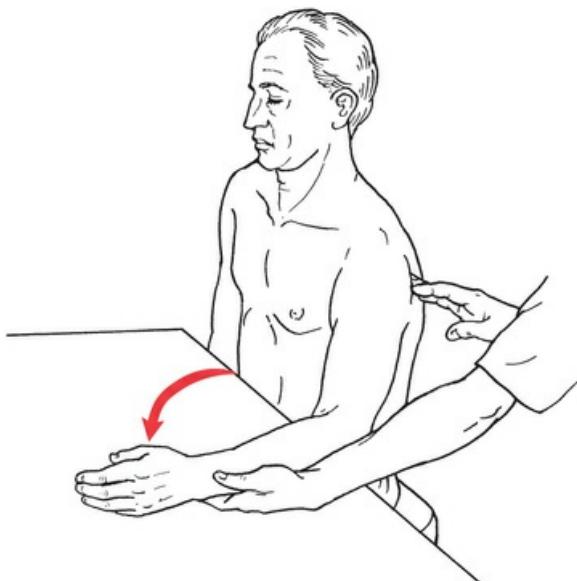


FIGURE 5.88

**Test:**

Patient attempts to move forearm away from the trunk (see Fig. 5.88).

**Instructions to Patient:**

"Try to push your forearm away from your stomach."

## Grading

### Grade 2:

Completes available range in this gravity-eliminated position.

### Grade 1:

Palpation of either or both muscles reveals contractile activity but no motion.

### Grade 0:

No discernable palpable contractile activity.

## Alternate Position for Grade 5, Grade 4, and Grade 3

### Position of Patient:

Prone with head turned toward test side. Shoulder abducted to 90° with arm fully supported on table; forearm hanging vertically over edge of table. Place a folded towel under the arm or use the therapist's hand to cushion the arm if the table has a sharp edge ([Fig. 5.89](#)).

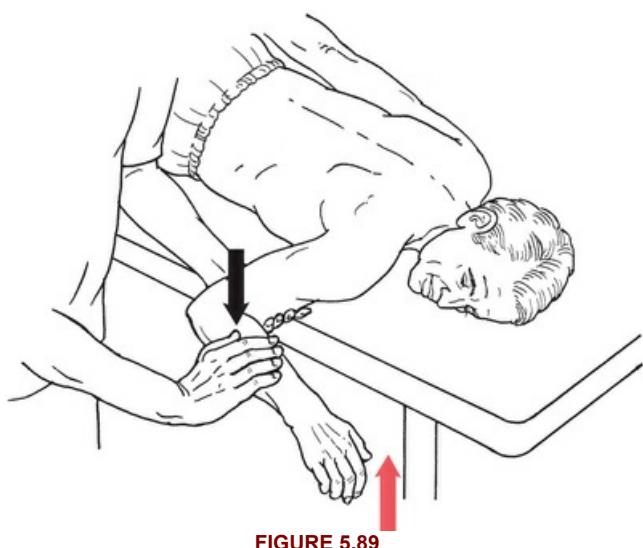


FIGURE 5.89

### Instructions to Therapist:

Stand at test side at level of patient's waist (see [Fig. 5.89](#)). Use one hand to give resistance over the forearm, as near the wrist as possible, for Grades 5 and 4. The other hand supports the elbow to provide some counter-pressure at the end of the range. NOTE: resistance will be much less than in the sitting position and care should be taken in this vulnerable position.

### Test:

Patient moves forearm upward through the range of external rotation.

### Instructions to Patient:

"Raise your arm to the level of the table. Hold it. Don't let me push it down." Therapist may need to demonstrate the desired motion.

## Grading

### Grade 5:

Holds test position against strong resistance.

#### **Grade 4:**

Holds test position, but end range yields or gives way with strong resistance.

#### **Grade 3:**

Completes available range of motion without manual resistance (Fig. 5.90).



**FIGURE 5.90**

## **Helpful Hints**

- External rotation (ER) at 0° abduction has been shown to be the most optimal position to isolate the infraspinatus muscle.<sup>30</sup> The teres minor generates a relatively constant ER torque throughout arm abduction movement.
- The optimal manual muscle test (MMT) position for the infraspinatus has the least activation of the supraspinatus muscle (see Fig. 5.85).<sup>30,35</sup>
- Range of motion for 60+ year old individuals is less than younger adults and averages 71–72° for men and women.<sup>36</sup>
- Range of motion averages for children and adolescents are 93°–99°.<sup>36</sup>

## **Suggested Exercises for the Infraspinatus**

- Prone horizontal abduction at 100° with ER and IR
- Side-lying ER with 0° abduction<sup>7,25</sup> (minimizes upper trapezius activity)
- D1 and D2 diagonal pattern flexion (may elicit upper trapezius)
- Standing EsR at 90° abduction (full can)<sup>7</sup>

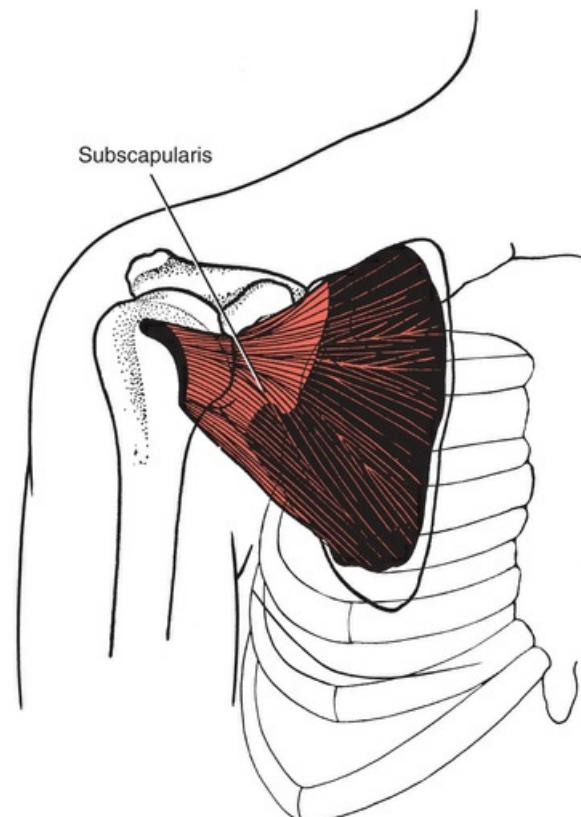
## **Suggested Exercises for the Teres Minor**

- Flexion above 120° with ER (thumb up)<sup>7</sup>
- Standing scapular rows at various degrees of flexion (45°, 90° and 135°)<sup>7</sup>
- Side-lying ER at 0° abduction<sup>7</sup>
- Prone horizontal abduction at 90°<sup>7</sup>
- Abduction with ER (thumb up and down)<sup>7</sup>



## Shoulder Internal Rotation

(*Subscapularis*)



ANTERIOR  
FIGURE 5.91

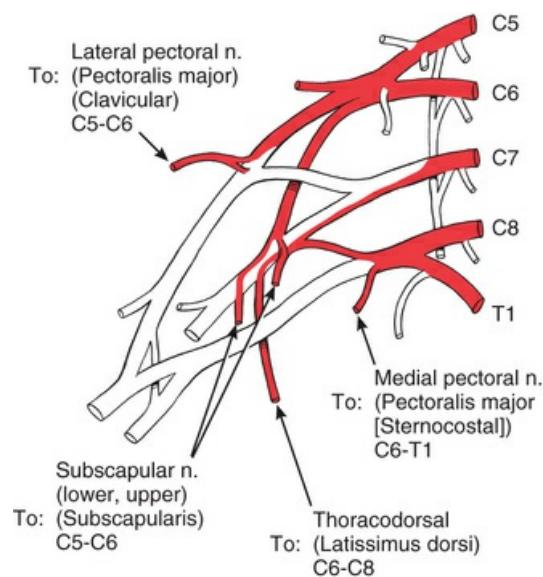
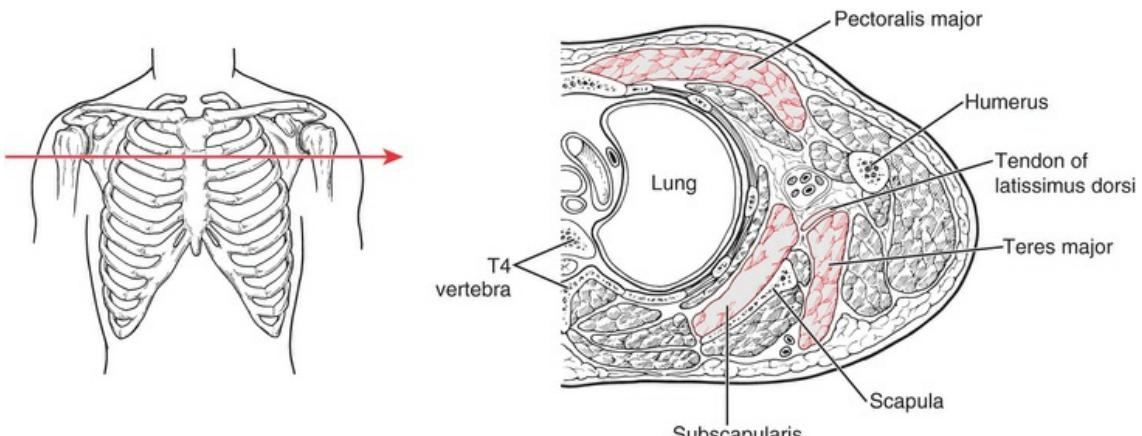


FIGURE 5.92



**FIGURE 5.93** Arrow indicates level of cross section.

## Range of Motion

0°–60°

**Table 5.13**  
**SHOULDER INTERNAL ROTATION**

I.D.	Muscle	Origin	Insertion	Function
134	Subscapularis	Scapula (fills fossa on costal surface) Intermuscular septa Aponeurosis of subscapularis	Humerus (lesser tubercle) Capsule of glenohumeral (G-H) joint (anterior)	Internal rotation of shoulder Maintains humeral head in glenoid fossa (with other rotator cuff muscles) Abduction of shoulder
138	Teres major	Scapula (dorsal surface of inferior angle)	Humerus (intertubercular sulcus, medial lip)	Internal rotation of shoulder Adduction and extension of shoulder Extension of shoulder from a flexed position
131	Pectoralis major	Sternal half of clavicle, entire anterior surface of the sternum	Lateral lip of the intertubercular sulcus of anterior humerus	
	Clavicular part	Clavicle (sternal half of anterior surface)	Humerus (intertubercular sulcus, lateral lip)	<i>Clavicular fibers:</i> Internal rotation of shoulder Flexion of shoulder Horizontal shoulder adduction
130	Latissimus dorsi	T6-T12, L1-L5, and sacral vertebrae (spinous processes) Supraspinous ligaments Ribs 9-12 (by slips that interdigitate with obliquus externus abdominis) Ilium (crest, posterior) Thoracolumbar fascia	Humerus (floor of intertubercular sulcus) Deep fascia of arm	Internal rotation of shoulder

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Short sitting with elbow flexed to 90°, forearm in neutral rotation, perpendicular to the trunk.

### Instructions to Therapist:

Stand in front of patient and ask patient to pull forearm toward the trunk. If full range is present (Grade 3), apply resistance. Stabilize the outside of the elbow with one hand while the other hand provides resistance at the volar (flexor) surface of the forearm, just proximal to the wrist (Fig. 5.94) so as not to elicit wrist flexors. Resistance is given on the volar surface in the direction away from the trunk. As in the tests for ER, this is a gravity-minimized position, so maximal resistance is used, if appropriate.

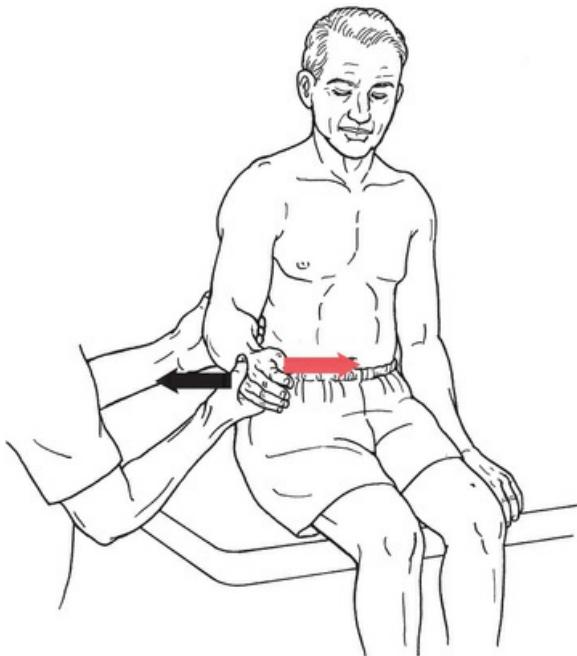


FIGURE 5.94

**Test:**

Patient internally rotates arm, pulling forearm toward trunk.

**Instructions to Patient:**

"Pull your forearm toward your stomach. Hold it. Don't let me pull it out."

**Grading**

**Grade 5:**

Holds test position against maximum resistance.

**Grade 4:**

Holds test position against strong resistance. Some yield is felt.

**Grade 3:**

Completes available range without manual resistance.

**Grade 2, Grade 1, and Grade 0**

**Position of Patient:**

Short sitting or sitting at a table, with elbow flexed and forearm in neutral rotation.

**Instructions to Therapist:**

Stand at test side or sit on low stool. One hand stabilizes the forearm while the other hand palpates for the tendon of the subscapularis, deep in the axilla ([Fig. 5.95](#)). NOTE: The hand of the therapist under the patient's hand will eliminate friction in the Grade 2 test if a flat surface is being used ([Fig. 5.96](#)). Alternatively, a powder board can be used.



FIGURE 5.95

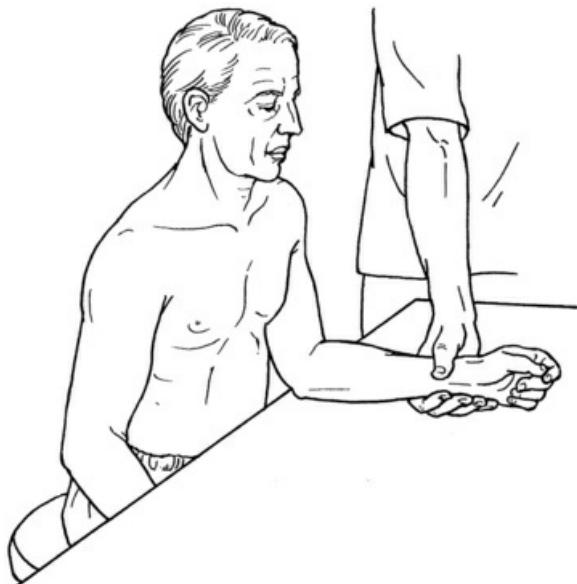


FIGURE 5.96

**Test:**

Patient attempts to internally rotate arm, pulling forearm toward trunk.

**Instructions to Patient:**

"Try to pull your forearm toward your stomach."

**Grading**

**Grade 2:**

Is not able to complete available range.

**Grade 1:**

Palpable contraction occurs.

**Grade 0:**

No discernable palpable contractile activity.

### **Alternate Test for Grade 5, Grade 4, and Grade 3**

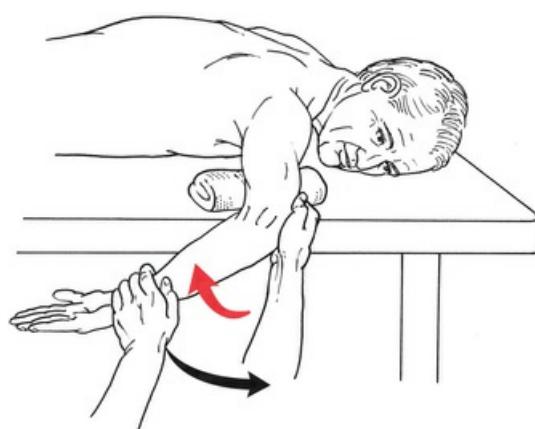
Used if patient cannot sit.

#### **Position of Patient:**

Prone with head turned toward test side. Shoulder is abducted to 90° with folded towel placed under distal arm and forearm hanging vertically over edge of table.

#### **Instructions to Therapist:**

Stand at test side. Hand giving resistance is placed on the volar side of the forearm just above the wrist. The other hand provides counterforce at the elbow ([Fig. 5.97](#)). The resistance hand applies resistance in a downward and forward direction; the counterforce is applied backward and slightly upward. Stabilize the scapular region if muscles are weak or perform test in the supine position.  
NOTE: resistance will be much less than in the sitting position.



**FIGURE 5.97**

#### **Test:**

Patient moves arm through available range of internal rotation (backward and upward).

#### **Instructions to Patient:**

"Move your forearm up and back. Hold it. Don't let me push it down." Demonstrate the desired motion to the patient.

### **Grading**

#### **Grade 5:**

Holds test position firmly against strong resistance.

#### **Grade 4:**

Holds test position, but there is a give against strong resistance.

#### **Grade 3:**

Completes available range with no manual resistance ([Fig. 5.98](#)).



**FIGURE 5.98**

## Helpful Hints

- Internal rotation is a stronger motion than external rotation. This is largely a factor of muscle mass.
- The movement most optimal for isolation and activation of the subscapularis muscle is the lift-off test against resistance, the clinical diagnostic test for subscapularis tears.<sup>37</sup> This movement can also be used as an exercise for the subscapularis.
- The belly press test is an alternative test to the lift-off test, useful when pain or limited motion prevents the shoulder from getting into the lift-off position.<sup>38</sup> It is performed in sitting or standing with the palm of the hand placed against the belly, just below the level of the xiphoid process. The patient is instructed to maximally push the hand into the belly by internally rotating the shoulder. A positive test is indicated when the patient drops the elbow toward the torso (shoulder adduction and extension), and inability to internally rotate the shoulder indicating a torn subscapularis tendon.
- The belly-press test was found to activate the upper subscapularis muscle more than the lift-off test, whereas the lift-off test was found to activate the lower subscapularis muscle more than the belly-press test.<sup>38</sup>
- The upper portion (innervated by the upper subscapularis nerve) is a more effective internal rotator at lower abduction angles compared with higher abduction angles. The lower subscapularis muscle activity (innervated by the lower subscapularis nerve) is unaffected by abduction angle.
- Performing internal rotation (IR) at 0° abduction produces similar amounts of upper and lower subscapularis activity.<sup>39</sup>

## Suggested Exercises for the Subscapularis

- Pushup or palm press<sup>7,24</sup>
- Internal rotation at 0°<sup>24,34</sup>
- Standing high, mid, and low scapular rows
- Flexion above 120° with ER (thumb up).<sup>7</sup>
- Pushup plus exercise<sup>34</sup>
- D2 diagonal<sup>34</sup>

- Dynamic hug<sup>34</sup>

## Elbow Flexion

(*Biceps, Brachialis, and Brachioradialis*)

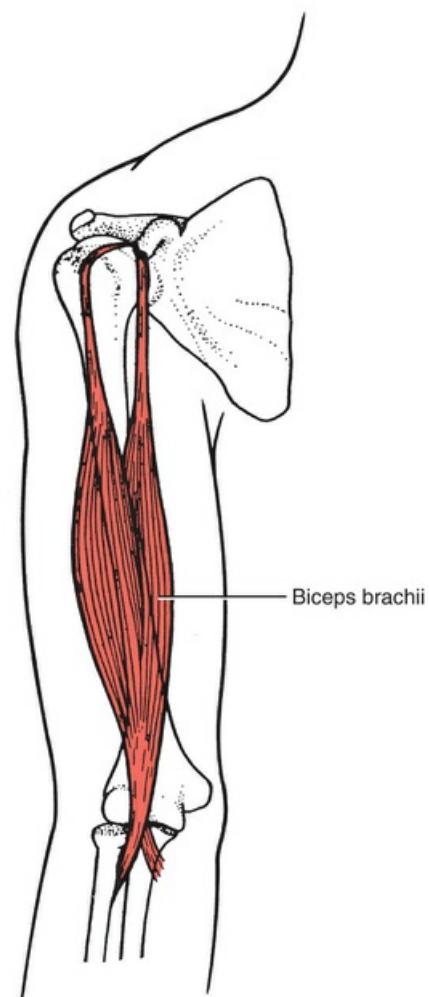
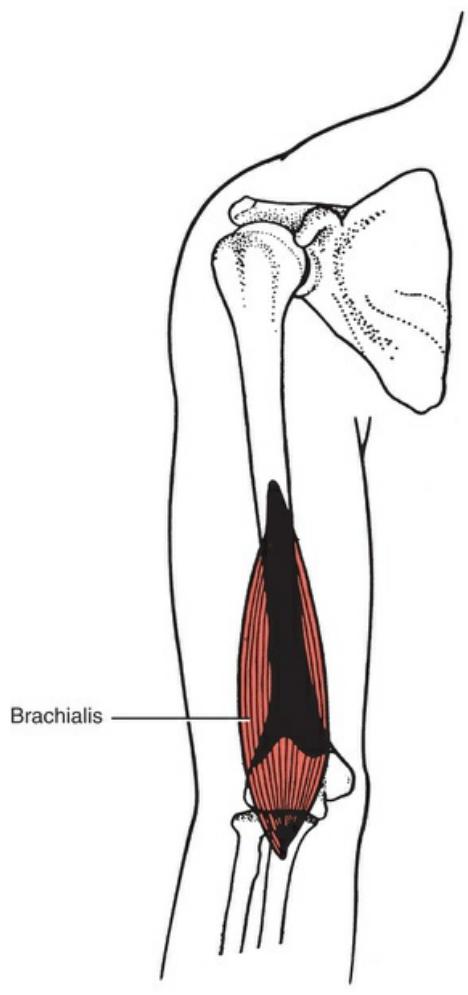


FIGURE 5.99



ANTERIOR  
**FIGURE 5.100**

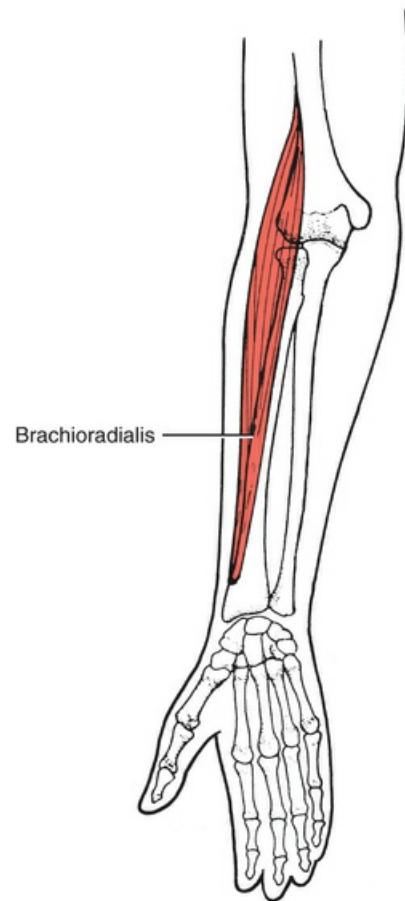


FIGURE 5.101

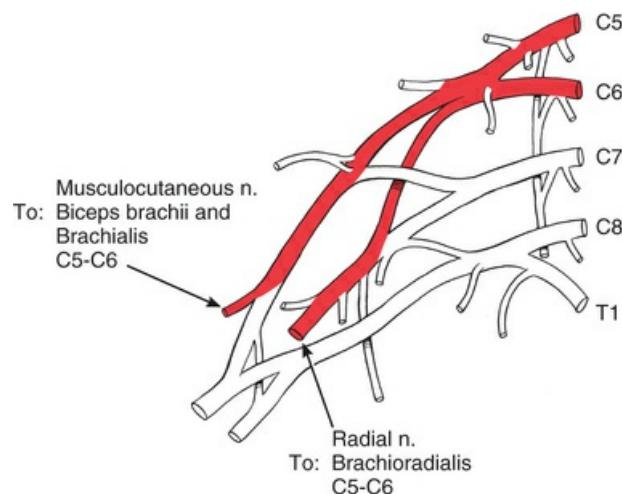
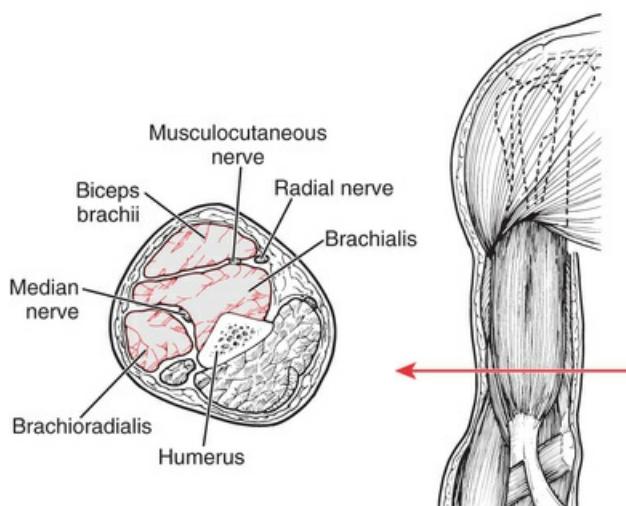


FIGURE 5.102



**FIGURE 5.103** Arrow indicates level of cross section.

## Range of Motion

0°–150°

**Table 5.14**  
**ELBOW FLEXION**

LD.	Muscle	Origin	Insertion	Function
141	Brachialis	Humerus (shaft anterior, distal $\frac{1}{2}$ ) Intermuscular septa (medial)	Ulna (tuberosity and coronoid process)	Flexion of elbow, forearm supinated or pronated
140	Biceps brachii Short head Long head	Scapula (coracoid process, apex) Scapula (supraglenoid tubercle) Capsule of glenohumeral (G-H) joint and glenoid labrum	Radius (radial tuberosity) Bicipital aponeurosis	<i>Both heads:</i> Flexion of elbow Supination of forearm (powerful) <i>Long head:</i> Stabilizes and depresses humeral head in glenoid fossa during deltoid activity
143	Brachioradialis	Humerus (lateral supracondylar ridge, proximal $\frac{2}{3}$ ) Lateral intermuscular septum	Radius (distal end just proximal to styloid process)	Flexion of elbow
<b>Others</b>				
146	Pronator teres	See <a href="#">Table 5.17</a>		
148	Extensor carpi radialis longus	See <a href="#">Table 5.19</a>		
151	Flexor carpi radialis	See <a href="#">Table 5.18</a>		
153	Flexor carpi ulnaris	See <a href="#">Table 5.18</a>		

The two heads of the biceps work together to accomplish flexion of the elbow. As in the three heads of the triceps, the multiple heads are considered reserves, as both work together to flex the elbow.

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Short sitting with arms at sides. The following are the positions of choice, but it is doubtful whether the individual muscles can be separated when strong effort is used. The brachialis is independent of forearm position.

### Biceps Brachii:

Forearm in supination ([Fig. 5.104](#)).

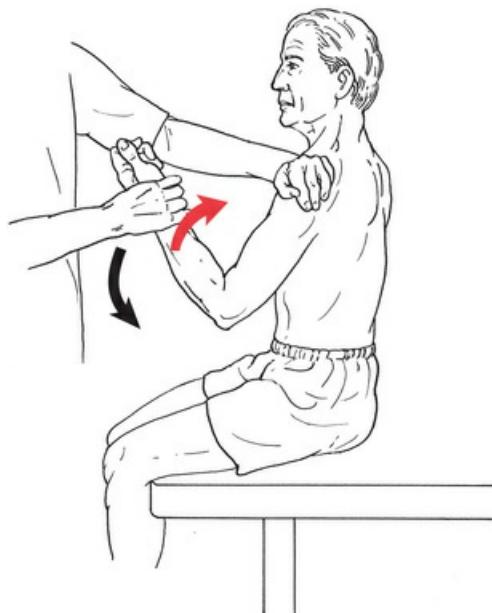


FIGURE 5.104

**Brachialis:**

Forearm in pronation ([Fig. 5.105](#)).

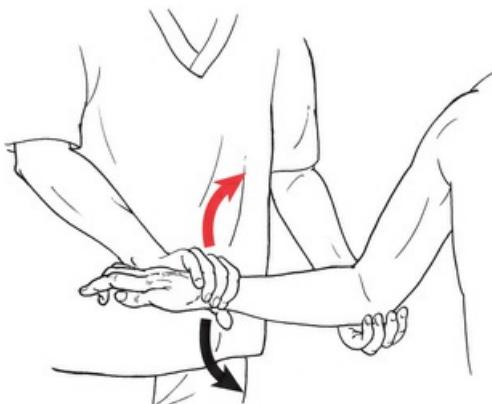
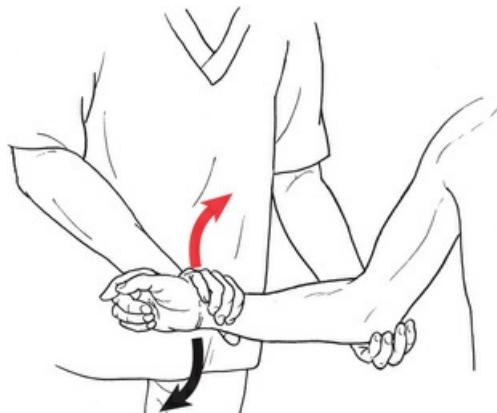


FIGURE 5.105

**Brachioradialis:**

Forearm in mid position between pronation and supination ([Fig. 5.106](#)).

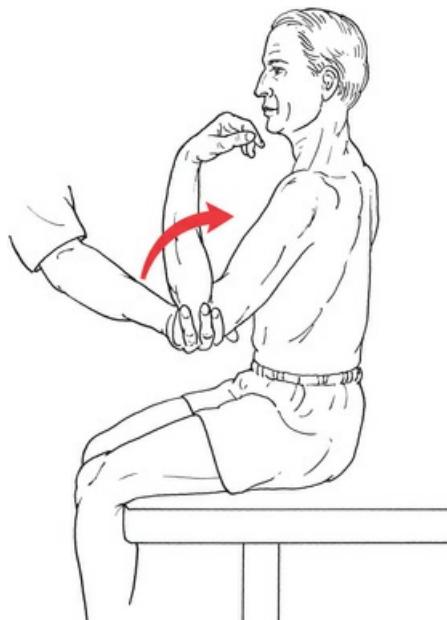


**FIGURE 5.106**

**Instructions to Therapist:**

Stand in front of patient toward the test side. Ask patient to bend elbow. If full range is present (Grade 3), apply appropriate resistance. Therapist's hand giving resistance is contoured over the volar (flexor) surface of the forearm proximal to the wrist (see Fig. 5.104). The other hand is placed over the anterior surface of the shoulder and applies counterforce by resisting any upper arm movement.

No resistance is given in a Grade 3 test. The test elbow is cupped by the therapist's hand for support (Fig. 5.107, biceps illustrated at end range).



**FIGURE 5.107**

**Test (All Three Forearm Positions):**

Patient flexes elbow through range of motion.

**Instructions to Patient (All Three Tests):**

**Grade 5 and Grade 4:**

"Bend your elbow. Hold it. Don't let me pull it down."

**Grade 3:**

"Bend your elbow."

### Grading

#### Grade 5:

Holds test position against maximal resistance.

#### Grade 4:

Holds test position against strong to moderate resistance, but the end point may not be firm.

#### Grade 3:

Completes available range with each forearm position.

### Grade 2

#### Position of Patient:

#### All Elbow Flexors:

Short sitting with arm flexed to 90° and internally rotated (to minimize gravity) and supported by therapist ([Fig. 5.108](#)). Forearm is supinated (biceps), pronated (brachialis), and in mid position (brachioradialis).

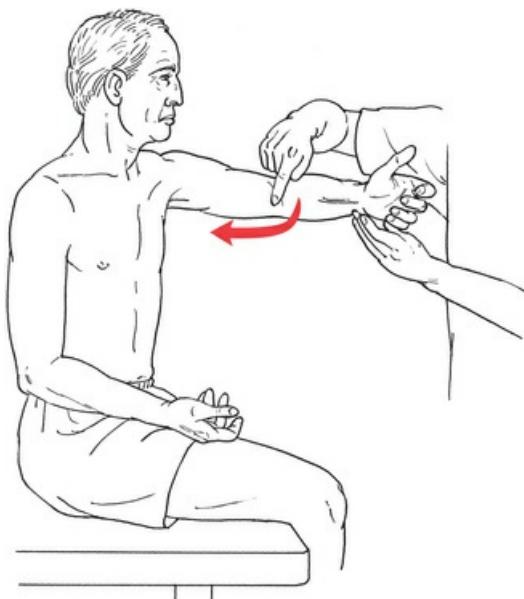


FIGURE 5.108

#### Alternate Position for Patients Unable to Sit:

Patient is side-lying with arm supported at the elbow in 90° flexion to minimize gravity. Elbow is flexed to about 45° with forearm supinated, pronated (for brachialis), and in mid position (for brachioradialis; [Fig. 5.109](#), biceps illustrated).



FIGURE 5.109

**Instructions to Therapist:**

**All Three Flexors:**

Stand in front of patient and support flexed arm under the elbow and wrist if necessary. Palpate the tendon of the biceps in the antecubital space (see Fig. 5.108). On the arm, the muscle fibers may be felt on the anterior surface of the middle two thirds of the biceps with the short head lying medial to the long head.

Palpate the brachialis in the distal arm medial to the tendon of the biceps. Palpate the brachioradialis on the lateral surface of the neutrally positioned forearm, where it forms the lateral border of the cubital fossa.

**Test:**

Patient attempts to flex the elbow.

**Instructions to Patient:**

"Try to bend your elbow."

**Grading**

**Grade 2:**

Completes range of motion with gravity minimized (in each of the muscles tested).

**Grade 1 and Grade 0**

**Positions of Patient and Therapist:**

Side-lying for all three muscles with therapist standing at test side. All other aspects are the same as for the Grade 2 test.

**Test:**

Patient attempts to bend elbow with hand supinated, pronated, and in mid position.

**Grading**

**Grade 1:**

Therapist can palpate a contractile response in each of the three muscles for which a Grade 1 is

given.

**Grade 0:**

No discernable palpable contractile activity.

## Helpful Hints

- The patient's wrist flexor muscles should remain relaxed throughout the test because strongly contracting wrist flexors may assist in elbow flexion. Recall that the wrist flexors originate above the elbow joint axis on the distal humerus.
- Only the brachioradialis contributes to pronation with elbow flexion.<sup>40</sup>
- During resisted shoulder flexion with the elbow straight, both heads of the biceps are always active.<sup>2</sup>
- Basmajian<sup>2</sup> noted that the three elbow flexors work together without a lot of predictability of one muscle's action over the others when lifting a load. Generally, they are stronger in elbow flexion with supination than pronation.
- The brachialis is considered the workhorse of the elbow flexors as it is active in isometric flexion and eccentric extension. The other two flexors are not as active in eccentric extension.<sup>2</sup>
- The biceps brachii is composed of 60% type II fibers.<sup>41</sup>

## Suggested Exercises for Biceps, Brachialis and Brachioradialis

- Dumbbell biceps curl and inclined dumbbell curl (shoulder extended) elicited the same maximal muscle activation (>40% MVC) concentrically and eccentrically throughout range.<sup>42</sup>

## Elbow Extension

(*Triceps brachii*)

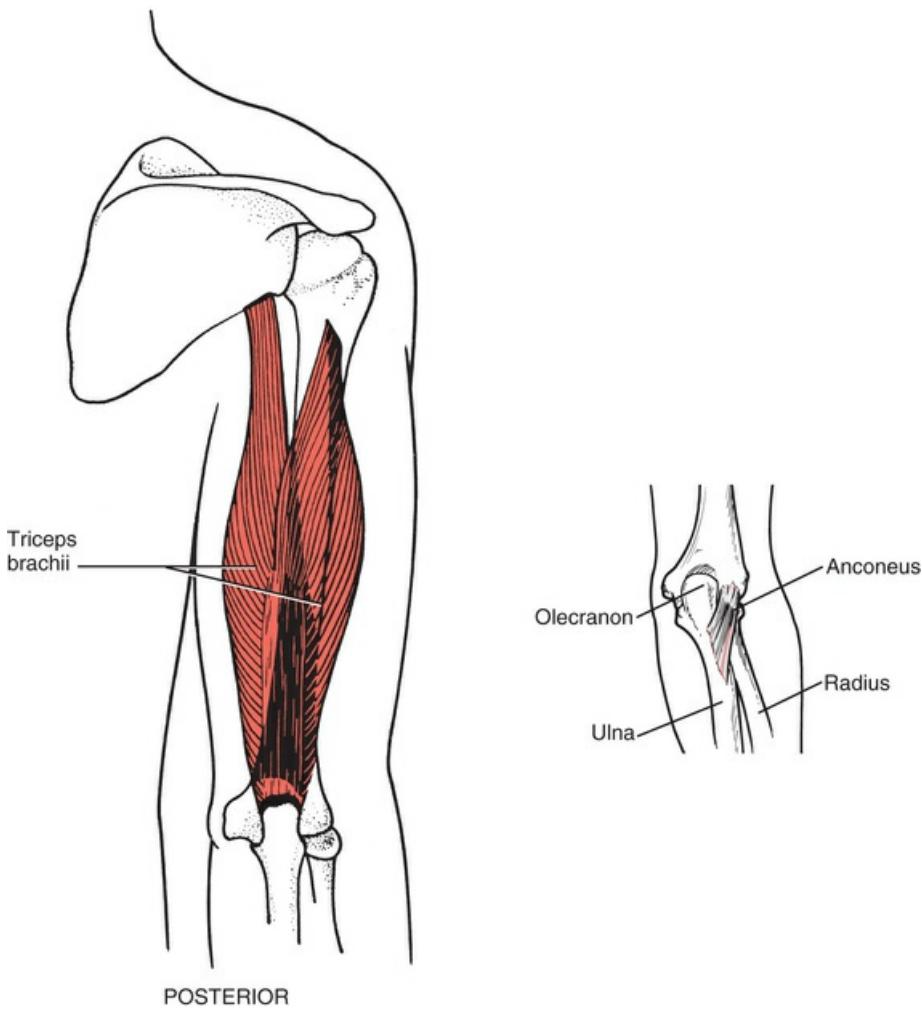
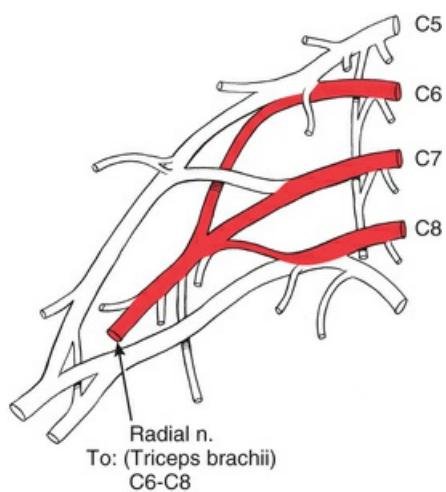
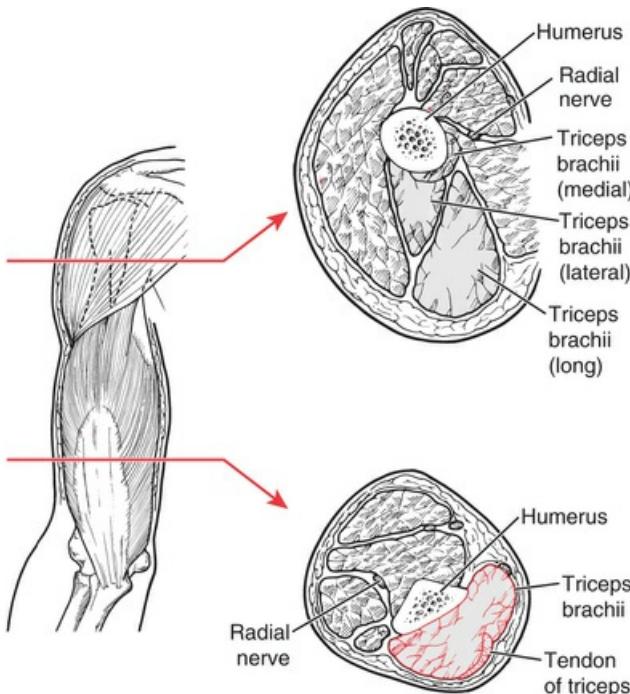


FIGURE 5.110



**FIGURE 5.111**



**FIGURE 5.112** Arrows indicates level of cross sections.

## Range of Motion

150° to -5° (many people, especially females, will have hyperextension of the elbow)

**Table 5.15**  
**ELBOW EXTENSION**

I.D.	Muscle	Origin	Insertion	Function
142	Triceps brachii		All heads have a common tendon to:	Extension of elbow head: Extension and adduction of shoulder (assist)
	Long head	Scapula (infraglenoid tuberosity and capsule of glenohumeral [G-H] joint)	Ulna (olecranon process, upper surface)	Long and lateral heads: Especially active in resisted extension, otherwise minimally active <sup>24</sup> Long head: Extension and adduction of shoulder (assist)
	Lateral head	Humerus (shaft: oblique ridge, posterior surface) Lateral intermuscular septum	Blends with antebrachial fascia Capsule of elbow joint	Long and lateral heads: Especially active in resisted extension, otherwise minimally active
	Medial head	Humerus (shaft: entire length of posterior surface) Medial and lateral intermuscular septa		Medial head: Active in all forms of extension

As in the biceps, all heads of the triceps brachii work together to extend the elbow. The triceps can fixate the elbow joint when the forearm and hand are used for fine movement (e.g., when writing). The triceps have a greater proportion of type II muscle fibers. The lateral head is used for movements requiring occasional high-intensity force, while the medial head enables precise, low-force movements.

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Prone on table. The patient starts the test with the shoulder in 90° of abduction and the elbow flexed to 90° and in neutral rotation (forearm hanging over the side of the table) (Fig. 5.113).

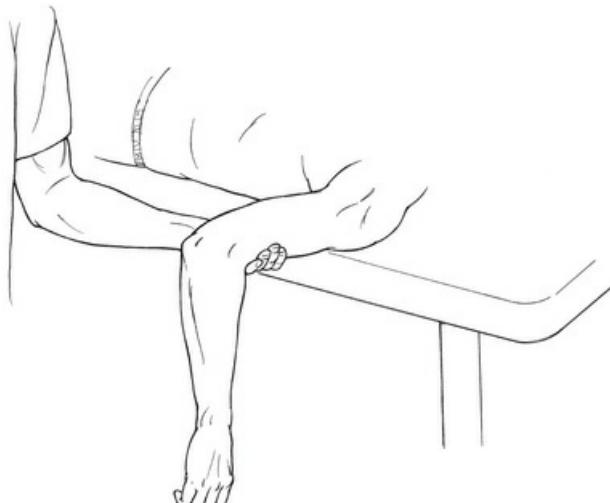


FIGURE 5.113

**Instructions to Therapist:**

Stand to the side of the patient. Ask patient to straighten the elbow. If full range is present (Grade 3), apply appropriate resistance. Provide support with one hand underneath the arm, just above the elbow. The other hand is used to apply downward resistance on the distal dorsal surface of the extended forearm just proximal to the wrist (Fig. 5.114 illustrates end position). Be sure to have the elbow in minimal flexion, so as not to allow the patient to “lock out” the elbow. This is especially important if hyperextension exists.

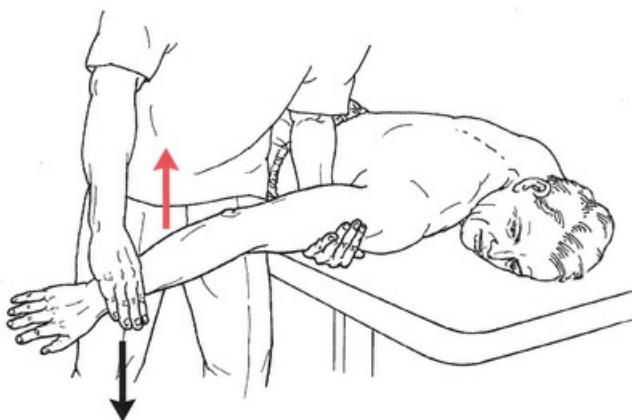


FIGURE 5.114

**Test:**

Patient straightens elbow

**Instructions to Patient:**

“Hold it. Don't let me bend it.”

**Grading**

**Grade 5:**

Holds test position firmly against maximal resistance.

**Grade 4:**

Holds test position against strong resistance, but there is a “give” to the resistance at the end range.

**Grade 3:**

Completes available range with no manual resistance ([Fig. 5.115](#)).

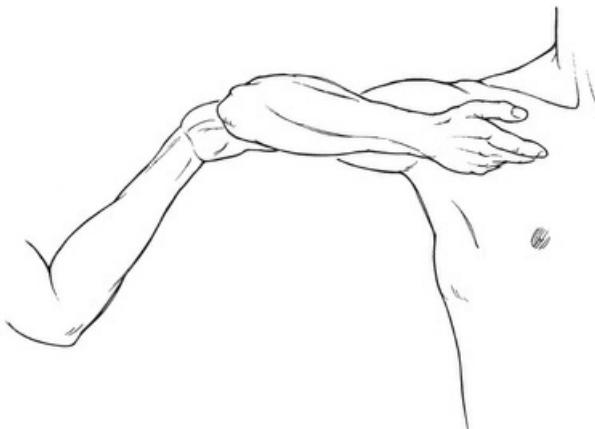


**FIGURE 5.115**

**Grade 2, Grade 1, and Grade 0**

**Position of Patient:**

Short sitting. The shoulder is abducted to 90° and neutral rotation with the elbow flexed to about 45° to minimize gravity. The entire limb is parallel to the floor ([Fig. 5.116](#)).



**FIGURE 5.116**

**Instructions to Therapist:**

Stand at test side of patient. For the Grade 2 test, support the limb at the elbow. For a Grade 1 or 0 test, support the limb under the forearm and palpate the triceps on the posterior surface of the arm just proximal to the olecranon process ([Fig. 5.117](#)).



FIGURE 5.117

**Test:**

Patient attempts to extend the elbow.

**Instructions to Patient:**

"Try to straighten your elbow."

**Grading**

**Grade 2:**

Completes available range with gravity minimized.

**Grade 1:**

Therapist can feel tension in the triceps tendon just proximal to the olecranon (see Fig. 5.117) or contractile activity in the muscle fibers on the posterior surface of the arm.

**Grade 0:**

No discernable palpable muscle activity.



FIGURE 5.119

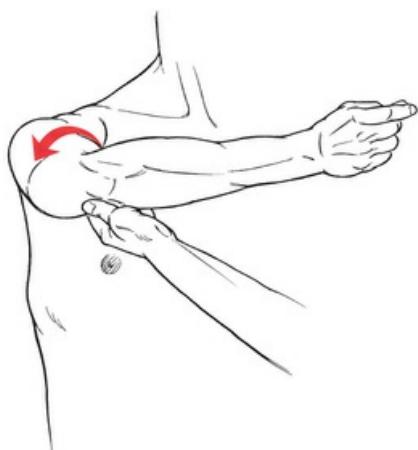


FIGURE 5.118

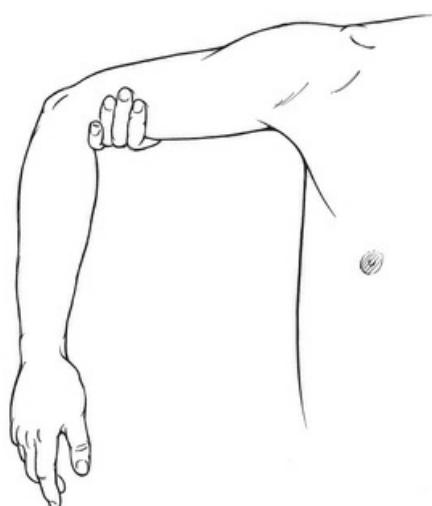


FIGURE 5.120

## Substitutions

- Via external rotation. When the patient is sitting with the arm abducted, elbow extension can be accomplished with a Grade 0 triceps (Fig. 5.118) when the patient externally rotates the shoulder, thus dropping the arm below the forearm. As a result, the elbow literally falls into extension. This can be prevented by using a table or powder board to support the arm.
- Via horizontal adduction. This substitution can accomplish elbow extension and is done purposefully by patients with a cervical cord injury and a Grade 0 triceps. With the distal segment fixed (as when the therapist stabilizes the hand or wrist), the patient horizontally adducts the arm and the thrust pulls the elbow into extension (Fig. 5.119). The therapist, therefore, should provide support at the elbow for testing purposes rather than at the wrist.

## Helpful Hints

- Give resistance in Grade 5 and Grade 4 tests with the elbow slightly flexed to avoid enabling

the patient to “lock” the elbow joint by hyperextending it.

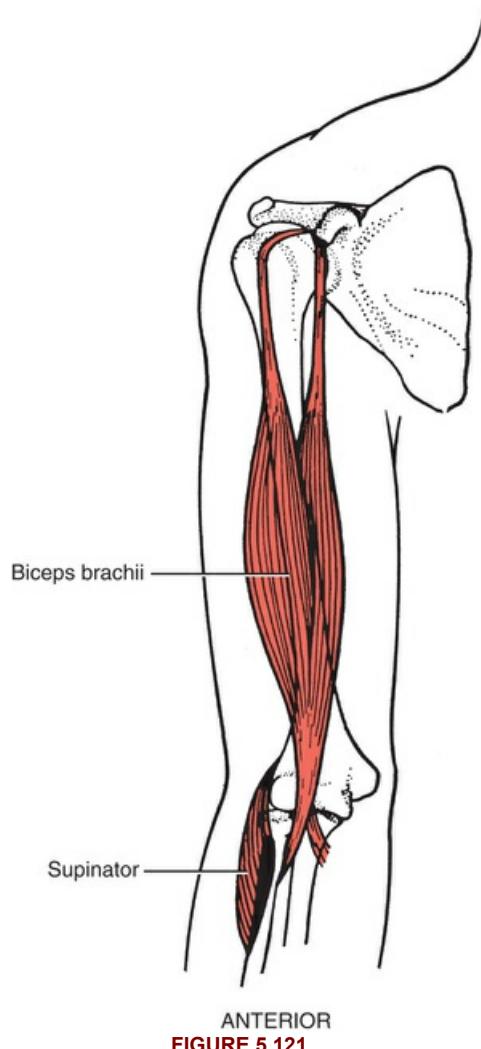
- Although elbow extension is tested in the prone position, the therapist must be aware that with the shoulder horizontally abducted the two-joint muscle is less effective, and the test grade may be lower than it should be.<sup>13</sup>
- An alternate position for Grades 5, 4, and 3 is with the patient short sitting. The therapist stands behind the patient, supporting the arm in 90° of abduction just above the flexed elbow ([Fig. 5.120](#)). The patient straightens the elbow against the resistance given just proximal to the wrist.
- Triceps strength is usually the limiting factor in pressing-type movements such as pushups.

## Suggested Exercises for Triceps Brachii

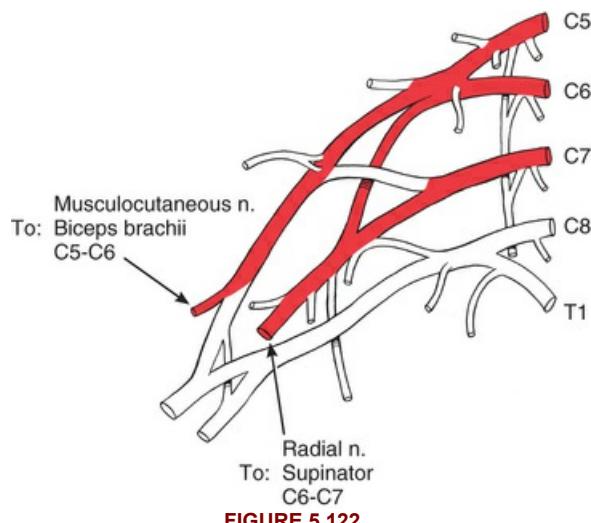
- Exercises that challenge the triceps close to full extension (lock outs) are likely to be highly beneficial.
- Close grip bench press
- Suspended pushups elicited more activity than conventional pushups<sup>43</sup>
- Standard pushups with narrow base hand position<sup>44</sup>
- Dips
- Triceps extension overhead
- Triceps press down using rope

## Forearm Supination

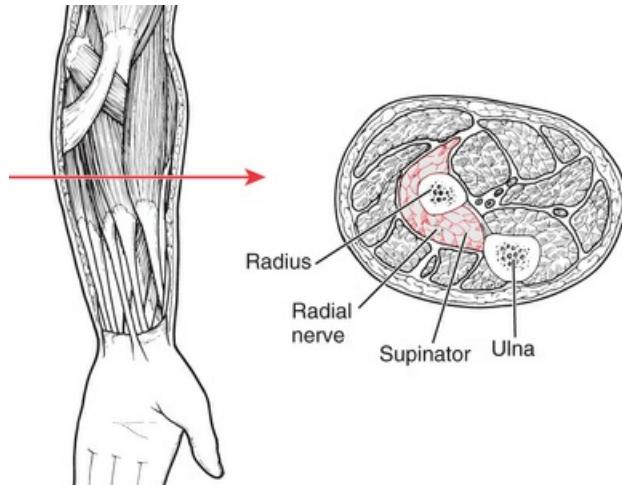
(*Supinator and Biceps brachii*)



ANTERIOR  
FIGURE 5.121



**FIGURE 5.122**



**FIGURE 5.123** Arrow indicates level of cross section.

## Range of Motion

0°–80°

**Table 5.16**  
**FOREARM SUPINATION**

I.D.	Muscle	Origin	Insertion	Function
140	Biceps brachii Both heads			Flexion of elbow Supination of forearm (powerful) if combined with elbow flexion
145	Supinator	Humerus (lateral epicondyle) Ulna (supinator crest) Radial collateral ligament of elbow joint Annular ligament of radioulnar joint Aponeurosis of supinator	Radius (shaft, lateral aspect of proximal 1/3)	Supination of forearm (pure)

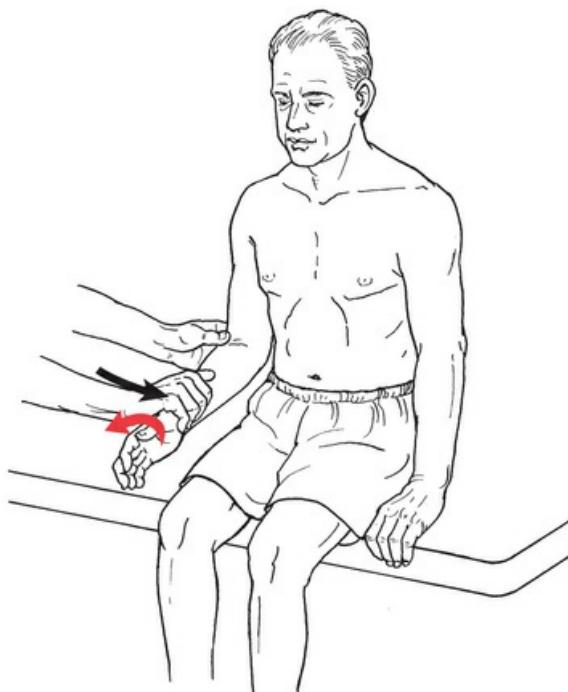
**Grade 5, Grade 4, Grade 3, and Grade 2**

**Position of Patient:**

Short sitting; arm at side and elbow flexed to 90°; forearm in full pronation to neutral. Alternatively, patient may sit at a table with elbow supported.

**Instructions to Therapist:**

Stand at side or in front of patient. Ask patient to turn the palm up as if holding soup in the hand. If sufficient range is present, proceed to apply resistance. One hand supports the elbow. Apply resistance with the heel of the therapist's hand over the dorsal (extensor) surface at the wrist, being careful not to grip the flexor surface of the forearm ([Fig. 5.124](#)).



**FIGURE 5.124**

**Test:**

Patient begins in pronation and supinates the forearm until the palm faces the ceiling. Therapist resists motion in the direction of pronation.

**Alternate Test:**

Grasp patient's hand as if shaking hands; cradle the elbow and resist via the hand grip ([Fig. 5.125](#)). This test is used if the patient has Grade 5 or 4 wrist and hand strength. It should not be used if there is wrist instability.

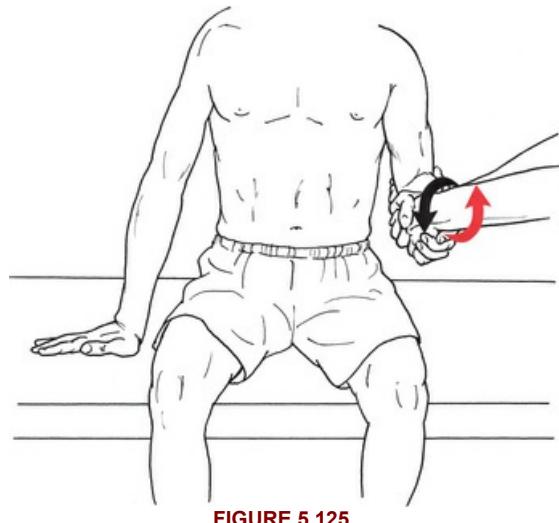


FIGURE 5.125

**Instructions to Patient:**

"Turn your palm up. Hold it. Don't let me turn it down. Keep your wrist and fingers relaxed."

**For Grade 3:**

"Turn your palm up."

**Grading**

**Grade 5:**

Holds test position against maximal resistance.

**Grade 4:**

Holds test position against strong to moderate resistance.

**Grade 3:**

Completes available range of motion without resistance ([Fig. 5.126](#), showing end range).

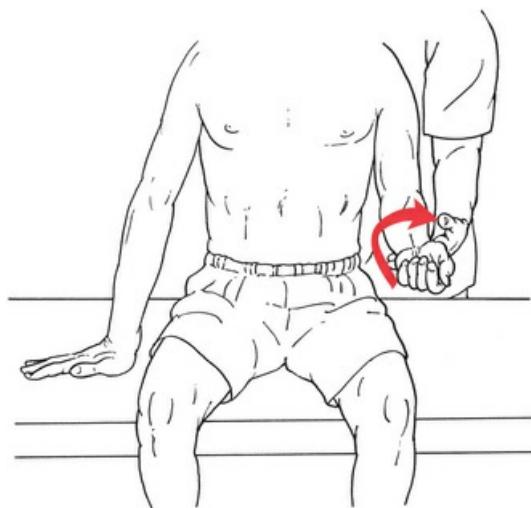


FIGURE 5.126

**Grade 2:**

Completes partial range of motion.

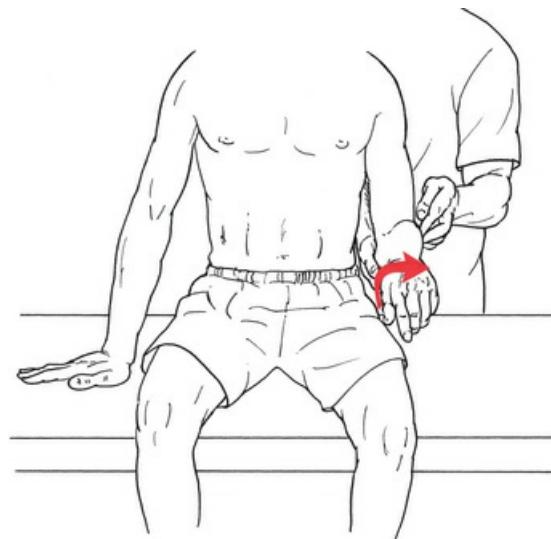
### Grade 1 and Grade 0

#### Position of Patient:

Short sitting. Arm and elbow are flexed as for the previous tests.

#### Instructions to Therapist:

Support the forearm just distal to the elbow. Palpate the supinator distal to the head of the radius on the dorsal aspect of the forearm ([Fig. 5.127](#)).



**FIGURE 5.127**

#### Test:

Patient attempts to supinate the forearm.

#### Instructions to Patient:

"Try to turn your palm so it faces the ceiling."

### Grading

#### Grade 1:

Slight contractile activity but no limb movement.

#### Grade 0:

No discernable palpable contractile activity.

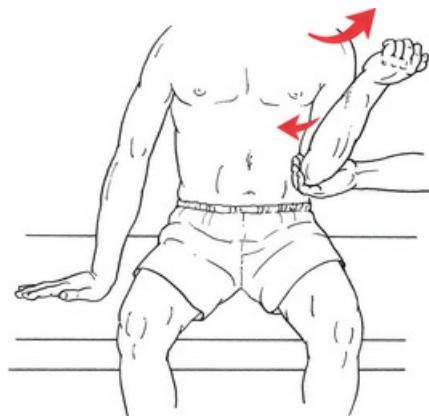


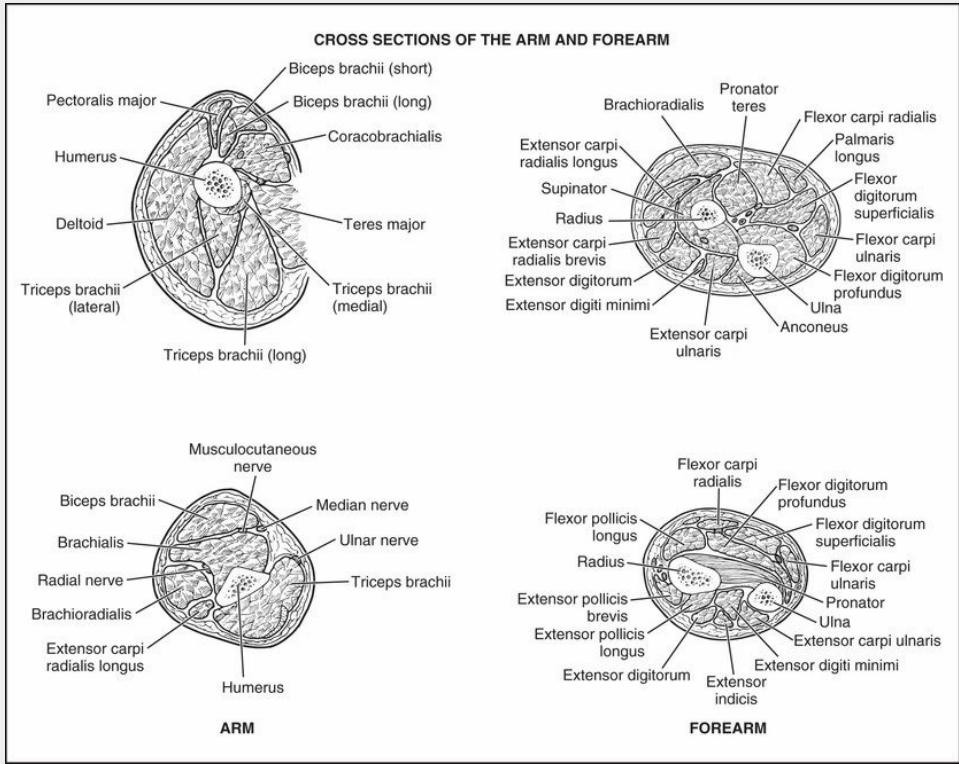
FIGURE 5.128

## Substitution

Patient may externally rotate and adduct the arm across the body (Fig. 5.128) as forearm supination is attempted. When this occurs, the forearm rolls into supination with no activity of the supinator muscle.

## Helpful Hints

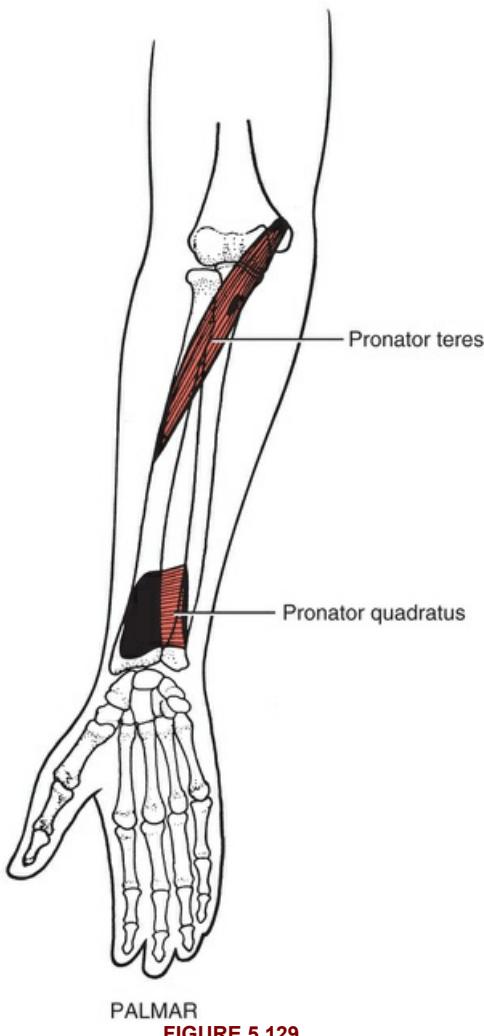
- It is controversial whether supination is stronger than pronation. Some studies report no difference and others report supination torque is more than pronation torque.<sup>45</sup>
- Biceps brachii activity is highest in mid-supination, when the length of the muscle is shorter.<sup>45</sup>
- The supinator is considered the prime mover of supination by some authorities, as supination is the only movement it performs, and forearm position is irrelevant. The biceps however, is a far stronger supinator as its mass is 5× that of the supinator, but the biceps performs optimally when elbow flexion and supination are combined.<sup>2,45</sup>

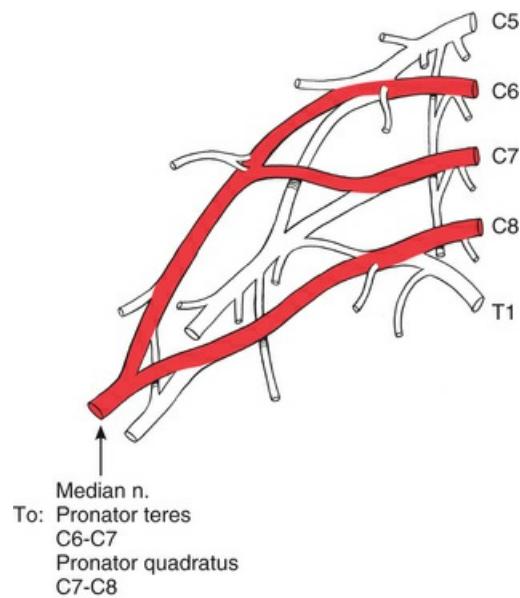


**PLATE 4** Cross sections of the arm and forearm.

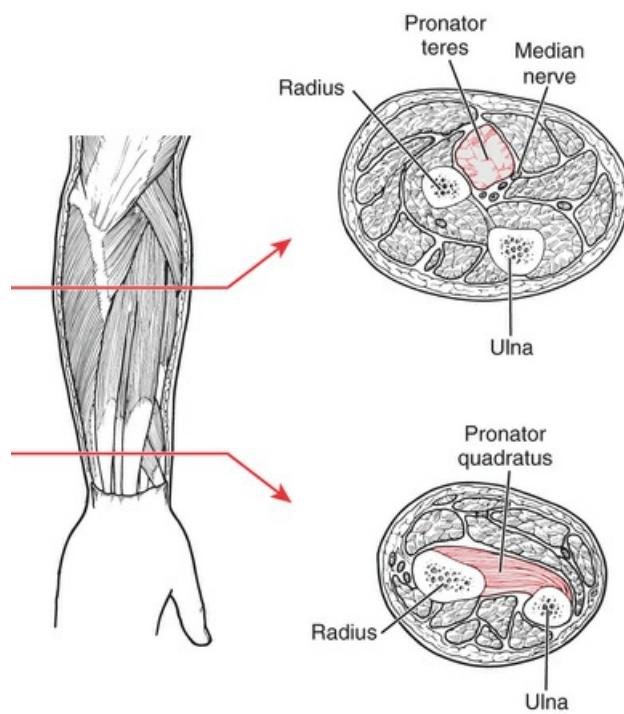
## Forearm Pronation

(*Pronator teres* and *Pronator quadratus*)





**FIGURE 5.130**



**FIGURE 5.131** Arrows indicate level of cross section.

## Range of Motion

0°–80°

<b>Table 5.17</b>
<b>FOREARM PRONATION</b>

L.D.	Muscle	Origin	Insertion	Function
146	Pronator teres		Radius (midshaft, lateral surface)	Pronation of forearm with resisted pronation or rapid pronation Elbow flexion (accessory) <sup>2,45</sup>
	Humeral head	Humerus (shaft proximal to medial epicondyle) Common tendon of origin of flexor muscles Intermuscular septum Antebrachial fascia		
	Ulnar head	Ulna (coronoid process, medial) Joins humeral head in common tendon		
147	Pronator quadratus	Ulna (oblique ridge on distal $\frac{1}{4}$ of anterior surface) Muscle aponeurosis	Radius (shaft, anterior surface distally; also area above ulnar notch)	Pronation of forearm Elbow flexion (accessory)
<b>Other</b>				
151	Flexor carpi radialis	See Table 5.18		Pronation of forearm (weak assist) Flexion of wrist Radial deviation (abduction) of wrist Extends fingers (tenodesis action) Flexion of elbow (weak assist)

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Short sitting or may sit at a table. Arm at side with elbow flexed to 90° and forearm in supination.

### Instructions to Therapist:

Stand at side or in front of patient. Ask patient to turn palm down from supinated position. If sufficient range is present, proceed to apply resistance in test position. Support the elbow. Hand used for resistance applies resistance with hypothenar eminence over radius on the volar (flexor) surface of the forearm at the wrist (Fig. 5.132). Avoid pressure on the head of the radius and gripping the forearm for patient comfort.



FIGURE 5.132

### Test:

Patient attempts to pronates the forearm. Therapist resists motion at the wrist in the direction of supination for Grades 4 and 5.

### **Alternate Test:**

Grasp patient's hand as if to shake hands, cradling the elbow with the other hand and resisting pronation via the hand grip. This alternate test may be used if the patient has Grade 5 or 4 wrist and hand strength. This alternate test should not be used in the presence of wrist instability.

### **Instructions to Patient:**

"Turn your palm down. Hold it. Don't let me turn it up. Keep your wrist and fingers relaxed."

### **Grading**

#### **Grade 5:**

Holds test position against maximal resistance.

#### **Grade 4:**

Holds test position against strong to moderate resistance.

#### **Grade 3:**

Completes available range without resistance ([Fig. 5.133](#), showing end range).



**FIGURE 5.133**

#### **Grade 2:**

Complete partial range of motion

### **Grade 1 and Grade 0**

### **Instructions to Therapist:**

Stand to the side of the patient. Support the forearm just distal to the elbow. The fingers of the other hand are used to palpate the pronator teres over the upper third of the volar (flexor) surface of the forearm on a diagonal line from the medial condyle of the humerus to the lateral border of the radius ([Fig. 5.134](#)).

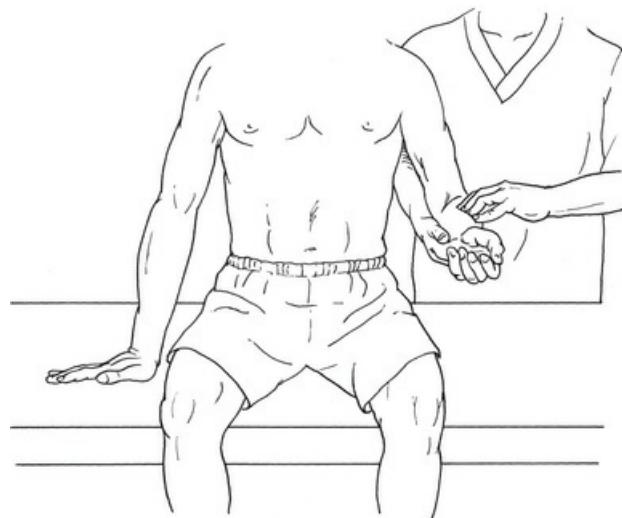


FIGURE 5.134

**Test:**

Patient attempts to pronate the forearm.

**Instructions to Patient:**

"Try to turn your palm down."

**Grading**

**Grade 1:**

Visible or palpable contractile activity with no motion of the part.

**Grade 0:**

No discernable palpable contractile activity.

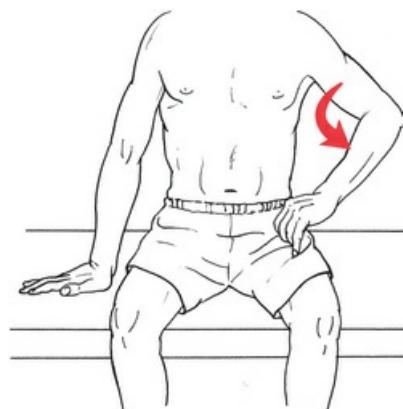


FIGURE 5.135

**Substitution**

Patient may internally rotate the shoulder or abduct it during attempts at pronation ([Fig. 5.135](#)). When this occurs, the forearm rolls into pronation without the benefit of activity by the pronator muscles.

## Helpful Hints

- Nondominant arm elicits 81%–95% of the force of the dominant arm in forearm rotation.<sup>46</sup>
- Pronation is strongest in the position of 45° of elbow flexion.<sup>47</sup>
- Men are 63% stronger in pronation and 68% stronger in supination than women, measuring as high as 12.6–14.8 Nm.<sup>48</sup>
- In isokinetic studies, women's forearm strength is equal to 5.0–5.4 Nm.<sup>48</sup>

## Wrist Flexion

(*Flexor carpi radialis* and *Flexor carpi ulnaris*)

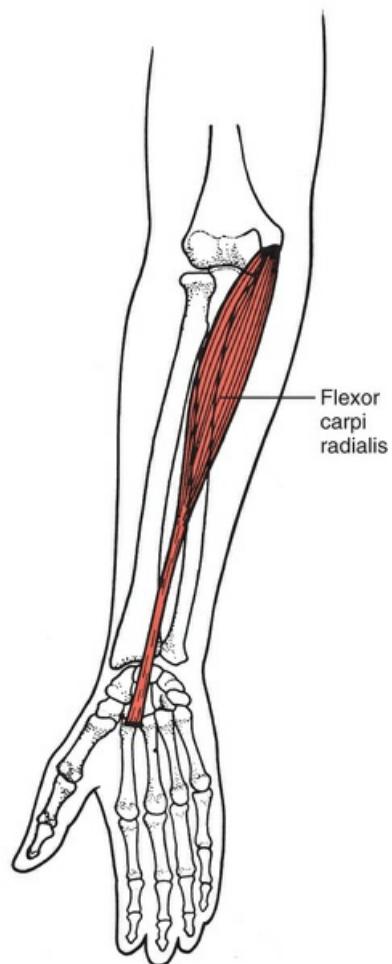
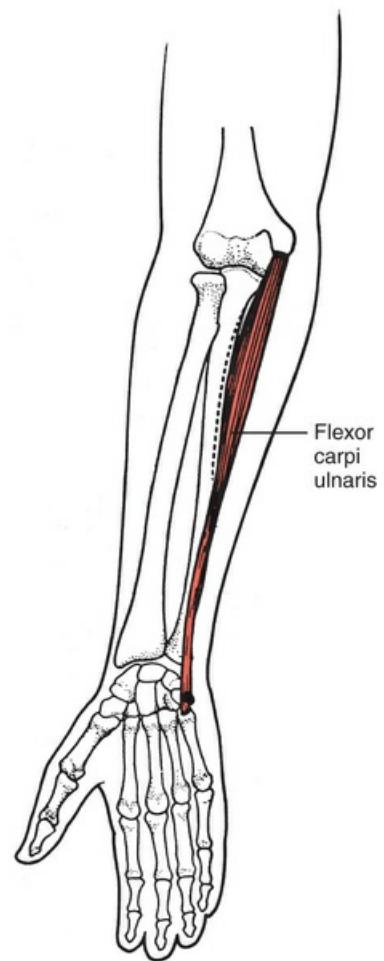


FIGURE 5.136



PALMAR

FIGURE 5.137

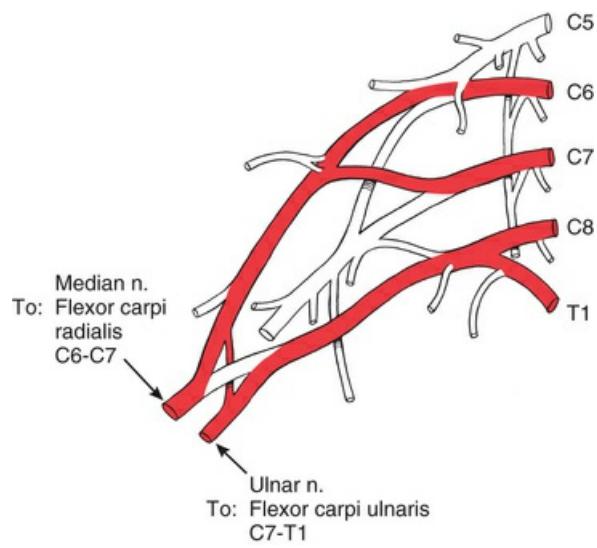
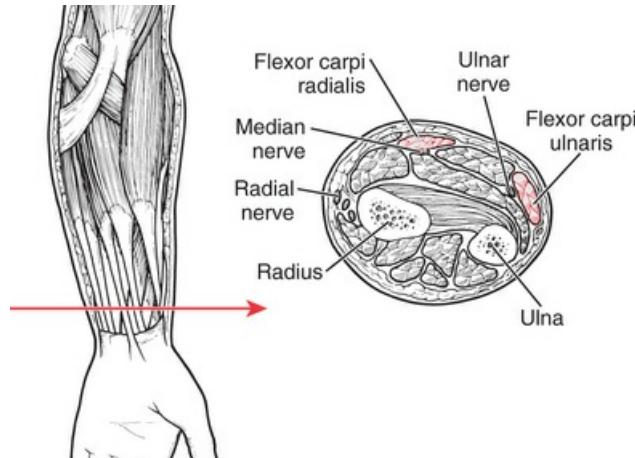


FIGURE 5.138



**FIGURE 5.139** Arrow indicates level of cross section.

## Range of Motion

0°–80°

**Table 5.18**  
**WRIST FLEXION**

I.D.	Muscle	Origin	Insertion	Function
151	Flexor carpi radialis	Humerus (medial epicondyle via common flexor tendon) Antebrachial fascia Intermuscular septum	2nd and 3rd metacarpals (base, palmar surface)	Flexion of wrist Radial deviation (abduction) of wrist Extends fingers (tenodesis action) Flexion of elbow (weak assist) Pronation of forearm (weak assist)
153	Flexor carpi ulnaris Two heads	Humeral head (medial epicondyle via common flexor tendon) Ulnar head (olecranon, medial margin; shaft, proximal $\frac{2}{3}$ posterior via an aponeurosis) Intermuscular septum	Pisiform bone Hamate bone 5th metacarpal, base	Flexion of wrist Ulnar deviation (adduction) of wrist Flexion of elbow (assist)
<b>Others</b>				
156	Flexor digitorum superficialis	See Table 5.20		
157	Flexor digitorum profundus	See Table 5.20		
169	Flexor pollicis longus	See Table 5.24		

## Grade 5 and Grade 4

### Position of Patient (All Tests):

Short sitting. Forearm is supinated (Fig. 5.140). Wrist is in neutral position or slightly extended.



FIGURE 5.140

**Test:**

Patient flexes the wrist, keeping the digits and thumb relaxed.

**Instructions to Therapist:**

Sit or stand in front of the patient and ask the patient to bend the wrist (Grade 3). If sufficient range is present, proceed to test strength by placing the hand in the test position. One hand supports the patient's forearm under the wrist (see Fig. 5.140) while the other hand applies resistance over the volar (palmar) surface of the hand (Fig. 5.141).

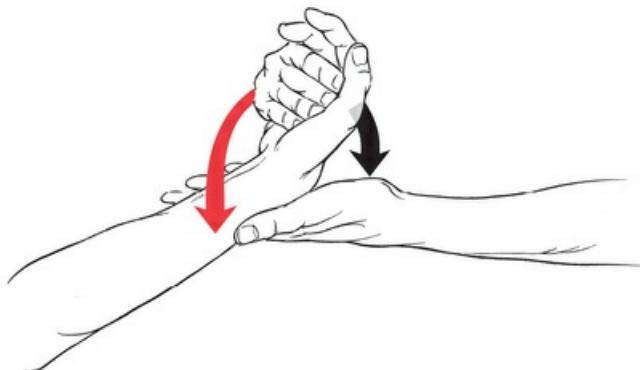


FIGURE 5.141

**To Test Both Wrist Flexors:**

Apply resistance to the palm of the test hand using four fingers or hypotenar eminence (see Fig. 5.141). Resistance is given evenly across the hand in a straight-down direction into wrist extension.

**To Test the Flexor Carpi Radialis:**

Place the patient's wrist in radial deviation and slight wrist extension. Resistance is applied with the index and long fingers over the first and second metacarpal (radial side of the hand) in the direction of extension and ulnar deviation (Fig. 5.142).



**FIGURE 5.142**

#### To Test the Flexor Carpi Ulnaris:

Place the wrist in ulnar deviation and slight wrist extension. Resistance is applied over the fifth metacarpal (ulnar side of the hand) in the direction of extension and radial deviation (Fig. 5.143).



**FIGURE 5.143**

#### Instructions to Patient (All Tests):

"Hold it. Don't let me pull it down. Keep your fingers relaxed."

#### Grading

##### Grade 5:

Holds test position of wrist flexion against maximal resistance.

##### Grade 4:

Holds test position of wrist flexion against strong to moderate resistance.

##### Grade 3:

#### Both Wrist Flexors:

Patient flexes the wrist through full range without resistance and without radial or ulnar deviation.

#### Flexor Carpi Radialis:

Patient flexes the wrist in radial deviation through full range without resistance. This is a small movement as compared with ulnar deviation described below (Fig. 5.144).



FIGURE 5.144

The illustration is shown from the extensor surface to better illustrate the small movement.

**Flexor Carpi Ulnaris:**

Patient flexes the wrist in ulnar deviation through full range without resistance ([Fig. 5.145](#)).

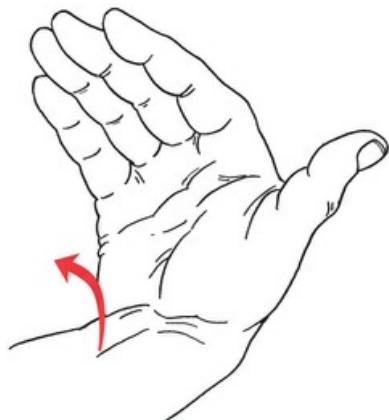


FIGURE 5.145

**Grade 2**

**Position of Patient:**

Sitting with elbow supported on table. Forearm in mid position with hand resting on ulnar side ([Fig. 5.146](#)).



FIGURE 5.146

**Instructions to Therapist:**

Support patient's forearm proximal to the wrist.

**Test:**

Patient flexes wrist with the ulnar surface gliding across or not touching the table (see Fig. 5.146, end position). To test the two wrist flexors separately, hold the forearm so that the wrist does not lie on the table and ask the patient to perform the flexion motion while the wrist is in ulnar and then radial deviation.

**Instructions to Patient:**

"Bend your wrist, keeping your fingers relaxed."

**Grading**

**Grade 2:**

Completes available range of wrist flexion with gravity minimized.

**Grade 1 and Grade 0**

**Position of Patient:**

Supinated forearm supported on table.

**Instructions to Therapist:**

Support the wrist in flexion; the index finger of the other hand is used to palpate the appropriate tendons.

Palpate the tendons of the flexor carpi radialis (Fig. 5.147) and the flexor carpi ulnaris (Fig. 5.148) in separate tests.



**FIGURE 5.147**



**FIGURE 5.148**

The flexor carpi radialis lies on the lateral palmar aspect of the wrist (see Fig. 5.141) lateral to the palmaris longus.

The tendon of the flexor carpi ulnaris (see Fig. 5.147) lies on the medial palmar aspect of the wrist (at the base of the fifth metacarpal).

**Test:**

Patient attempts to flex the wrist.

**Instructions to Patient:**

“Try to bend your wrist. Relax. Bend it again.” Patient should be asked to repeat the test so the therapist can feel the tendons during both relaxation and contraction.

**Grading**

**Grade 1:**

One or both tendons may exhibit visible or palpable contractile activity, but the part does not move.

**Grade 0:**

No discernable palpable contractile activity.

## **Helpful Hint**

Flexor carpi ulnaris contributes to adduction (ulnar deviation) most strongly in the supinated position as compared with the pronated and neutral positions.<sup>49</sup>

## **Suggested Exercises**

- Wrist curls with resistance

## Wrist Extension

(*Extensor carpi radialis longus*, *Extensor carpi radialis brevis*, and *Extensor carpi ulnaris*)

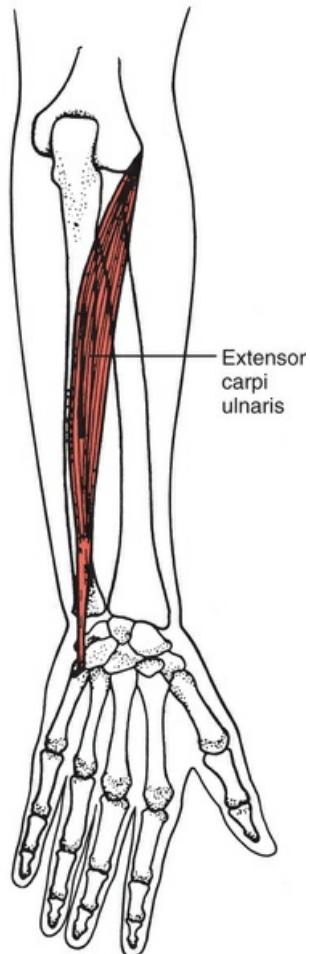
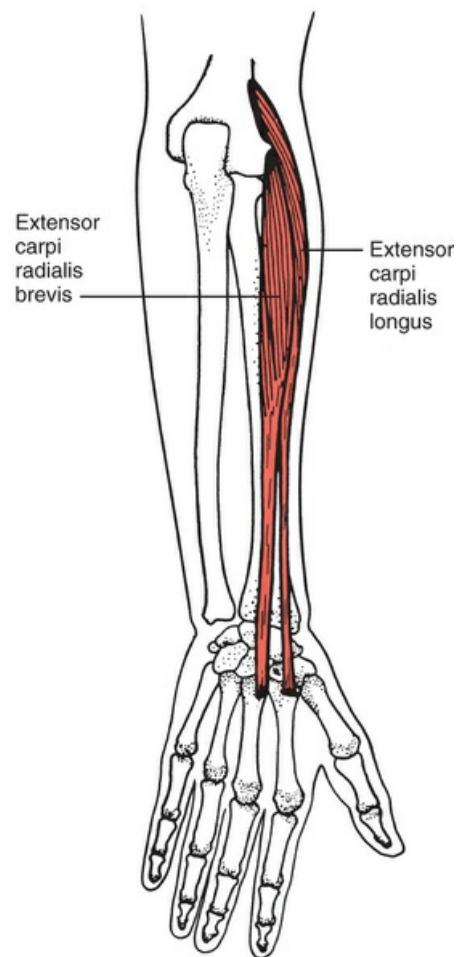
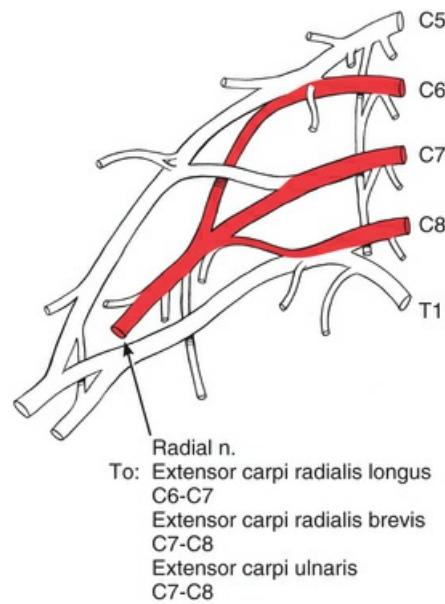


FIGURE 5.149

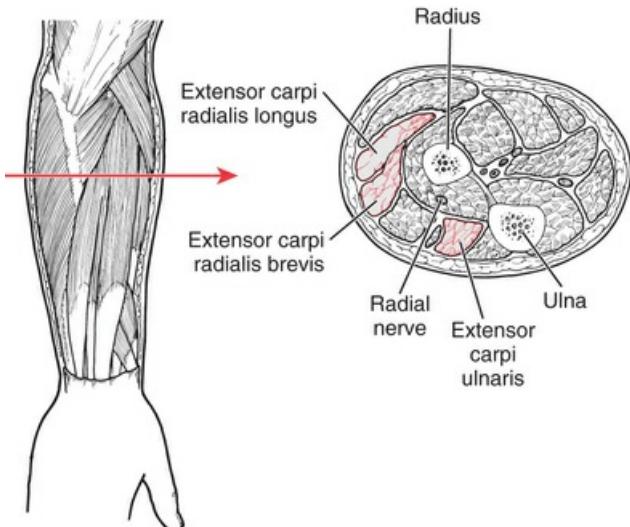


DORSAL VIEWS

**FIGURE 5.150**



**FIGURE 5.151**



**FIGURE 5.152** Arrow indicates level of cross section.

## Range of Motion

0°–70°

**Table 5.19**

### WRIST EXTENSION

I.D.	Muscle	Origin	Insertion	Function
148	Extensor carpi radialis longus	Humerus (lateral supracondylar ridge, distal  Common forearm extensor tendon Lateral intermuscular septum	2nd metacarpal bone (base on radial side of dorsal aspect)	Extension and radial deviation of wrist Synergist for finger flexion by stabilization of wrist Elbow flexion (accessory)
149	Extensor carpi radialis brevis	Humerus (lateral epicondyle via common forearm extensor tendon) Radial collateral ligament of elbow joint Aponeurosis of muscle	3rd metacarpal bone (base of dorsal surface on radial side) 2nd metacarpal (occasionally)	Extension of wrist Radial deviation of wrist (weak) Finger flexion synergist (by stabilizing the wrist)
150	Extensor carpi ulnaris	Humerus (lateral epicondyle via common extensor tendon) Ulna (posterior border by an aponeurosis)	5th metacarpal bone (tubercle on medial side of base)	Extension of wrist Ulnar deviation (adduction) of wrist
<b>Others</b>				
154	Extensor digitorum	See Table 5.20		
158	Extensor digiti minimi	See Table 5.20		
155	Extensor indicis	See Table 5.20		

The ability to extend the wrist is an essential function for most hand activity. A minimum of 25° of wrist extension is necessary for optimal grip strength.<sup>50</sup>

The radial wrist extensors are considerably stronger than the ulnar wrist extensor. The extensor carpi radialis brevis' muscle belly is 5× larger than the extensor carpi radialis longus.<sup>51</sup> Wrist extensor strength of the dominant side is approximately 10% stronger than the non-dominant side.<sup>52</sup> There is a strong correlation between grip strength and wrist extension strength. Lateral epicondylitis (tennis elbow), most often affects the extensor carpi radialis brevis at its insertion on the lateral epicondyle, resulting in painful wrist extension.

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Short sitting. Elbow is flexed, forearm is fully pronated, and forearm is supported on the table.

#### Instructions to Therapist:

Sit or stand at a diagonal in front of patient. Ask the patient to lift hand (Grade 3). If sufficient range is available, proceed to apply resistance by placing the patient's hand in the test position of full extension (Fig. 5.153). The hand used for resistance is placed over the dorsal (extensor) surface of

the metacarpals.

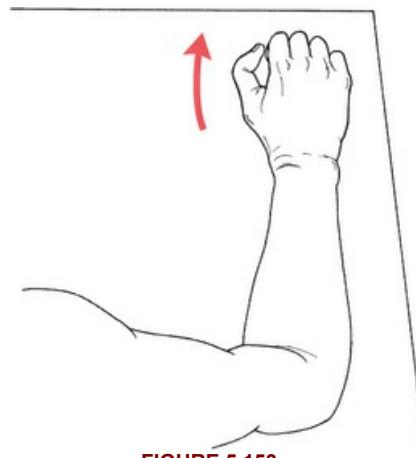


FIGURE 5.153

To test all three muscles, the patient extends the wrist without deviation. Resistance is given with four fingers or hypothenar eminence in a forward and downward direction over the second to fifth metacarpals for Grades 4 and 5 ([Fig. 5.154](#)).



FIGURE 5.154

To test the extensor carpi radialis longus and brevis (extension with radial deviation), position wrist in extension and radial deviation. Resistance is given on the dorsal (extensor) surface of the second and third metacarpals (radial side of hand) in the direction of flexion and ulnar deviation ([Fig. 5.155](#)).



**FIGURE 5.155**

To test the extensor carpi ulnaris (extension and ulnar deviation), position wrist in extension and ulnar deviation. Patient extends (lifts) the wrist, leading with the ulnar side of the hand. Resistance is given on the dorsal (extensor) surface of the fifth metacarpal (ulnar side of hand) in the direction of flexion and radial deviation (Fig. 5.156).



**FIGURE 5.156**

#### Test:

For the combined test of the three wrist extensor muscles, the patient extends the wrist (lifts the hand) through the full available range. Do not permit extension of the fingers.

To test the two radial extensors, the patient extends the wrist, leading with the thumb side of the hand. The wrist may be prepositioned in some extension and radial deviation to direct the patient's motion.

To test the extensor carpi ulnaris, the patient extends the wrist, leading with the ulnar side of the hand. The therapist may preposition the wrist to direct the movement toward the ulna.

#### Instructions to Patient:

"Hold it. Don't let me push it down."

For Grade 3: "Bring your hand up." (Add "to the side" when testing for radial or ulnar deviation.)

#### Grading

##### Grade 5:

Holds test position against maximal resistance. Full extension is not required for the tests of radial

and ulnar deviation.

#### **Grade 4:**

Holds test position of wrist extension against strong to moderate resistance when all muscles are being tested. When testing the individual muscles, full wrist extension range of motion will not be achieved.

#### **Grade 3:**

Completes full range of motion without resistance in the test for all three muscles. In the separate tests for the radial and ulnar extensors, the deviation required precludes full range of motion.

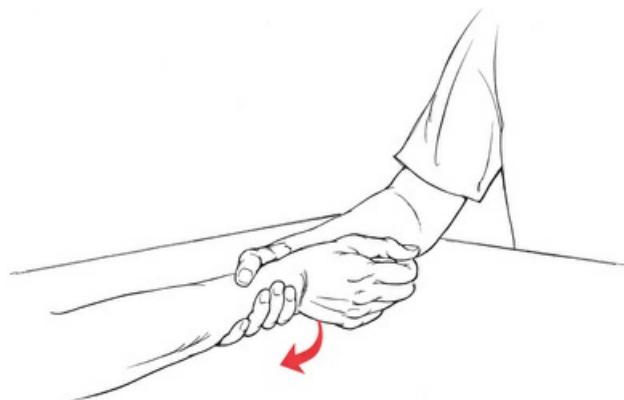
#### **Grade 2**

##### **Position of Patient:**

Forearm supported on table in neutral position.

##### **Instructions to Therapist:**

Support the patient's wrist. This elevates the hand from the table and removes friction ([Fig. 5.157](#)).



**FIGURE 5.157**

##### **Test:**

Patient extends the wrist.

##### **Instructions to Patient:**

"Bend your hand back."

#### **Grading**

#### **Grade 2:**

Completes full range with gravity minimized.

#### **Grade 1 and Grade 0**

##### **Position of Patient:**

Hand and forearm supported on table with forearm fully pronated.

##### **Instructions to Therapist:**

Support the patient's wrist in extension. The other hand is used for palpation. Use one finger to palpate one muscle in each test.

#### **Extensor Carpi Radialis Longus:**

Palpate the tendon on the dorsum of the wrist in line with the second metacarpal (Fig. 5.158).

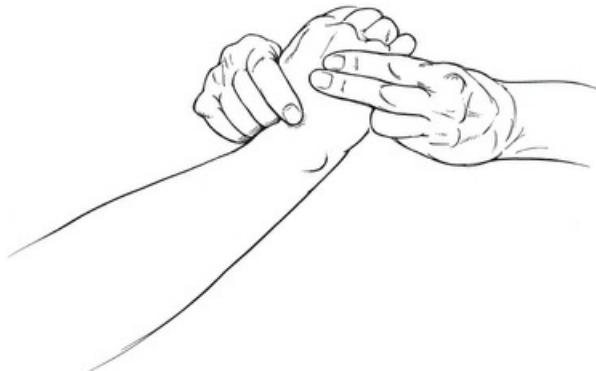


FIGURE 5.158

**Extensor Carpi Radialis Brevis:**

Palpate the tendon on the dorsal surface of the wrist in line with the third metacarpal bone (Fig. 5.159).



FIGURE 5.159

**Extensor Carpi Ulnaris:**

Palpate the tendon on the dorsal wrist surface proximal to the fifth metacarpal and just distal to the ulnar styloid process (Fig. 5.160).



**FIGURE 5.160**

**Test:**

Patient attempts to extend the wrist.

**Instructions to Patient:**

"Try to lift your hand."

**Grading**

**Grade 1:**

For any given muscle, there is visible or palpable contractile activity, but no wrist motion ensues.

**Grade 0:**

No discernable contractile activity.

**Substitution**

The most common substitution occurs when the finger extensors are allowed to participate. This can be avoided to a large extent by ensuring that the patient's fingers are relaxed and are not permitted to extend.

**Helpful Hints**

- Preferred position of the wrist when gripping is 35° of extension and 7° of ulnar deviation, where grip strength is the strongest. A minimum of 25° of wrist extension is necessary for optimal grip strength.<sup>50</sup>
- A patient with complete quadriplegia at C5-C6 will have only the radial wrist extensors remaining. Radial deviation during extension is therefore the prevailing extensor motion at the wrist.

**Suggested Exercises for Wrist Extensors**

- Wrist curls in pronated position

- Gripping/squeezing a ball or putty
- Wrist radial and ulnar deviation

## Introduction to Testing the Muscles of the Hand

Evaluating the hand following a nerve injury is the primary reason single muscles or movements are tested. Because of the innervation pattern of the hand, grading of movements may be more appropriate than grading specific muscles. Because the hand muscles have multiple functions and can be active in combined movements, the therapist should incorporate knowledge of function, anatomy and kinesiology to master strength testing of the hand. For example, the only muscles of the hand that can be purely isolated are the first dorsal interosseous (radial abduction of the index finger) and the flexor pollicis longus (flexion of the thumb interphalangeal [IP] joint).<sup>53</sup>

Alternatively, grip strength is considered a gross, functional measure of hand strength. Asking the patient to make a fist and straighten out the fingers will provide a general idea of active range of motion of the digits and help to provide focus of the muscular exam.

When evaluating the muscles of the hand, care must be taken to use graduated and appropriate resistance, especially following surgical intervention. Because of the small muscle mass of the hand muscles, the therapist should use one or two fingers to resist hand motions.

Clinical judgment is required when applying appropriate resistance in a safe fashion, especially in the postsurgical hand. In the postop hand, the therapist may only want to assure the presence of a muscle contraction, as certain movements may be prohibited by the surgeon. Similarly, the amount of motion allowed or encouraged should be monitored in conjunction with the surgeon. Too much force or too quickly applied force may be harmful to the surgical repair or reconstruction. The therapist should have a thorough understanding of the type of surgery and any contraindications to movement before muscle testing the postop hand. Considerable practice in testing normal hands and comparing injured hands with their normal contralateral sides should provide some of the necessary judgment with which to approach the surgically repaired hand.

It is difficult to differentiate between Grades 5 and 4 in many of the small muscles of the hand, and differentiating between Grades 5 and 4 may not be clinically relevant. Therefore, Grades 5 and 4 have been combined for some muscles. It takes experience and skill to discern weakness in the actively contracting hand muscle. This text remains true to the principles of testing in the ranges of grades 5, 4, and 3 with respect to gravity. It is admitted, however, that the influence of gravity on the fingers is inconsequential, so gravity and antigravity positions are not considered in valid muscle tests of the hand.

Two common groupings of the hand muscles are the intrinsics, innervated mostly by the median and ulnar nerve, and the extrinsics, innervated primarily by the radial and median nerves. The extrinsics originate in the forearm and the intrinsics originate distal to the wrist. In general, each finger has six muscles controlling its movements, three extrinsic muscles (two long flexors and one long extensor) and three intrinsic muscles (dorsal and palmar interosseous and lumbrical muscles). The little finger and index finger each have an additional extrinsic extensor.<sup>54</sup>

The hand section of this chapter is organized by extrinsics, intrinsics, and the thumb (combined extrinsic and intrinsics).

### Extrinsic Muscles

The extrinsic muscles of the hand originate above the wrist on the forearm and are made up of flexors and extensors. The tendons of the extrinsics are held in place at the wrist by the palmar carpal ligament and flexor retinaculum. The extrinsics are innervated by the radial, ulnar, and median nerves.

## Finger PIP and DIP Flexion

(*Flexor digitorum superficialis* and *Flexor digitorum profundus*)

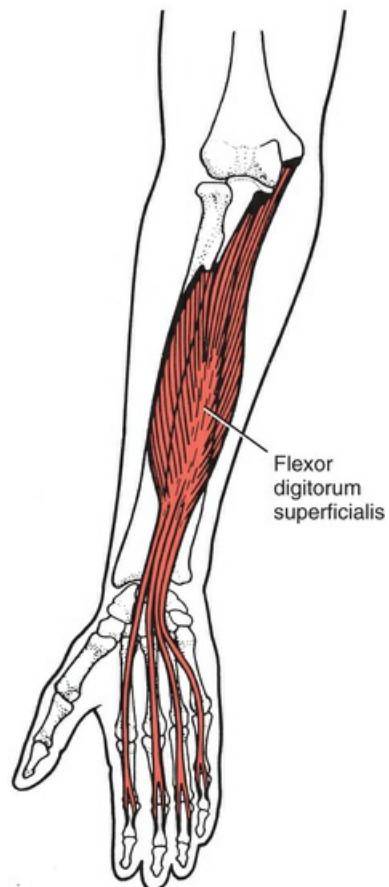
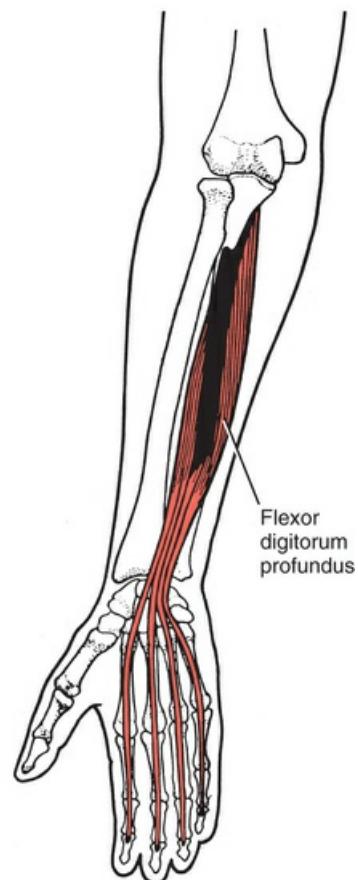
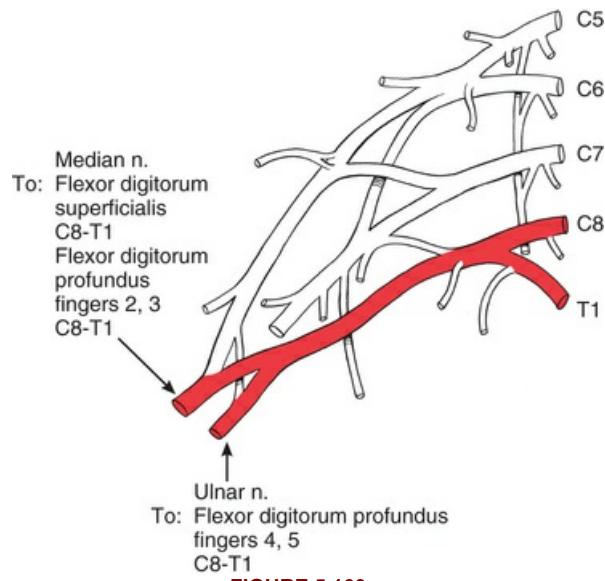


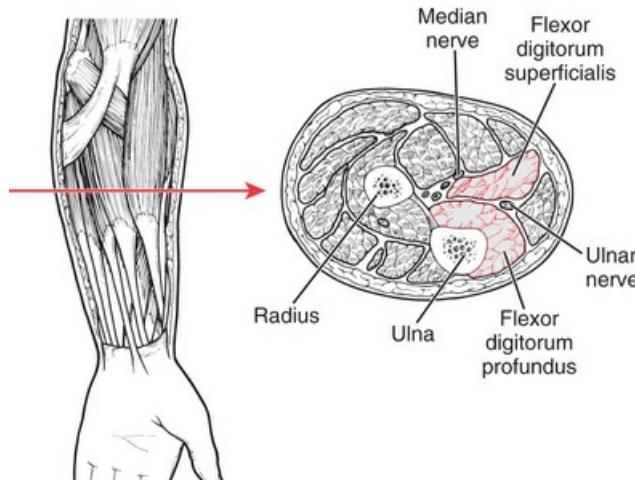
FIGURE 5.161



PALMAR  
**FIGURE 5.162**



**FIGURE 5.163**



**FIGURE 5.164** Arrow indicates level of cross section.

## Range of Motion

PIP joints: 0°–100°

DIP joints: 0°–90°

**Table 5.20**  
**PIP AND DIP FINGER FLEXION**

L.D.	Muscle	Origin	Insertion	Function
156	Flexor digitorum superficialis (2 heads)	Humeroulnar head: humerus (medial epicondyle via common flexor tendon)  Ulna (medial collateral ligament of elbow joint); coronoid process (medial side) Intermuscular septum Radial head: radius (oblique line on anterior shaft)	Four tendons arranged in 2 pairs Superficial pair: middle and ring fingers (sides of middle phalanges)  Deep pair: index and little fingers (sides of middle phalanges)	Flexion of PIP joints of digits 2–5 Flexion of MCP joints of digits 2–5 (assist) Flexion of wrist (accessory, especially in forceful grasp)
157	Flexor digitorum profundus	Ulna (proximal $\frac{3}{4}$ of anterior and medial shaft; medial coronoid process) Interosseous membrane (ulnar)	Four tendons to digits 2–5 (distal phalanges, at base of palmar surface)	Flexion of DIP joints of digits 2–5 Flexion of MCP and PIP joints of digits 2–5 (assist) Flexion of wrist (accessory)

MCP, Metacarpophalangeal; PIP, proximal phalanges.

The flexor digitorum superficialis (FDS) is innervated by the median nerve while the flexor digitorum profundus (FDP) is innervated by the median and ulnar nerve. The FDP has two heads, flexing the middle and ring fingers together and the index and little fingers. If a tendon injury or nerve injury is the reason for testing, each digit should be tested separately. Otherwise, all digits can be tested together to assess the integrity and strength of the finger flexors.

## Combined DIP and PIP Tests

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Forearm supinated, wrist in neutral. Fingers are relaxed.

#### Instructions to Therapist:

Sit in front of the patient, with patient's forearm and hand supported on a table with wrist fully supinated. Ask patient to touch the pads of the fingers to the distal palm while keeping the metacarpals extended (flat on the table) (Fig. 5.165).



FIGURE 5.165

If sufficient range is present, proceed to apply resistance. Stabilization is provided by the hand position. With a finger of the hand providing resistance in the patient's palm under the digits, pull up to try to straighten the digits ([Fig. 5.166](#)).

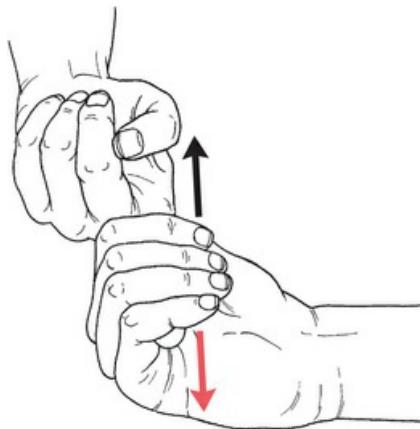


FIGURE 5.166

## Grading

### Grade 5 and Grade 4:

Holds against strong resistance.

### Grade 3:

Completes range of motion without resistance.

### Grade 2, Grade 1, and Grade 0:

Refer to isolated proximal phalanges (PIP) and distal phalanges (DIP) tests.

## PIP Tests

(*Flexor digitorum superficialis*)

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

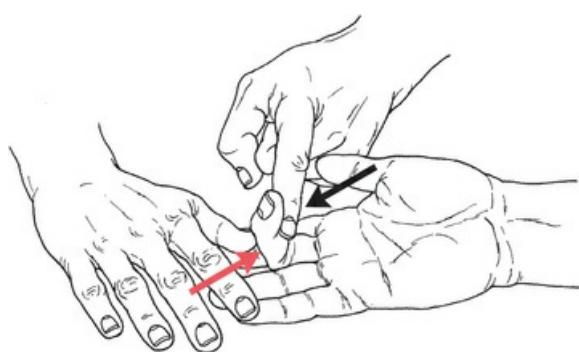
Forearm supinated, wrist in neutral. Finger to be tested is in slight flexion at the metacarpophalangeal (MCP) joint ([Fig. 5.167](#)).



**FIGURE 5.167**

#### Instructions to Therapist:

Hold all fingers (except the one being tested) in extension at all joints (see [Fig. 5.167](#)) so as to block the action of the profundus action. Isolation of the index finger may not be complete. Ask the patient to bend the middle joint towards the proximal palm. If full range is present (Grade 3), apply appropriate resistance. Therapist resists the distal end of the middle phalanx of the test finger in the direction of extension ([Fig. 5.168](#)).



**FIGURE 5.168**

#### Test:

Patient flexes the PIP joint without flexing the DIP joint. Do not allow motion of any joints of the other fingers. Repeat for other fingers, if indicated. Alternatively, you can test all fingers together (see [Fig. 5.166](#), combined test above).

Flick the terminal end of the finger being tested with the thumb to make certain that the flexor digitorum profundus is not active; that is, the DIP joint goes into extension. The distal phalanx should be relatively floppy.

**Instructions to Patient:**

"Bend your index [then long, ring, and little] finger at the middle joint; hold it. Don't let me straighten it. Keep your other fingers relaxed."

**Grading**

**Grade 5 and Grade 4:**

Holds against strong finger resistance.

**Grade 3:**

Completes range of motion without resistance (see [Fig. 5.167](#)).

**Grade 2, Grade 1, and Grade 0**

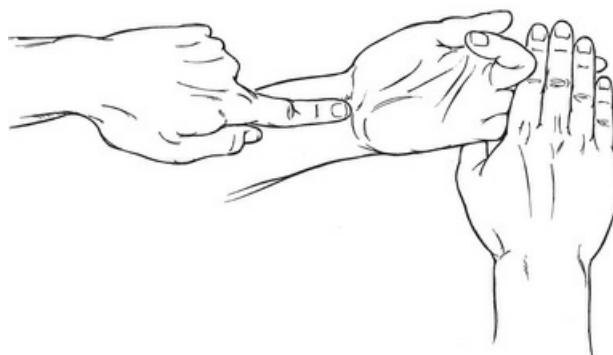
**Position of Patient:**

Forearm is in mid position to eliminate the influence of gravity on finger flexion.

**Instructions to Therapist:**

Same as for Grades 5, 4, and 3.

Palpate the flexor digitorum superficialis on the palmar surface of the wrist between the palmaris longus and the flexor carpi ulnaris ([Fig. 5.169](#)).



**FIGURE 5.169**

**Test:**

Patient flexes the PIP joint.

**Instructions to Patient:**

"Bend your middle finger." (Select other fingers individually.)

**Grading**

**Grade 2:**

Completes range of motion.

**Grade 1:**

Palpable or visible contractile activity, which may or may not be accompanied by a flicker of motion.

**Grade 0:**

No discernable palpable contractile activity.

## **Substitutions**

- The major substitution for this motion is offered by the flexor digitorum profundus, and this will occur if the DIP joint is allowed to flex.
- If the wrist is allowed to extend, tension increases in the long finger flexors, and may result in passive flexion of the IP joints. This is referred to as a “tenodesis” action.
- Relaxation of IP extension will result in passive IP flexion.

## **Helpful Hint**

Many people cannot isolate the little finger. When this is the case, test the little and ring fingers at the same time.

## DIP Tests

(*Flexor digitorum profundus*)

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Forearm in supination, wrist in neutral, and proximal PIP joint in extension.

#### Instructions to Therapist:

Stabilize the middle phalanx in extension by grasping it on either side (Fig. 5.170). Ask the patient to bend the tip of the finger. If full range is present (Grade 3), apply appropriate resistance. Resistance is provided on the distal phalanx in the direction of extension (not illustrated).



FIGURE 5.170

#### Test:

Test each finger individually if indicated. Patient flexes distal phalanx of each finger. Test all digits together by patient flexing all distal phalanxes together.

#### Instructions to Patient:

"Bend the tip (or tips) of your finger. Hold it (them). Don't let me straighten it (them)."

### Grading

#### Grade 5 and Grade 4:

Able to hold flexed position against strong, finger resistance.

#### Grade 3:

Completes active range without resistance (see Fig. 5.170).

### Grade 2, Grade 1, and Grade 0

Testing grades 2, 1, and 0 is the same as that used with higher grades except that the position of the forearm is in neutral to eliminate the influence of gravity.

Grades are assigned as for the PIP tests.

The tendon of the flexor digitorum profundus can be palpated on the palmar surface of the middle phalanx of each finger.

## Substitutions

- The wrist must be kept in a neutral position and must not be allowed to extend, to rule out the tenodesis effect of the wrist extensors.
- Don't be fooled if the patient extends the distal phalanges joint and then relaxes, which can give the impression of active finger flexion.
- In a power grip task, greater forces are applied on the distal phalanges of the long fingers compared with the middle and proximal ones, making the flexor digitorum profundus an important muscle to strengthen.<sup>55</sup>

## Finger MCP Extension

(*Extensor digitorum, Extensor indicis, and Extensor digiti minimi*)

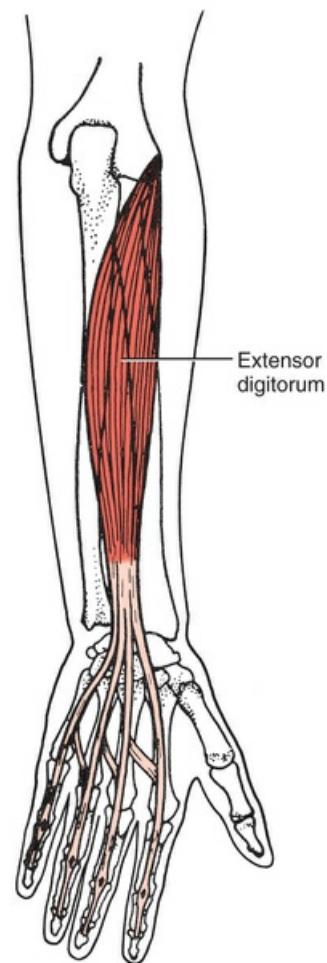
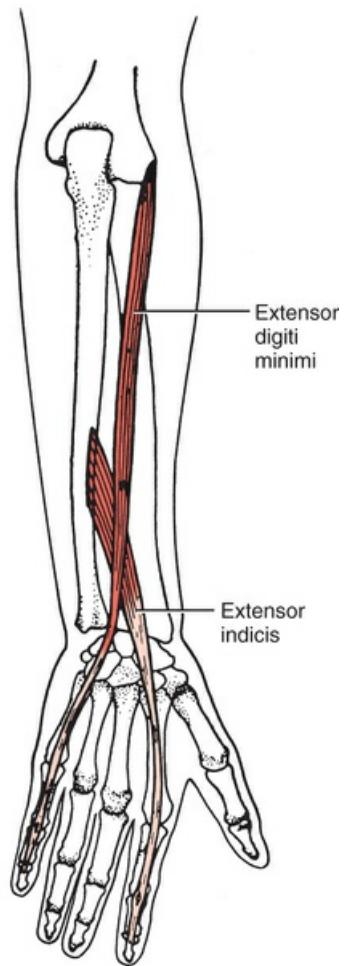
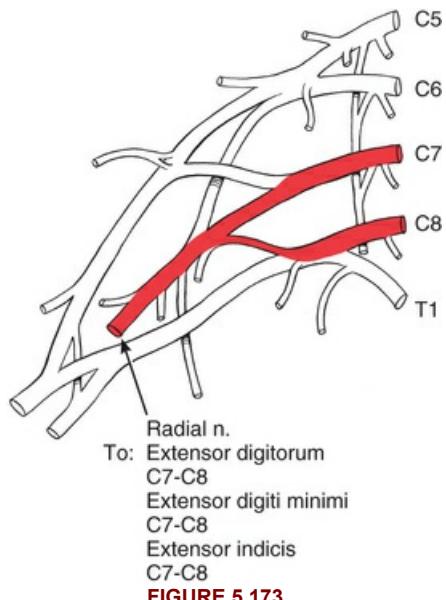


FIGURE 5.171

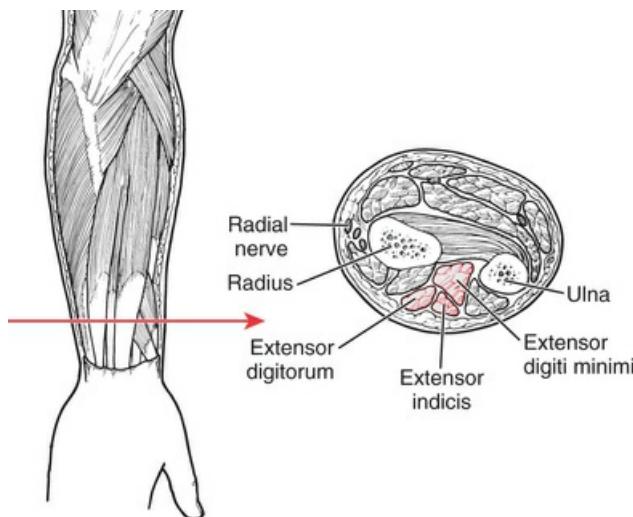


DORSAL

**FIGURE 5.172**



**FIGURE 5.173**



**FIGURE 5.174** Arrow indicates level of cross section.

## Range of Motion

0°–45°

**Table 5.21**  
**MCP FINGER EXTENSION**

I.D.	Muscle	Origin	Insertion	Function
154	Extensor digitorum	Humerus (lateral epicondyle via common extensor tendon) Intermuscular septum Antebrachial fascia	Via 4 tendons to digits 2–5 (via the extensor expansion, to dorsum of middle and distal phalanges; one tendon to each finger)	Extension of metacarpophalangeal (MCP) and proximal (PIP) and distal interphalangeal (DIP) joints, digits 2–5 Extensor digitorum can extend any and all joints over which it passes via the dorsal expansion Independent action of the extensor digitorum: Hyperextends MCP joint (proximal phalanges) by displacing dorsal expansion proximally Extends interphalangeal (IP) joints (middle and distal phalanges) when MCP joints are slightly flexed by intrinsics Wrist extension (accessory) Abduction of ring, index, and little fingers with extension but no such action on the middle finger
155	Extensor indicis	Ulna (posterior surface of shaft) Interosseous membrane	2nd digit (via tendon of extensor digitorum into extensor hood)	Extension of MCP joint of index finger Extension of IP joints (with intrinsics) Adduction of index finger (accessory) Wrist extension (accessory)
158	Extensor digiti minimi	Humerus (lateral epicondyle via common extensor tendon) Intermuscular septa	5th digit (extensor hood)	Extension of MCP, IP, and DIP joints of digit 5 (little finger) Wrist extension (accessory) Abduction of digit 5 (accessory)

## Grade 5, Grade 4, and Grade 3

### Position of Patient:

Forearm in pronation, wrist in neutral. MCP and IP joints are in relaxed flexion posture.

### Instructions to Therapist:

Sit at table or side of patient. Stabilize the wrist in neutral. Place the index finger of the resistance hand across the dorsum of all proximal phalanges just distal to the MCP joints to stabilize. Ask the patient to straighten the knuckles as far as possible. Demonstrate motion to patient and instruct to copy. If full range is present (Grade 3), apply appropriate resistance. Give resistance in the direction of flexion.

### Test:

#### Extensor Digitorum:

Patient extends MCP joints (all fingers simultaneously), allowing the IP joints to be in slight flexion ([Fig. 5.175](#)).



**FIGURE 5.175**

#### **Extensor Indicis:**

Patient extends the MCP joint of the index finger.

#### **Extensor Digiti Minimi:**

Patient extends the MCP joint of the 5th digit.

#### **Instructions to Patient:**

“Straighten (lift) your knuckles as far as they will go.”

### **Grading**

#### **Grade 5 and Grade 4:**

Able to hold position with appropriate level of resistance. (Extensor is not as strong as the flexor.)

#### **Grade 3:**

Completes active range without resistance.

#### **Grade 2, Grade 1, and Grade 0**

#### **Procedures:**

Test is the same as that for Grades 5, 4, and 3 except that the forearm is in the mid position.

The four tendons of the extensor digitorum, the tendon of the extensor indicis, and the tendon of the extensor digiti minimi are readily apparent on the dorsum of the hand as they course in the direction of each finger.

### **Grading**

#### **Grade 2:**

Completes range.

#### **Grade 1:**

Visible tendon activity but no joint motion.

#### **Grade 0:**

No discernable palpable contractile activity.

## Substitution

Flexion of the wrist will produce interphalangeal extension through a tenodesis action.

## Helpful Hints

- Metacarpophalangeal extension of the fingers is not a strong motion, and only slight resistance is required to “break” the end position.
- It is usual for the active range of motion to be considerably less than the available passive range. In this test, therefore, the “full available range” is not used, and the active range is accepted.
- Another way to check whether there is functional extensor strength in the fingers is to “flick” the proximal phalanx of each finger downward; if the finger rebounds, it is functional.

## Intrinsic Muscles

The intrinsic muscles are traditionally divided into five groups: thenar, hypotenar, palmar interossei, dorsal interossei, and lumbricals (Table 5.22). The primary function of the interossei is MCP flexion/stabilization with extension of the IP joints. This motion is assisted by the lumbricals which can contract without adding flexion torque at the MCP joint.<sup>54</sup> Although efficient, the lumbricals are weak with the smallest physiological cross-sectional area of all the intrinsic hand muscles. Without the interossei, the fingers are unstable and will collapse into the “claw” (i.e., intrinsic minus) position of hyperextension of the MCP joint and flexion of the IP joints when loaded.<sup>54</sup> The Mannerfelt sign is a sign of interosseous muscle weakness when the index PIP joint “collapses” resulting in hyperflexion, often greater than 90°. Another sign of weakness is the Thomas sign, when wrist flexion occurs to try to open the hand by means of increasing the pull on the extensor digitorum.<sup>54</sup>

The inability to adduct and abduct the fingers occurs with the loss of the interossei muscles. These actions are quite important to people who play musical instruments or operate keyboards, but for most people does not result in a severe deficit.<sup>54</sup>

**Table 5.22**

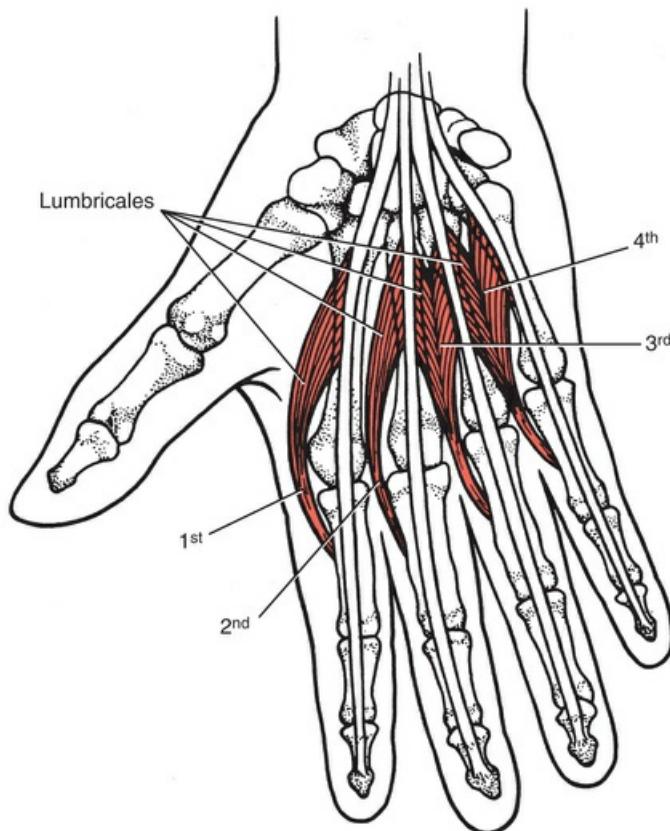
**GROUPS OF INTRINSIC HAND MUSCLES**

Groups	Function	Muscles
Thenar	Thumb is brought lateral to medial position across the palm in opposition to the 4 ulnar digits	Abductor pollicis brevis Flexor pollicis brevis Opponens pollicis
Hypotenar	Little finger is brought in opposition to the thumb	Opponens digiti minimi Adductor pollicis
Palmar interossei (3)	Adduct the 4 ulnar digits together toward the 3rd finger First palmar interossei; tip pinch	
Dorsal interossei	First dorsal interossei: key pinch <sup>54</sup> Flex the MCP joints and extend the IP joints; adduct the 4 ulnar digits toward the 3rd finger	4 interossei Abductor digiti minimi
Lumbricals	Extension of the IP joints in any position of the MCP joints	2 radial lumbricals 2 ulnar lumbricals

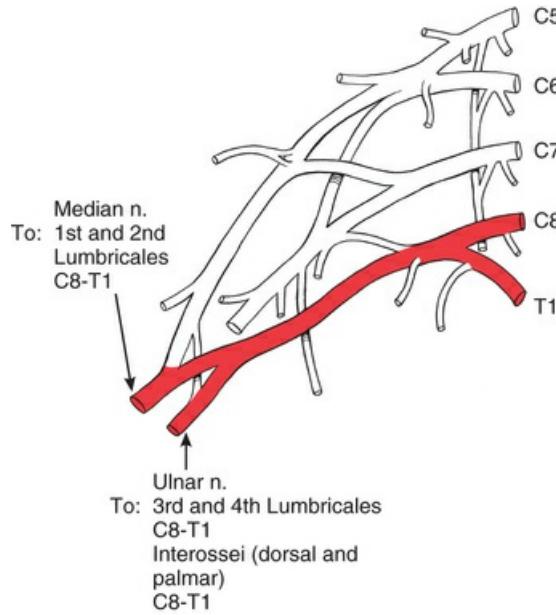
IP, Interphalangeal; MCP, metacarpophalangeal.

## Finger MCP Flexion

(*Interossei and Lumbricals*)



PALMAR  
**FIGURE 5.176**



**FIGURE 5.177**

## Range of Motion

MCP joints: 0°–90°

**Table 5.23**  
**MCP FLEXION AND ABDUCTION AND ADDUCTION OF THE FINGERS**

I.D.	Muscle	Origin	Insertion	Function
164	Dorsal interossei (four bipennate muscles) 1st dorsal interosseous (often named <i>Abductor indicis</i> )	Metacarpal bones (each muscle arises by two heads from adjacent sides of metacarpals between which each lies)	All: dorsal expansion Proximal phalanges (bases)	Abduction of fingers away from an axis drawn through the center of the long (middle) finger Flexion of fingers at MCP joints (assist) Extension of fingers at IP joints (assist) Thumb adduction (assist)
		1st dorsal: between thumb and index finger	1st dorsal: index finger (radial side)	Contributes 73% to the overall moment of MCP flexion <sup>56</sup>
		2nd dorsal: between index and long finger	2nd dorsal: long finger (radial side)	
		3rd dorsal: between long and ring fingers	3rd dorsal: long finger (ulnar side)	
		4th dorsal: between ring and little fingers	4th dorsal: ring finger (ulnar side)	
165	Palmar interossei three muscles (a 4th muscle often is described)	Metacarpal bones 2, 4, and 5 (muscles lie on palmar surfaces of metacarpals rather than between them) No palmar interosseous on long finger All muscles lie on aspect of metacarpal facing the long finger	All: Dorsal expansion Proximal phalanges	Adduction of fingers (index, ring, and little) toward an axis drawn through the center of the long finger Flexion of MCP joints (assist) Extension of IP joints (assist) Opposition of digit 5 (3rd interosseous)
		1st palmar: 2nd metacarpal (ulnar side)	1st palmar: index finger (ulnar side)	
		2nd palmar: 4th metacarpal (radial side)	2nd palmar: ring finger (radial side)	
		3rd palmar: 5th metacarpal (radial side)	3rd palmar: little finger (radial side)	
159	Abductor digiti minimi	Pisiform bone Tendon of flexor carpi ulnaris Pisohamate ligament	5th digit (base of proximal phalanx, ulnar side) Dorsal expansion of extensor digiti minimi	Abduction of 5th digit away from ring finger Flexion of proximal phalanx of 5th digit at the MCP joint Opposition of 5th digit (assist)
163	Lumbricals (4 in number)	Tendons of flexor digitorum profundus:	Extensor digitorum expansion Each muscle runs distally to the <i>radial</i> side of its corresponding digit, attaches to the dorsal digital expansion	Flexion of MCP joints (proximal phalanges) of digits 2–5 and simultaneous extension of the PIP and DIP joints
	1st lumbrical	Index finger (radial side, palmar surface)	1st lumbrical to index finger	
	2nd lumbrical	Middle finger (radial side, palmar surface)	2nd lumbrical to long finger	
	3rd lumbrical	Middle and ring fingers (double heads from adjacent sides of tendons)	3rd lumbrical to ring finger	
	4th lumbrical	Ring and little fingers (adjacent sides of tendons)	4th lumbrical to little finger	Opposition of digit 5 (4th lumbrical) Flexion of MCP joints (proximal phalanges) of digits 2–5 and simultaneous extension of the PIP and DIP joints
<b>Others</b>				
156	Flexor digitorum superficialis	See Table 5.20		
157	Flexor digitorum profundus	See Table 5.20		
160	Flexor digiti minimi brevis			
161	Opponens digiti minimi			
154	Extensor digitorum (no action on long finger)	See Table 5.21		
158	Extensor digiti minimi (little finger)	See Table 5.21		

DIP, Distal phalanges; IP, interphalangeal; MCP, metacarpophalangeal; PIP, proximal phalanges.

The lumbricals are the smallest muscles of all the intrinsic hand muscles and thus are weak as compared with the interossei muscles. It is impossible to separate the interossei from the lumbricals because of their synergistic action through the extensor hood mechanism.<sup>54</sup> The lumbricals have a rich composition of muscle spindles making them important for sensory input and in fast, alternating movements, for example, in typing and playing musical instruments.<sup>54</sup>

The test for the interossei and lumbricals is often called the lumbrical test, but it is the interossei that are being graded for their strength in stabilizing the MCP joints in flexion and therefore is more accurately referred to as the intrinsics-plus test (or roof-top)<sup>53</sup> (Fig. 5.178). This position demands the interosseous muscles (and to some extent the lumbricals) to move adjacent joints in opposite directions, creating a competition between movement at the MCP and IP joints.

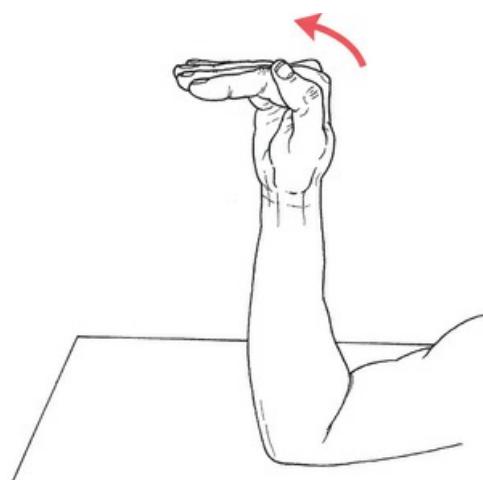


FIGURE 5.178

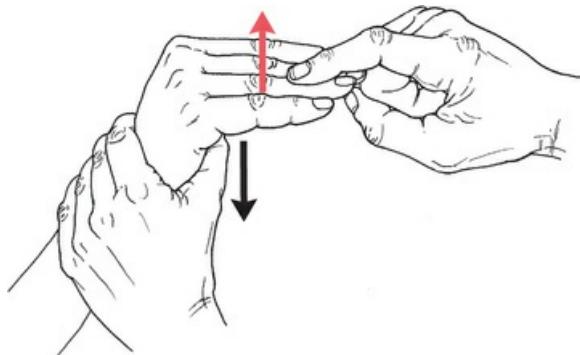
### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Short sitting or elbow flexed and resting on table with hand pointed up. Forearm in neutral. Hand relaxed.

#### Instructions to Therapist:

Sit in front or to the side of the patient. Demonstrate the intrinsic plus position (see Fig. 5.178) to patient and insist on practice to get the motions performed correctly and simultaneously. While stabilizing the metacarpals (dorsum of hand on the table) to maintain flexion of the MCP joints, ask the patient to lift the fingers so that IP joints are straight. This action tests the lumbricals of each finger. If this position can be achieved (Grade 3), apply appropriate resistance over each digit, one finger at a time, distal to the PIP joint (pushing down) (Fig. 5.179).



**FIGURE 5.179**

To test the MCP flexion part of the lumbrical function, the patient should be in the intrinsic plus position in fully pronated position. Stabilize the metacarpals. Give resistance on the palmar PIP, in the direction of extension ([Fig. 5.180](#)).



**FIGURE 5.180**

#### **Test:**

Patient simultaneously flexes the MCP joints and extends the IP joints (intrinsic plus position). Fingers may be tested separately if indicated ([see Fig. 5.179](#)). Do not allow fingers to curl; they must remain extended.

#### **Instructions to Patient:**

MCP joint portion: "Lift your fingers up. Hold them. Don't let me move your fingers."

IP portion: "Hold your fingers straight. Don't let me bend them."

#### **Grading (Both Movements Are Graded Together)**

##### **Grade 5 and Grade 4:**

Patient holds position against strong resistance. Resistance can be given to fingers individually because of the variant strength of the different interossei and lumbricals and because the interossei and lumbricals have different innervations.

##### **Grade 3:**

Patient completes both motions correctly and simultaneously without resistance.

##### **Grade 2, Grade 1, and Grade 0**

#### **Position of Patient:**

Forearm and wrist in mid position to remove influence of gravity. MCP joints are fully extended; all IP joints are flexed.

**Instructions to Therapist:**

Stabilize metacarpals.

**Test:**

Patient attempts to flex MCP joints through full available range while extending IP joints ([Fig. 5.181](#)).



**FIGURE 5.181**

**Instructions to Patient:**

"Try to straighten your fingers while keeping your knuckles bent." Demonstrate motion to patient and allow practice.

**Grading**

**Grade 2:**

Completes full range of motion in gravity-minimized position.

**Grade 1:**

Except in the hand that is markedly atrophied, the palmar interossei and lumbricals cannot be palpated. A grade of 1 is given for minimal motion.

**Grade 0:**

A grade of 0 is given in the absence of any discernable palpable contraction.

**Substitution**

The long finger flexors may substitute for the lumbricals. To avoid this pattern, make sure that the patient's interphalangeal joints fully extend.

**Helpful Hint**

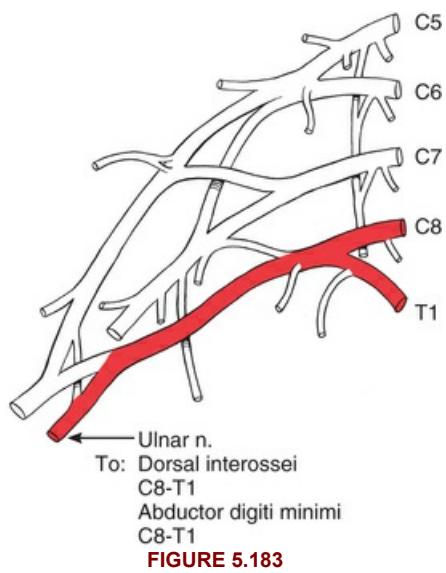
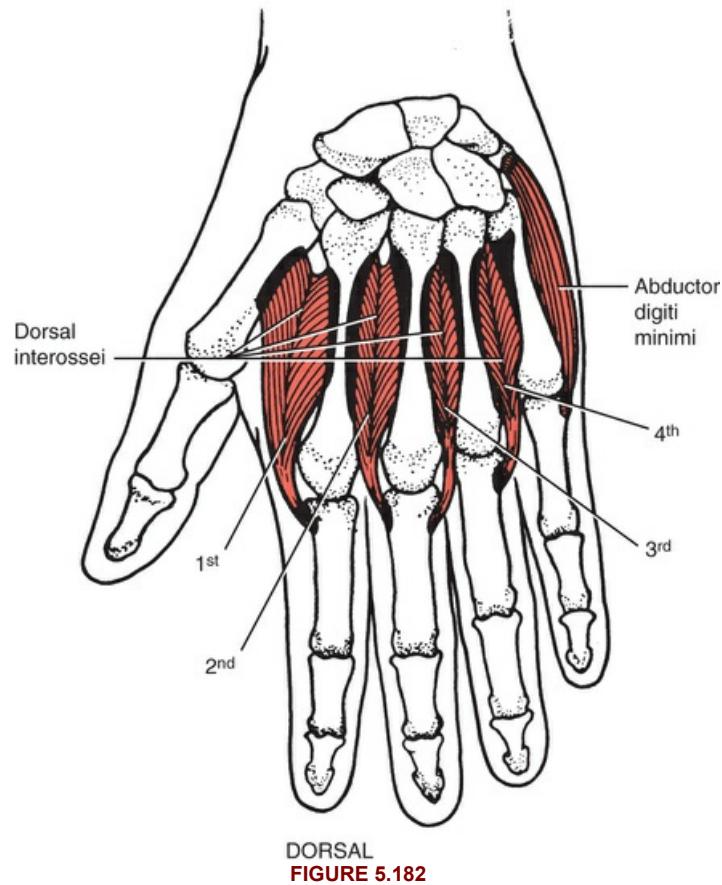
In the normal hand, the MCP and interphalangeal (IP) joints extend at the same time and also flex

at the same time. When attempting to flex the MCP joints and extend the IP joints simultaneously, it is increasingly difficult to maintain full IP extension at or near end-range of MCP joint flexion. The converse is also true: full MCP joint flexion is not possible if full IP joint extension is maintained.

- In most cases of early nerve palsy, weakness of the index and middle fingers is apparent when they are tested in the intrinsic-plus position.<sup>53</sup>

## Finger Abduction

(*Dorsal interossei*)



## Range of Motion

0°–20°

### Grade 5 and Grade 4

#### Position of Patient:

Forearm pronated, wrist in neutral. Fingers start in extension and adduction. MCP joints in neutral and avoid hyperextension.

#### Instructions to Therapist:

Sit at table or side of patient. Support the wrist in neutral. Ask the patient to spread the fingers. If full range is present (Grade 3), apply appropriate resistance. The fingers of the other hand are used to give resistance on the distal phalanx, on the radial side of the finger, and the ulnar side of the adjacent finger (i.e., they are squeezed together). The direction of resistance will cause any pair of fingers to approximate ([Fig. 5.184](#)).



FIGURE 5.184

#### Test:

Abduction of fingers (individual tests):

#### Dorsal Interossei:

- Abduction of ring finger toward little finger
- Abduction of middle finger toward ring finger
- Abduction of middle finger toward index finger
- Abduction of index finger toward thumb

The long (middle) finger (digit 3, finger 2) will move one way when tested with the index finger and the opposite way when tested with the ring finger (see [Fig. 5.182](#), which shows a dorsal

interosseous on either side). When testing the little finger with the ring finger, the abductor digiti minimi is being tested along with the fourth dorsal interosseous.

#### **Abductor Digiti Minimi:**

Patient abducts fifth digit away from ring finger.

#### **Instructions to Patient:**

"Hold your fingers apart. Don't let me push them together."

#### **Grading**

Neither the dorsal interossei nor the abductor digiti minimi will tolerate much resistance.

#### **Grade 5 and Grade 4:**

Patient holds test position against strong finger resistance. [Fig. 5.185](#) illustrates the test for second and fourth dorsal interossei. Alternatively, provide resistance for a Grade 5 test by flicking each finger toward adduction; if the finger tested rebounds, the grade is 5.



**FIGURE 5.185**

#### **Grade 3:**

Patient can abduct any given finger. Remember that the long finger has two dorsal interossei and therefore must be tested as it moves away from the midline in both directions ([Fig. 5.186](#)).

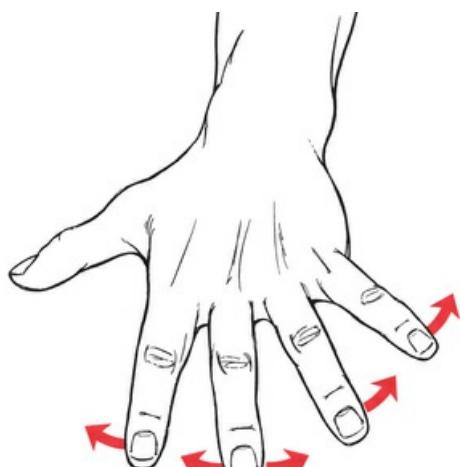


FIGURE 5.186

### Grade 2, Grade 1, and Grade 0

#### Procedures and Grading:

Same as for higher grades in this test. A Grade 2 should be assigned if the patient can complete only a partial range of abduction for any given finger. The only dorsal interosseous that is readily palpable is the first at the base of the proximal phalanx ([Fig. 5.187](#)).

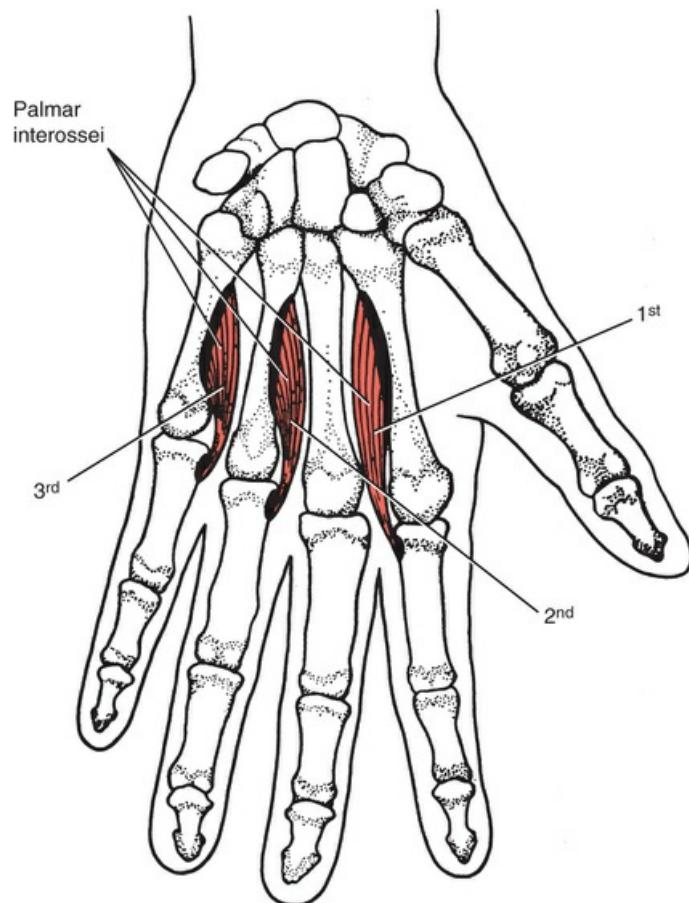


FIGURE 5.187

The abductor digiti minimi is palpable on the ulnar border of the hand.

## Finger Adduction

(*Palmar interossei*)



PALMAR  
FIGURE 5.188

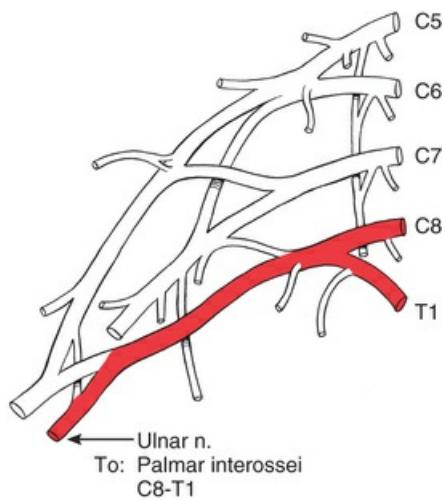


FIGURE 5.189

## Range of Motion

20°–0°

### Grade 5 and Grade 4

#### Position of Patient:

Forearm pronated (palm down), wrist in neutral, and fingers extended and adducted. MCP joints are neutral; avoid flexion.

#### Instructions to Therapist:

Sit at table or to side of patient. Ask the patient to hold the fingers together. If the patient is able (Grade 3) and resistance is appropriate, grasp the middle phalanx on each of two adjoining fingers ([Fig. 5.190](#)) and try to pull the finger in the direction of abduction for each finger tested. The therapist is trying to “pull” the fingers apart. Each finger should be resisted separately.



FIGURE 5.190

#### Test:

Adduction of fingers (individual tests):

- Adduction of little finger toward ring finger
- Adduction of ring finger toward long finger
- Adduction of index finger toward long finger
- Adduction of thumb toward index finger

Occasionally there is a fourth palmar interosseous (not illustrated in [Fig. 5.188](#)) that some consider a separate muscle from the adductor pollicis. In any event, the two muscles cannot be clinically separated.

Because the middle finger (also called the long finger, digit 3, or finger 2) has no palmar interosseous, it is not tested in adduction.

#### Instructions to Patient:

“Hold your fingers together. Don’t let me spread them apart.”

## Grading

### Grade 5 and Grade 4:

Patient holds test position against strong finger resistance. Distinguishing between Grades 5 and 4 is difficult and clinically, perhaps not important. The grade awarded will depend on the amount of the therapist's experience with normal hands.

### Grade 3:

Patient can adduct fingers toward middle finger (Fig. 5.191).



FIGURE 5.191

### Grade 2, Grade 1, and Grade 0

#### Procedures:

Same as for Grades 5, 4, and 3.

For Grade 2, the patient can adduct each of the fingers tested through a partial range of motion. The test for Grade 2 is begun with the fingers abducted.

Palpation of the palmar interossei is rarely feasible. By placing the therapist's finger against the side of a finger to be tested, the therapist may detect a slight outward motion for a muscle less than Grade 2.

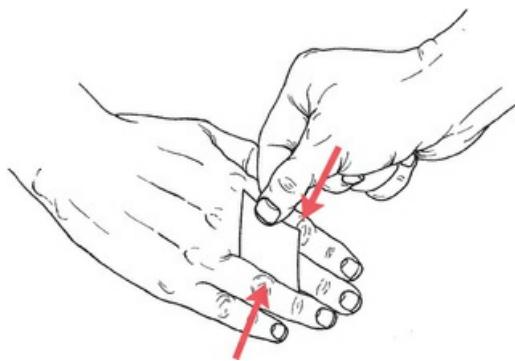


FIGURE 5.192

## **Substitution**

Caution must be used to ensure that finger flexion does not occur because the long finger flexors can contribute to adduction.

## **Helpful Hints**

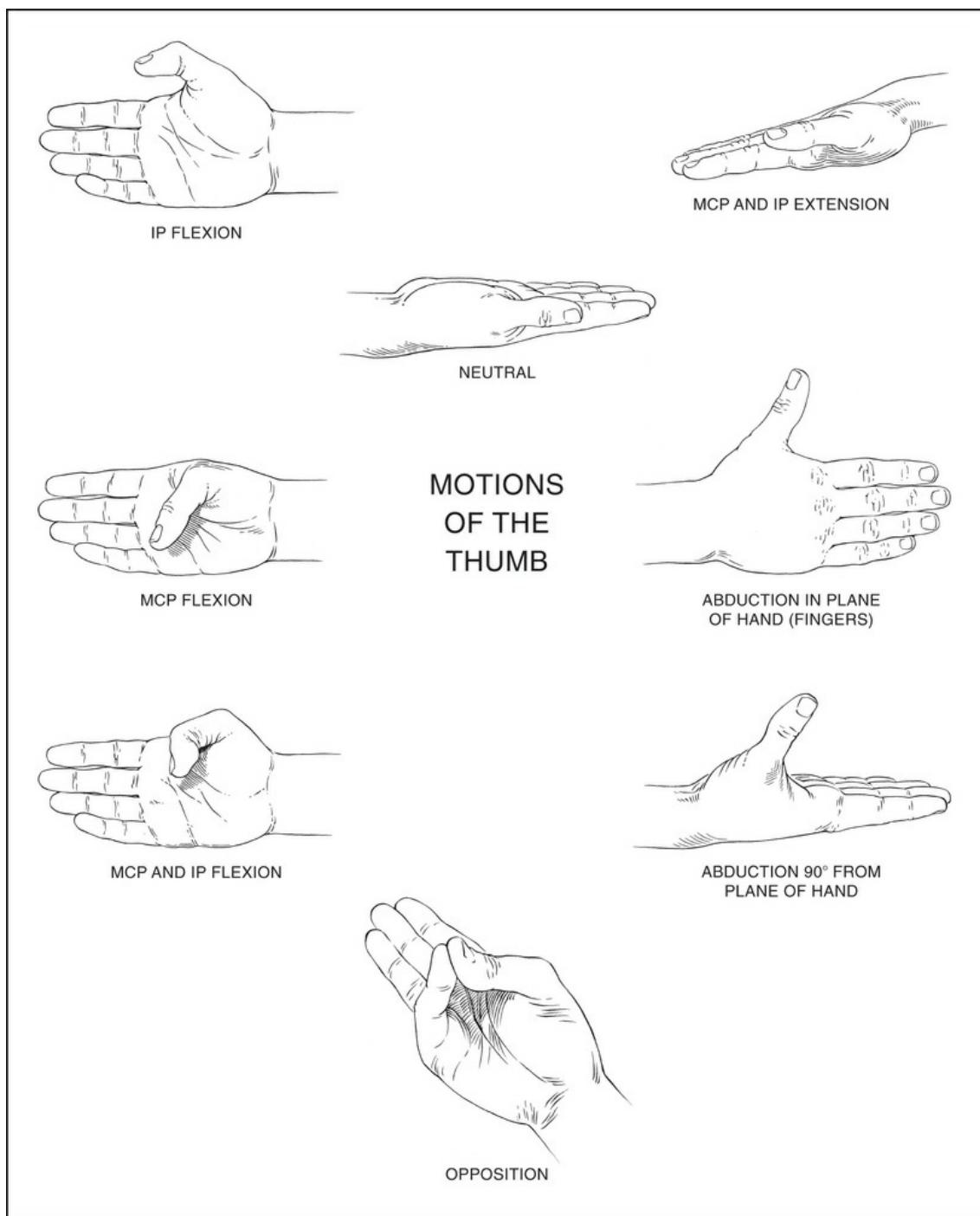
- The fingers can be assessed quickly by grasping the distal phalanx and flicking the finger in the direction of abduction. If the finger rebounds or snaps back, that interosseous is functional.
- A quick test for ulnar nerve integrity is to place a piece of paper between each finger and instruct the patient to not let the therapist pull the paper out from between the fingers ([Fig. 5.192](#)).

## **Thumb Muscles**

The thumb muscles are made up of three extrinsics and four intrinsics. Three of these muscles, the abductor pollicis brevis (APB), opponens pollicis (OP), and flexor pollicis brevis (FPB), form the fleshy mass at the radial border of the thumb. There are eight motions of the thumb ([Plate 5](#)), which are possible because of the medial and lateral rotation at its carpometacarpal (CMC) joint.<sup>57</sup> To fully understand the muscles of the thumb, the complex motions of the thumb must be understood. The thumb musculature dynamically allows for precision pinching and power gripping. Thumb stability is actively maintained by muscles rather than articular constraints.

The thenar intrinsics that medially rotate and oppose the thumb (APB, OP, and FPB) can be quickly assessed by asking the patient to touch the tip of the thumb to each of the pads of the fingers, so that thumb nail is parallel to the finger tips. It is important to palpate the thenar muscles to note an active contraction.

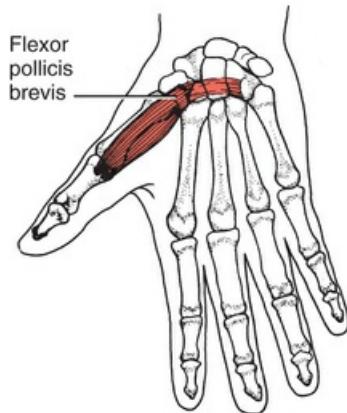
It is difficult to differentiate between Grade 5 and 4 in many of the small muscles of the hand, and may not be clinically relevant. Therefore, Grades 5 and 4 have been combined for some muscles. It takes experience and skill to discern weakness in the actively contracting hand muscle.



**PLATE 5** Motions of the thumb.

## Thumb MCP and IP Flexion

(*Flexor pollicis brevis* and *Flexor pollicis longus*)



PALMAR  
**FIGURE 5.193**

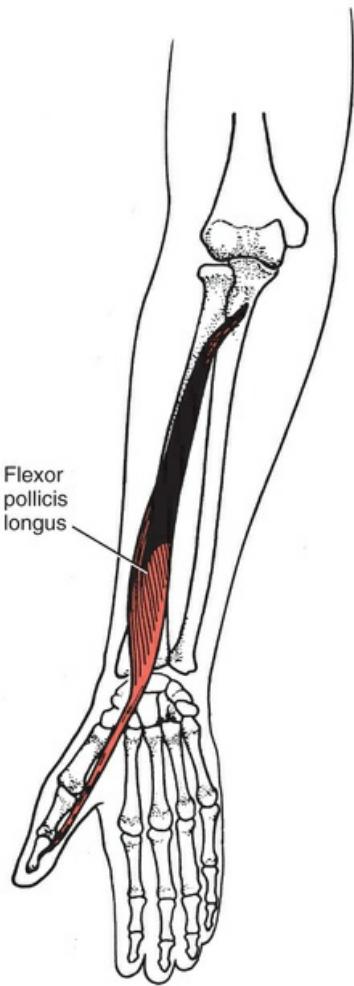


FIGURE 5.194

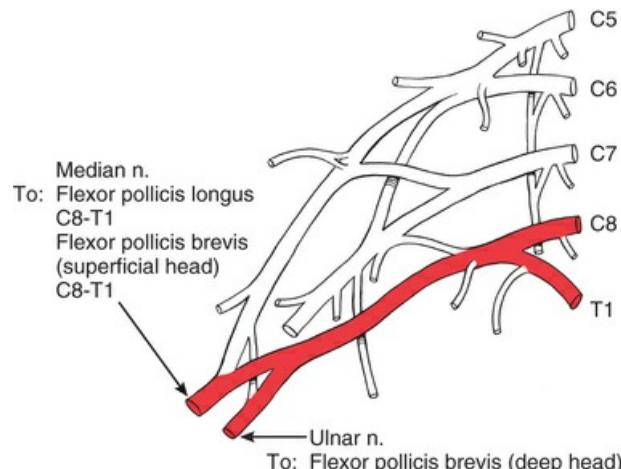
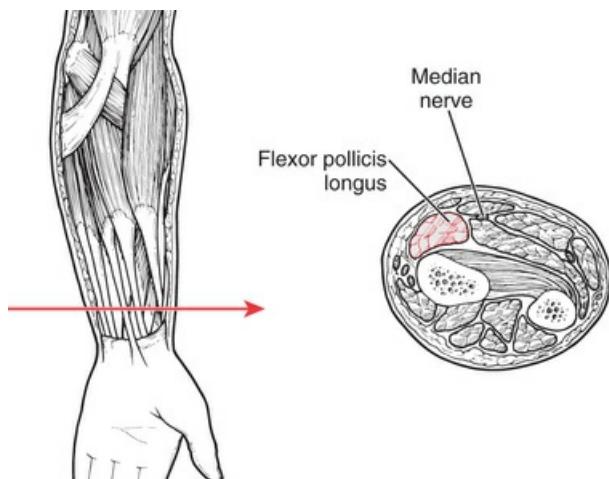


FIGURE 5.195



**FIGURE 5.196** Arrow indicates level of cross section.

## Range of Motion

MCP flexion: 0°–50°

IP flexion: 0°–80°

**Table 5.24**  
**THUMB MCP AND IP FLEXION**

L.D. Muscle	Origin	Insertion	Function
<i>MCP Flexion</i>			
170	Flexor pollicis brevis Superficial head (often blended with opponens pollicis)	Flexor retinaculum (distal) Trapezoid bone (tubercle, distal)	Thumb (base of proximal phalanx, radial side)
	<i>Deep head</i>	Trapezium bone Capitate bone Palmar ligaments of distal carpal bones	Flexion of the MCP and CMC joints of the thumb Opposition of thumb (assist)
<i>IP Flexion</i>			
169	Flexor pollicis longus	Radius (anterior surface of middle $\frac{1}{2}$ ) and adjacent interosseous membrane Ulna (coronoid process, lateral border [variable]) Humerus (medial epicondyle [variable])	Thumb (base of distal phalanx, palmar surface)
			Flexion of IP joint of thumb Flexion of the MCP and CMC joints of thumb (accessory) Flexion of wrist (accessory)

CMC, Carpometacarpal; IP, interphalangeal; MCP, metacarpophalangeal.

## Thumb MCP and IP Flexion

(*Flexor pollicis brevis*)

The FPB is an intrinsic muscle of the thumb. The innervation of the two heads can be variable, innervated by the median nerve, the ulnar nerve, or both.<sup>58</sup> The FPB and longus are implicated in texting motions.

### Grade 5 to Grade 0

**Position of Patient:**

Forearm in supination, wrist in neutral. Carpometacarpal (CMC) joint is at 0°; IP joint is at 0°. Thumb in adduction, lying relaxed and adjacent to the second metacarpal.

**Instructions to Therapist:**

Sit at table or to side of patient. Demonstrate thumb flexion and have patient practice the motion. Stabilize the first metacarpal firmly to avoid any wrist or CMC motion. Ask the patient to bend the thumb toward the palm, keeping the IP straight. If the motion can be accomplished (Grade 3), apply appropriate resistance with one-finger resistance to MCP flexion on the proximal phalanx in the direction of extension ([Fig. 5.197](#)).



**FIGURE 5.197**

**Test:**

Patient flexes the MCP joint of the thumb, keeping the IP joints straight (see [Fig. 5.197](#)).

**Instructions to Patient:**

"Don't bend the tip of the finger. Hold it. Don't let me pull it back."

### Grading

#### Grade 5 and Grade 4:

Can hold position against strong thumb resistance. Distinguishing between Grades 5 and 4 is difficult and clinically, perhaps not important. The grade awarded will depend on the amount of the therapist's experience with normal hands.

#### Grade 3:

Completes full range of motion.

#### Grade 2:

Cannot complete full range of motion.

#### Grade 1:

Palpate the muscle by initially locating the tendon of the flexor pollicis longus in the thenar eminence (Fig. 5.198). Then palpate the muscle belly of the FPB on the ulnar side of the longus tendon in the thenar eminence.



FIGURE 5.198

#### Grade 0:

No discernable palpable activity.

### Substitution by Flexor Pollicis Longus

- The long thumb flexor can substitute but only after flexion of the IP joint begins. To avoid this substitution, do not allow flexion of the distal joint of the thumb.
- Work-related thumb pain in physiotherapists is related to decreased stability and strength of the thumb.<sup>59</sup> This instability may result in the inability to maintain thumb extension during mobilization techniques, a frequent complaint of therapists.<sup>60</sup>

## Thumb IP Flexion

(*Flexor pollicis longus*)

### Grade 5 to Grade 0

#### Position of Patient:

Forearm supinated with wrist in neutral and MCP joint of thumb in extension.

#### Instructions to Therapist:

Sit at table or side of patient. Stabilize the MCP joint of the thumb firmly in extension by grasping the patient's thumb across that joint. Ask the patient to bend the tip of the thumb. If sufficient range is present (Grade 3), apply resistance with the tip of your finger against the palmar surface of the distal phalanx of the thumb in the direction of extension ([Fig. 5.199](#)).

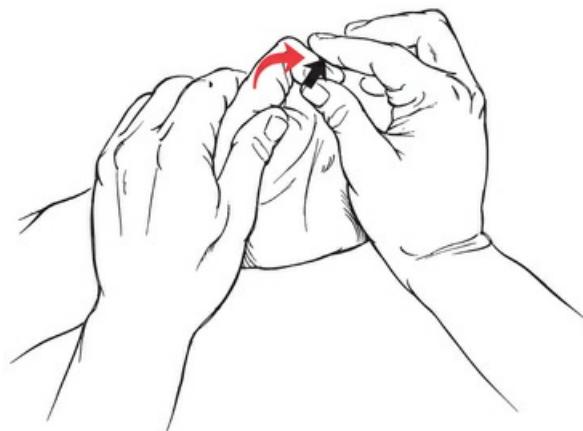


FIGURE 5.199

#### Test:

Patient flexes the IP joint of the thumb.

#### Instructions to Patient:

"Bend the end of your thumb. Hold it. Don't let me straighten it."

### Grading

#### Grade 5 and Grade 4:

Patient tolerates maximal finger resistance from therapist for Grade 5. This muscle is very strong, and a Grade 4 muscle will also tolerate strong resistance.

#### Grade 3:

Completes a full range of motion with minimal resistance because gravity is minimized.

#### Grade 2:

Holds test position.

#### Grade 1 and Grade 0:

Palpate the tendon of the flexor pollicis longus on the palmar surface of the proximal phalanx of the thumb. Palpable activity is graded 1; no discernable palpable activity is graded 0.

## **Substitution**

Do not allow the distal phalanx of the thumb to extend at the beginning of the test. If the distal phalanx is extended and then relaxes, the therapist may think active flexion has occurred.

## Thumb MCP and IP Extension

(*Extensor pollicis brevis* and *Extensor pollicis longus*)

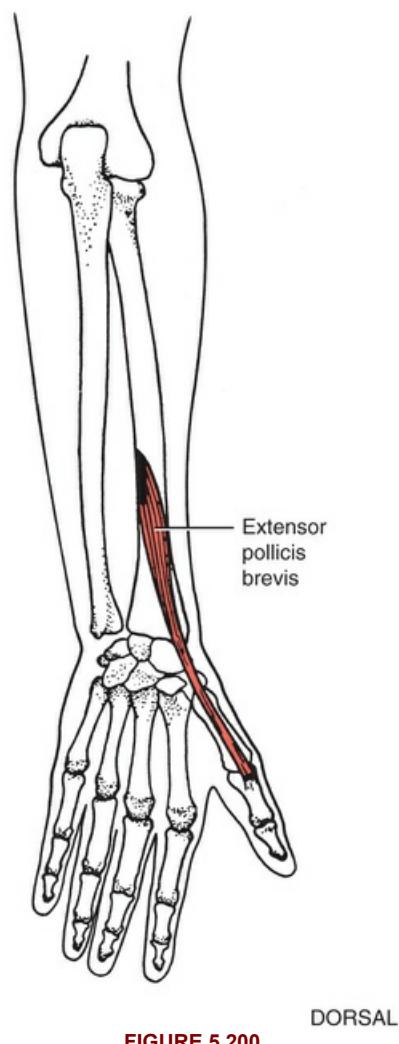


FIGURE 5.200

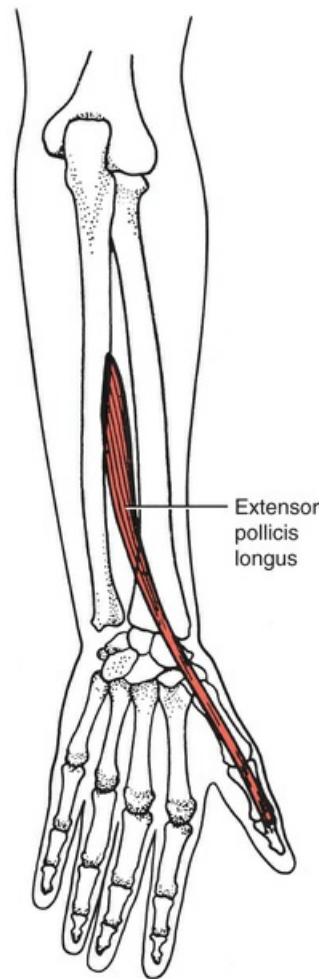


FIGURE 5.201

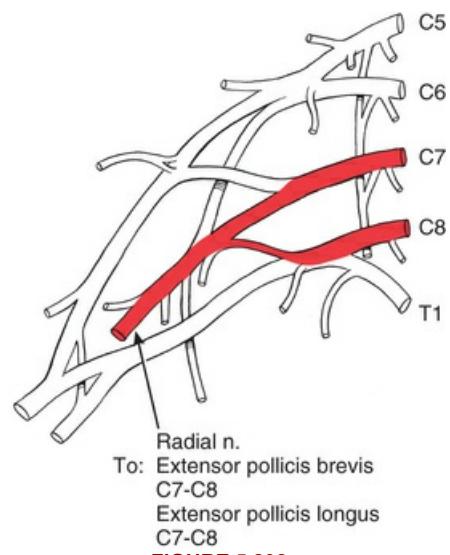
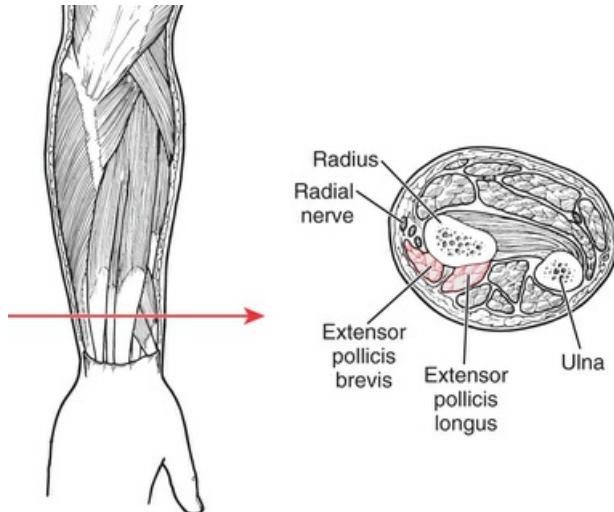


FIGURE 5.202



**FIGURE 5.203** Arrow indicates level of cross section.

## Range of Motion

MCP extension: 50°–0°

IP extension: 80°–0°

**Table 5.25**  
**THUMB MCP AND IP EXTENSION**

L.D. Muscle	Origin	Insertion	Function
<i>MCP Extension</i>			
168	Extensor pollicis brevis (radiomedial wall of "anatomical snuffbox")	Radius (posterior surface) Adjacent interosseous membrane	Extension of MCP joint of thumb Extension and abduction of 1st CMC joint of thumb Radial deviation of wrist (accessory)
<i>IP Extension</i>			
167	Extensor pollicis longus (ulnar wall of "anatomical snuffbox")	Ulna (shaft, middle $\frac{1}{3}$ on posterior-lateral surface) Adjacent interosseous membrane	Extension of the thumb at all joints: Distal phalanx (alone) MCP and CMC joints (along with extensor pollicis brevis and abductor pollicis longus) Radial deviation of wrist (accessory)

CMC, Carpometacarpal; IP, interphalangeal; MCP, metacarpophalangeal.

## Thumb MCP and IP Extension

(*Extensor pollicis brevis and Extensor pollicis longus*)

The extensor pollicis brevis (EPB) is a muscle with common variations that often blends with the extensor pollicis longus (EPL); therefore it is not possible to separate the brevis from the longus by clinical tests, and the test for the longus prevails. The EPL and EPB with the abductor pollicis longus form the borders of the anatomical snuff box. The snuff box is most visible with thumb extension.

### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Forearm in mid position, wrist in neutral with ulnar side of hand resting on the table. Thumb relaxed in a flexion posture.

#### Instructions to Therapist:

Sit or stand near the patient. Use the table to support the hand. Ask patient to lift just the thumb. If full range is present (Grade 3), apply the appropriate resistance over the dorsal surface of the distal phalanx of the thumb in the direction of flexion (Fig. 5.204).



FIGURE 5.204

#### Test:

Patient lifts the thumb from the table, extending the IP joint of the thumb.

#### Instructions to Patient:

"Hold it. Don't let me push it down."

### Grading

#### Grade 5 and Grade 4:

This is not a strong muscle, so resistance must be applied accordingly. The distinction between Grades 5 and 4 is based on comparison with the contralateral normal hand and, barring that, extensive experience in testing the hand.

#### Grade 3:

Completes full range of motion without resistance.

### Grade 2, Grade 1, and Grade 0

#### Position of Patient:

Forearm in pronation with wrist in neutral and thumb in relaxed flexion posture to start.

**Instructions to Therapist:**

Stabilize the wrist over its dorsal surface. Stabilize the fingers by gently placing the other hand across the fingers just below the MCP joints ([Fig. 5.205](#)).



**FIGURE 5.205**

**Test:**

Patient extends distal joint of the thumb (see [Fig. 5.205](#)).

**Instructions to Patient:**

“Straighten the end of your thumb.”

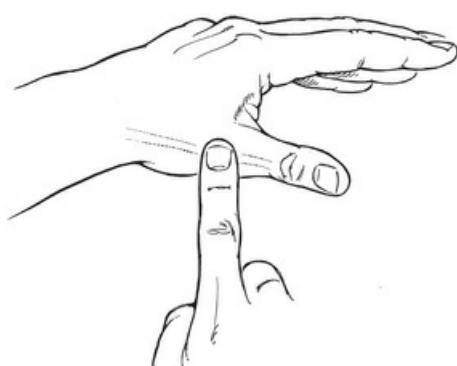
**Grading**

**Grade 2:**

Thumb completes range of motion.

**Grade 1:**

Palpate the tendon of the extensor pollicis longus on the ulnar side of the “anatomical snuffbox” or, alternatively, on the dorsal surface of the proximal phalanx ([Fig. 5.206](#)).



**FIGURE 5.206**

**Grade 0:**

No discernable palpable contractile activity.

## Substitution

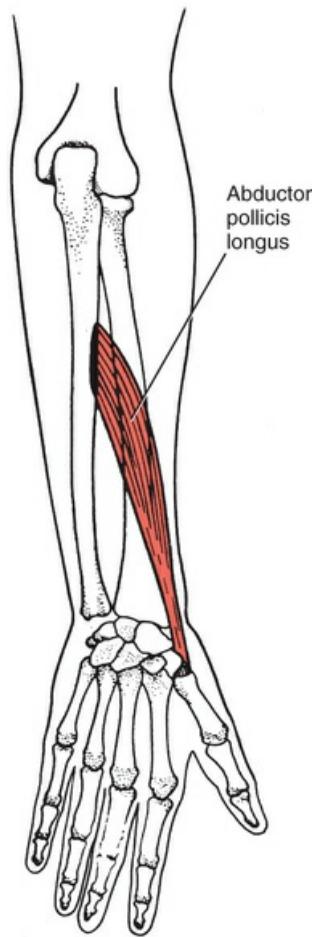
The muscles of the thenar eminence (abductor pollicis brevis (APB), flexor pollicis brevis (FPB), and adductor pollicis (AP) can extend the interphalangeal joint by flexing the carpometacarpal joint (an extensor tenodesis).

## Helpful Hints

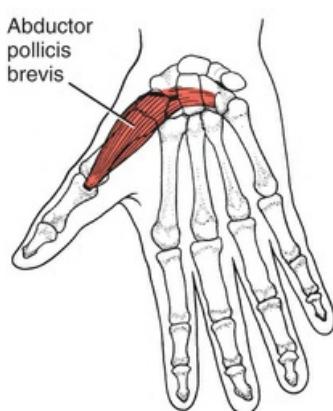
- A quick way to assess the functional status of the long thumb extensor is to flick the distal phalanx into flexion; if the finger rebounds or snaps back, it is a useful muscle.
- The trapeziometacarpal (TMC) joint is the most common site of symptomatic osteoarthritis in the hand, with radiographic prevalence of 7% for men and 15% for women over age,<sup>30,61</sup> reaching 90% in both men and women at 80 years of age.<sup>62</sup>
- TMC arthritis leads to a loss of abduction-adduction in the TMC joint and at the MCP joint and often reduces pronation-supination.<sup>63</sup>
- TMC pain affects the ability to open jars (grasp) and turn keys (pinch).
- Resisted thumb extension that reproduced the patients' pain had a sensitivity of 0.94 and specificity of 0.95 for trapeziocarpal (TMC) arthritis. A positive test of either adduction or extension movements yielded a sensitivity of 1.00 and specificity of 0.91 for TMC arthritis.<sup>62</sup>
- The dorsal radial ligament is the prime opposer of TMC translation, and is also mechanically robust, anatomically thick, and well innervated.<sup>64</sup>

## Thumb Abduction

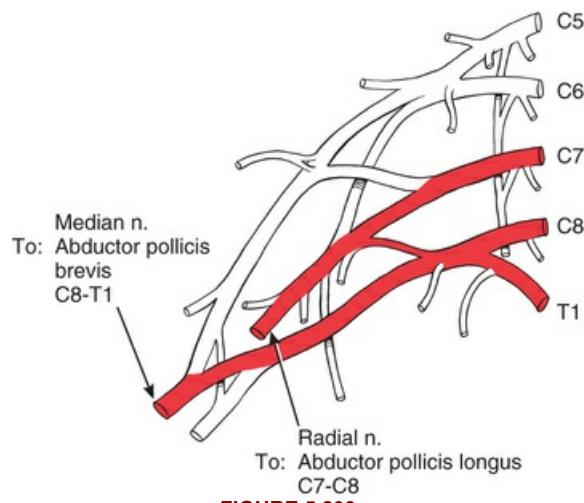
(*Abductor pollicis longus and Abductor pollicis brevis*)



DORSAL  
FIGURE 5.207



PALMAR  
FIGURE 5.208



**FIGURE 5.209**

## Range of Motion

0°–70°

**Table 5.26**

### THUMB ABDUCTION

I.D.	Muscle	Origin	Insertion	Function
166	Abductor pollicis longus (radiolateral wall of "anatomical snuffbox")	Ulna (posterior surface laterally) Radius (shaft, middle of posterior aspect) Interosseous membrane	Thumb: 1st metacarpal (radial side of base) Trapezium bone	Abduction of thumb at carpometacarpal (CMC) joint Extension of thumb at interphalangeal (IP) joint (in concert with thumb extensors) Radial deviation of wrist (assist)
171	Abductor pollicis brevis	Flexor retinaculum Scaphoid bone (tubercle) Trapezium bone (tubercle) Tendon of abductor pollicis longus	Medial fibers: Thumb (base of proximal phalanx, radial side) Lateral fibers: Extensor expansion of thumb	Abduction of thumb CMC and metacarpophalangeal (MCP) joints (in a plane 90° from the palm) Opposition of thumb (assist) Extension of IP joint (assist)
<b>Others</b>				
152	Palmaris longus (if present)			
168	Extensor pollicis brevis	See Table 5.25		

## Thumb Abduction

The palmaris longus can abduct the thumb, if present.<sup>65</sup>

### Abductor Pollicis Longus

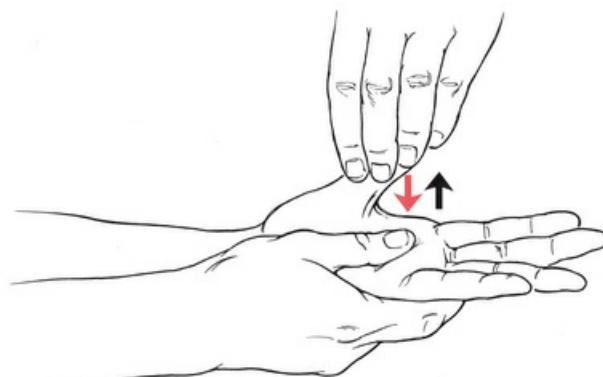
#### Grade 5 to Grade 0

##### Position of Patient:

Forearm supinated and wrist in neutral; thumb relaxed in adduction.

##### Instructions to Therapist:

Sit or stand near the patient. Demonstrate the movement. Then stabilize the metacarpals of the four fingers and the wrist. Ask the patient to lift the thumb straight up to 90° from the palm. If full range of motion is present (Grade 3), then apply appropriate resistance on the **distal** end of the first metacarpal in the direction of adduction ([Fig. 5.210](#)).



**FIGURE 5.210**

##### Test:

Patient abducts the thumb away from the hand in a plane parallel to the finger metacarpals.

##### Instructions to Patient:

"Lift your thumb straight up."

### Grading

#### Grade 5 and Grade 4:

Can hold against strong resistance. Distinguishing Grades 5 and 4 may be difficult.

#### Grade 3:

Completes full range of motion without resistance.

#### Grade 2:

Completes partial range of motion.

#### Grade 1:

Palpate tendon of the abductor pollicis longus at the base of the first metacarpal on the radial side of the extensor pollicis brevis ([Fig. 5.211](#)). It is the most lateral tendon at the wrist.

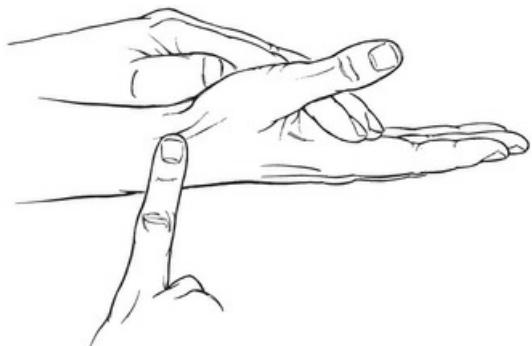


FIGURE 5.211

#### Grade 0:

No discernable palpable contractile activity.

### Substitution

The extensor pollicis brevis can substitute for the abductor pollicis longus. If the line of pull is toward the dorsal surface of the forearm (extensor pollicis brevis), substitution is occurring.

### Helpful Hints

- If the abductor pollicis longus is stronger than the brevis, the thumb will deviate toward the radial side of the hand.
- If the abductor pollicis brevis is stronger, deviation will be toward the ulnar side.
- De Quervain's tenosynovitis, affecting the abductor pollicis longus and extensor pollicis brevis tendons, is indicated by the Finkelstein Test. To perform this test, ask the patient to close the fingers around the thumb so the thumb is tucked into the palm. Then ask the patient to ulnarily deviate the wrist. If pain is on the thumb side of the wrist, the test is positive. The condition has been linked to texting more than 50 messages/day.<sup>66,67</sup> Can also be referred to as "Gamer's thumb."

## **Thumb Abduction**

### **Abductor Pollicis Brevis**

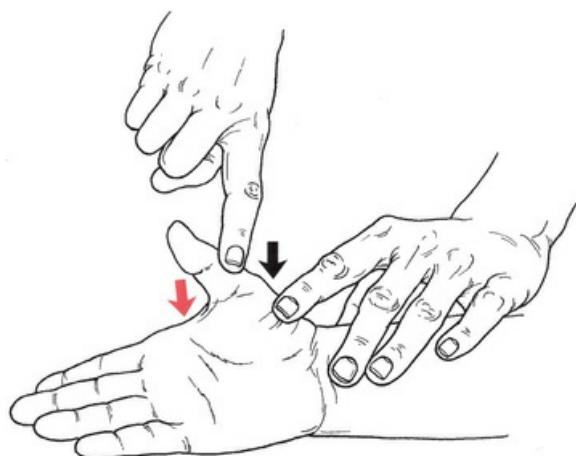
#### **Grade 5, Grade 4, and Grade 3**

##### **Position of Patient:**

Dorsum of hand is on table with forearm in supination, wrist in neutral, and thumb relaxed in adduction.

##### **Instructions to Therapist:**

Sit or stand near the patient. Demonstrate the movement. Ask the patient to lift the thumb to point towards the ceiling. If full range is present (Grade 3), apply appropriate resistance with index finger to the lateral aspect of the proximal phalanx of the thumb in the direction of adduction ([Fig. 5.212](#)).



**FIGURE 5.212**

##### **Test:**

Patient abducts the thumb in a plane perpendicular to the palm. Observe wrinkling of the skin over the thenar eminence.

##### **Instructions to Patient:**

"Lift your thumb vertically until it points to the ceiling." Demonstrate motion to the patient.

## **Grading**

### **Grade 5:**

Holds motion with maximal finger resistance.

### **Grade 4:**

Tolerates moderate resistance.

### **Grade 3:**

Completes full range of motion without resistance.

#### **Grade 2, Grade 1, and Grade 0**

##### **Position of Patient:**

Forearm in mid position, wrist in neutral, and thumb relaxed in adduction.

**Instructions to Therapist:**

Stabilize wrist in neutral.

**Test:**

Patient abducts thumb in a plane perpendicular to the palm.

**Instructions to Patient:**

"Try to lift your thumb so it points at the ceiling."

**Grading**

**Grade 2:**

Completes partial range of motion.

**Grade 1:**

Palpate the belly of the APB in the center of the thenar eminence, medial to the OPP ([Fig. 5.213](#)).



**FIGURE 5.213**

**Grade 0:**

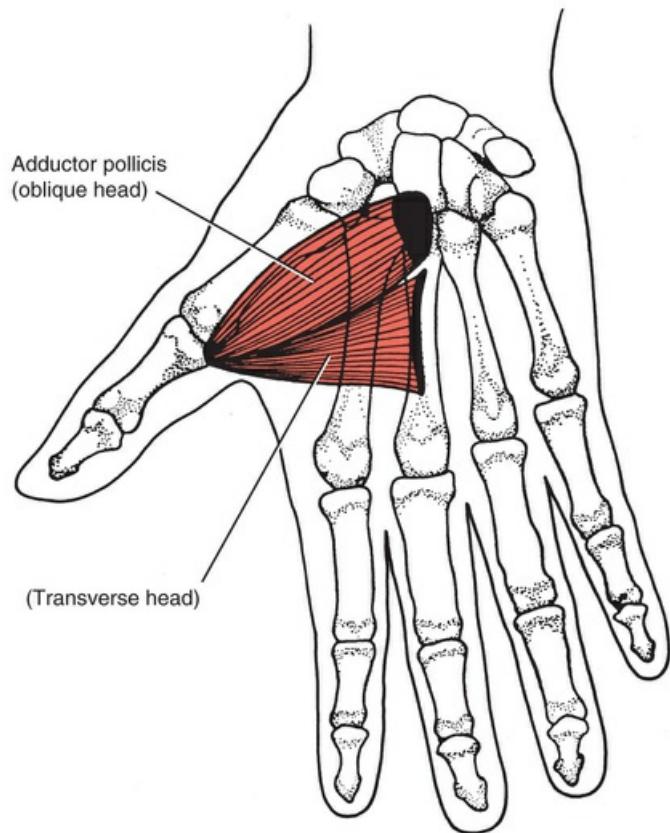
No discernable palpable contractile activity.

**Substitution**

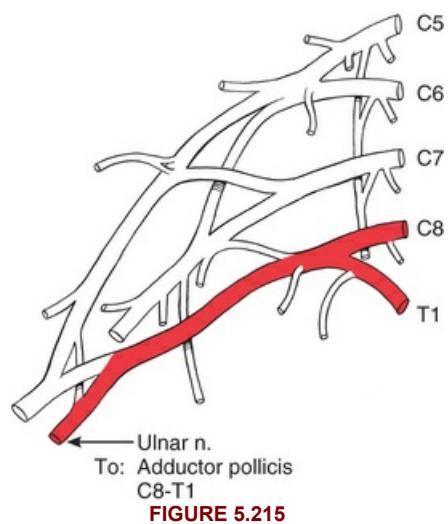
If the plane of motion is not perpendicular, but toward the radial side of the hand, the substitution may be by the abductor pollicis longus.

## Thumb Adduction

(*Adductor pollicis*)



PALMAR  
**FIGURE 5.214**



To: *Adductor pollicis*  
C8-T1  
**FIGURE 5.215**

## Range of Motion

70°–0°

**Table 5.27**

### THUMB ADDUCTION

I.D.	Muscle	Origin	Insertion	Function
173	Adductor pollicis		Thumb (proximal phalanx, ulnar side of base)	Adduction of carpometacarpal (CMC) joint of thumb (approximates the thumb to the palm) Adduction and flexion of metacarpophalangeal (MCP) joint (assist)
	Oblique head	Capitate bone 2nd and 3rd metacarpals (bases) Palmar ligaments of carpal bones Sheath of tendon of flexor carpi radialis		
	Transverse head	3rd metacarpal bone (palmar surface of distal $\frac{2}{3}$ )		

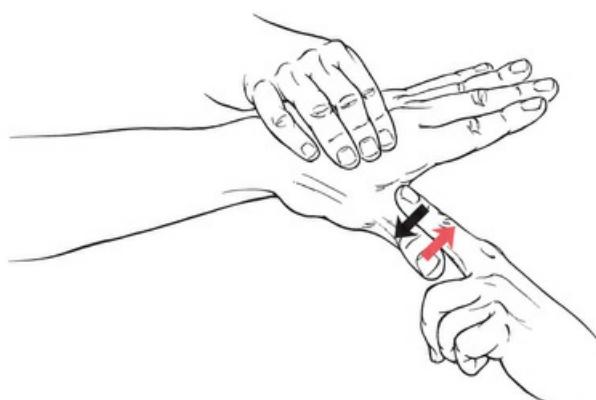
### Grade 5, Grade 4, and Grade 3

#### Position of Patient:

Forearm in pronation, wrist in neutral, and thumb relaxed and hanging down in abduction.

#### Instructions to Therapist:

Sit or stand near the patient. Demonstrate the movement. Stabilize the metacarpals of the four fingers by grasping the patient's hand around the ulnar side. If full range is present (Grade 3), apply appropriate resistance on the medial side of the proximal phalanx of the thumb in the direction of abduction (Fig. 5.216). Do not allow ulnar deviation. Alternatively, place a sheet of paper between the thumb and the index finger (adduction) and ask the patient to hold it while the therapist tries to pull the paper away. This is strong movement and the patient should be able to hold a paper without difficulty.



**FIGURE 5.216**

#### Test:

Patient adducts the thumb by bringing the first metacarpal up to the second metacarpal.

#### Instructions to Patient:

"Bring your thumb up to your index finger." OR "Hold the paper. Don't let me pull it out."

### Grading

#### **Grade 5 and Grade 4:**

Holds test position against strong resistance. Patient can resist rigidly (Grade 5), or the muscle yields (Grade 4).

#### **Grade 3:**

Completes full range of motion without resistance.

#### **Grade 2 and Grade 1**

##### **Position of Patient:**

Forearm in mid position, wrist in neutral resting on table, and thumb in abduction.

##### **Instructions to Therapist:**

Stabilize wrist on the table, and use a hand to stabilize the finger metacarpals ([Fig. 5.217](#)).



**FIGURE 5.217**

##### **Test:**

Patient moves thumb horizontally in adduction. The end position is shown in [Fig. 5.217](#).

##### **Instructions to Patient:**

"Return your thumb to its place next to your index finger." Demonstrate motion to patient.

#### **Grading**

#### **Grade 2:**

Completes full range of motion.

#### **Grade 1:**

Palpate the adductor pollicis on the palmar side of the web space of the thumb by grasping the web between the index finger and thumb ([Fig. 5.218](#)). The adductor lies between the first dorsal interosseous and the first metacarpal bone. This muscle is difficult to palpate, and the therapist may have to ask the patient to perform a palmar pinch to assist in its location.

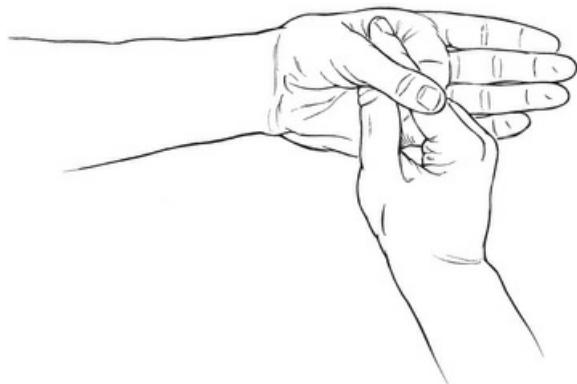


FIGURE 5.218



FIGURE 5.219

## Substitutions

- A positive Froment's sign indicates the lack of strength of the adductor pollicis when the motor branch of the ulnar nerve is affected. The patient will use the flexor pollicis longus for pinch grip which will result in obvious bending of the interphalangeal joint of the thumb (Fig. 5.219).
- The extensor pollicis longus may attempt to substitute for the adductor pollicis, in which case the carpometacarpal joint will extend (not shown).

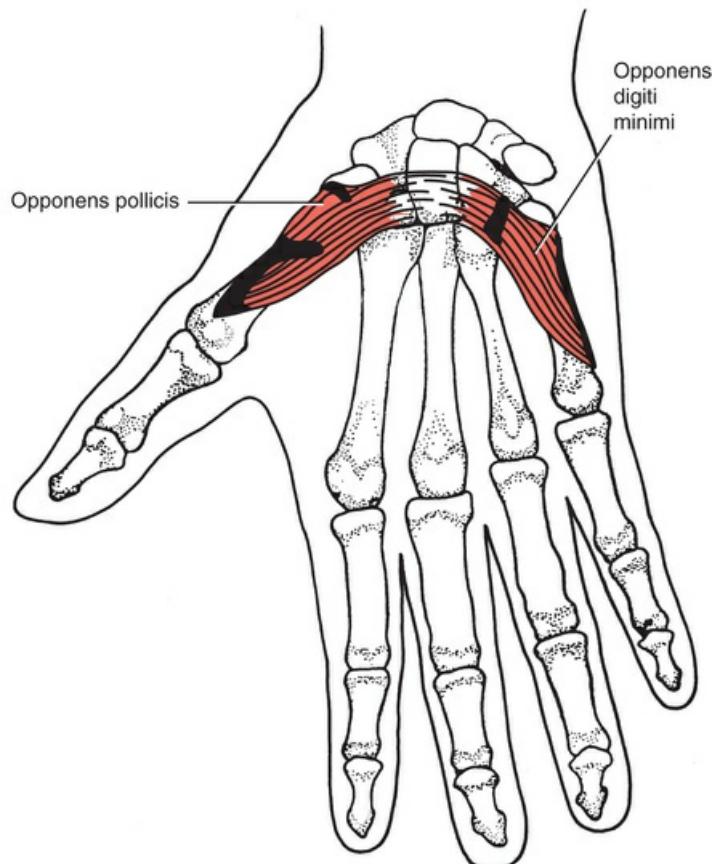
## Helpful Hints

- Resisted thumb adduction that reproduces the patient's pain had a sensitivity of 0.94 and specificity of 0.93 for trapeziometacarpal (TMC) arthritis. A positive test of either thumb adduction or thumb extension yielded a sensitivity of 1.00 and specificity of 0.91 for TMC arthritis.<sup>62</sup>
- The tip pinch (index finger to thumb) is the functional task that is most compromised in people with MCP osteoarthritis.<sup>68</sup>



## Opposition (Thumb to Little Finger)

(*Opponens pollicis* and *Opponens digiti minimi*)



PALMAR  
FIGURE 5.220

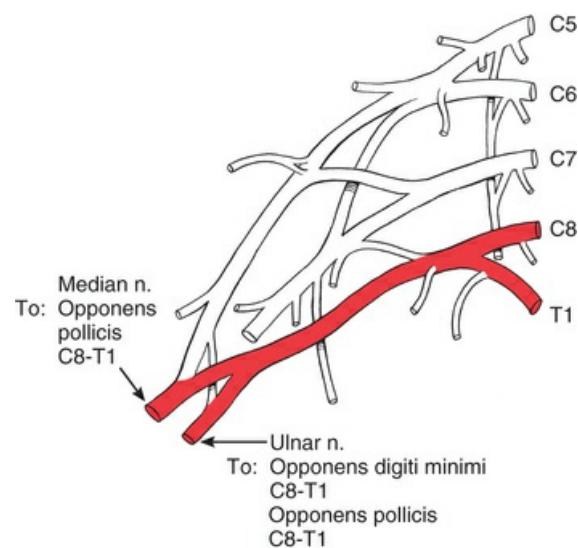


FIGURE 5.221

## Range of Motion

Pad of thumb to pad of fifth digit

**Table 5.28**  
**OPOSITION (THUMB TO LITTLE FINGER)**

L.D.	Muscle	Origin	Insertion	Function
172	Opponens pollicis	Trapezium bone (tubercle) Flexor retinaculum	1st metacarpal (entire length of lateral border and adjoining lateral half of palmar surface)	Flexion of carpometacarpal (CMC) joint medially across the palm Medial rotation of CMC joint
161	Opponens digiti minimi	Hamate (hook) Flexor retinaculum	5th metacarpal (whole length of ulnar margin and adjacent palmar surface)	
Others				
171	Abductor pollicis brevis	See <a href="#">Table 5.26</a>		
170	Flexor pollicis brevis	See <a href="#">Table 5.24</a>		

This motion is a combination of abduction, flexion, and medial rotation of the thumb. The two muscles in thumb-to-fifth-digit opposition (opponens pollicis and opponens digiti minimi) should be graded separately.

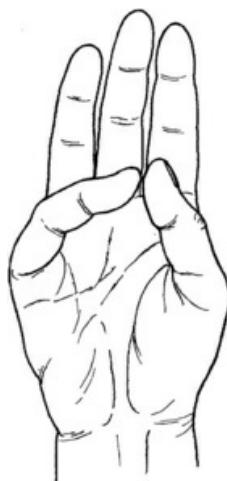
### Grade 5 to Grade 0

#### Position of Patient:

Forearm is supinated and supported on table, wrist in neutral, and thumb in adduction with MCP and IP flexion.

#### Instructions to Therapist:

Sit or stand near patient. Ask patient to bring the thumb and little finger together (Grade 3) ([Fig. 5.222](#)). The table provides stabilization of the hand. Both thumb and fifth digits should be observed individually. If full range is present in each movement (Grade 3), apply appropriate finger resistance at CMP joint of thumb and digit to test both actions simultaneously [Fig. 5.223](#).



**FIGURE 5.222**

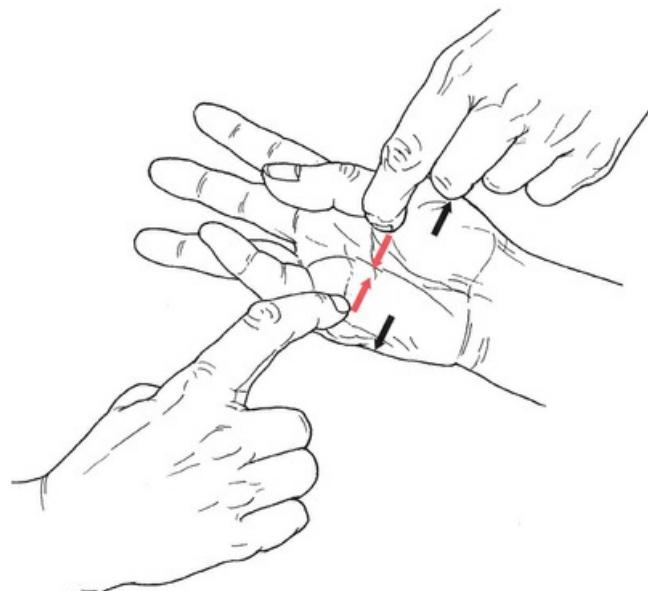


FIGURE 5.223

**Opponens Pollicis:**

Apply resistance for the opponens pollicis (OP) at the head of the 1st metacarpal in the direction of lateral rotation, extension, and adduction ([Fig. 5.224](#)).



FIGURE 5.224

**Opponens Digitii Minimi:**

Give resistance for the opponens digitii minimi on the palmar surface of the 5th metacarpal in the direction of medial rotation (flattening the palm) ([Fig. 5.225](#)).



FIGURE 5.225

**Test:**

Patient approximates the pad of the thumb and pad of fifth digit (see Fig. 5.222). Such apposition must be pad to pad and not tip to tip. Opposition also can be evaluated by asking the patient to hold an object between the thumb and little finger (in opposition), which the therapist tries to pull it away.

**Instructions to Patient:**

"Bring your thumb to your little finger and touch the two pads, forming the letter 'O' with your thumb and little finger." Demonstrate motion to the patient and require practice.

**Grading**

**Grade 5:**

Holds against maximal thumb resistance.

**Grade 4:**

Holds against moderate resistance.

**Grade 3:**

Moves thumb and fifth digit through full range of opposition without resistance.

**Grade 2:**

Moves through range of opposition. (The two opponens muscles are evaluated separately.)

**Grade 1:**

Palpate the OP along the radial shaft of the 1st metacarpal (Fig. 5.226). It lies lateral to the APB. During Grades 5 and 4 contractions, the therapist will have difficulty in palpating the OP because of nearby muscles. In Grade 3 muscles and below, the weaker contractions do not obscure palpation.

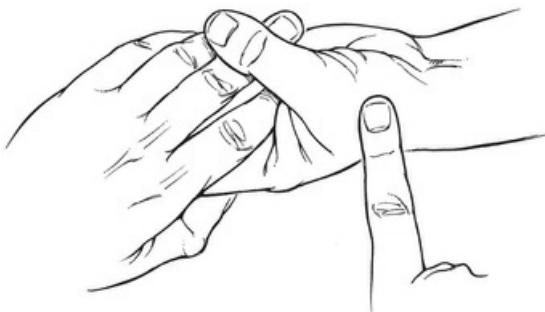


FIGURE 5.226

Palpate the opponens digiti minimi on the hypothenar eminence on the radial side of the fifth metacarpal (Fig. 5.227). The therapist should be careful not to cover the muscle with the finger or thumb used for palpation lest any contractile activity be missed.



FIGURE 5.227

#### Grade 0:

No discernable palpable contractile activity.

### Substitutions

- The flexor pollicis longus and the flexor pollicis brevis can draw the thumb across the palm toward the little finger. If such motion occurs in the plane of the palm, it is not opposition; contact will be at the tips, not the pads, of the digits.
- The abductor pollicis brevis may substitute, but the rotation component of the motion will not be present.

### Helpful Hints

The muscles involved in opening a 66-mm diameter jar lid are the flexor pollicis longus, flexor pollicis brevis, abductor pollicis brevis, adductor pollicis and opponens pollicis.<sup>69</sup>

Pinch strength, especially key pinch is less in patients with early thumb CMC arthritis.<sup>70</sup>



## Grip Strength

Grip strength is an efficient way to measure the composite strength of the hand and wrist, but grip strength is also related to general health and age. For example, grip strength peaks at 20 to 40 years and declines thereafter with advancing age.<sup>71,72</sup> In the older adult, grip strength has been shown to be a reliable predictor of mortality.<sup>73</sup> In many clinics, grip strength is used as a general indicator of total body strength.<sup>74,75</sup>

### Position of Patient:

Seated erect with shoulders level and neutrally rotated. The elbow is flexed to 90°, forearm in neutral and wrist between 0° and 30° of extension (Fig. 5.228A).<sup>71</sup>

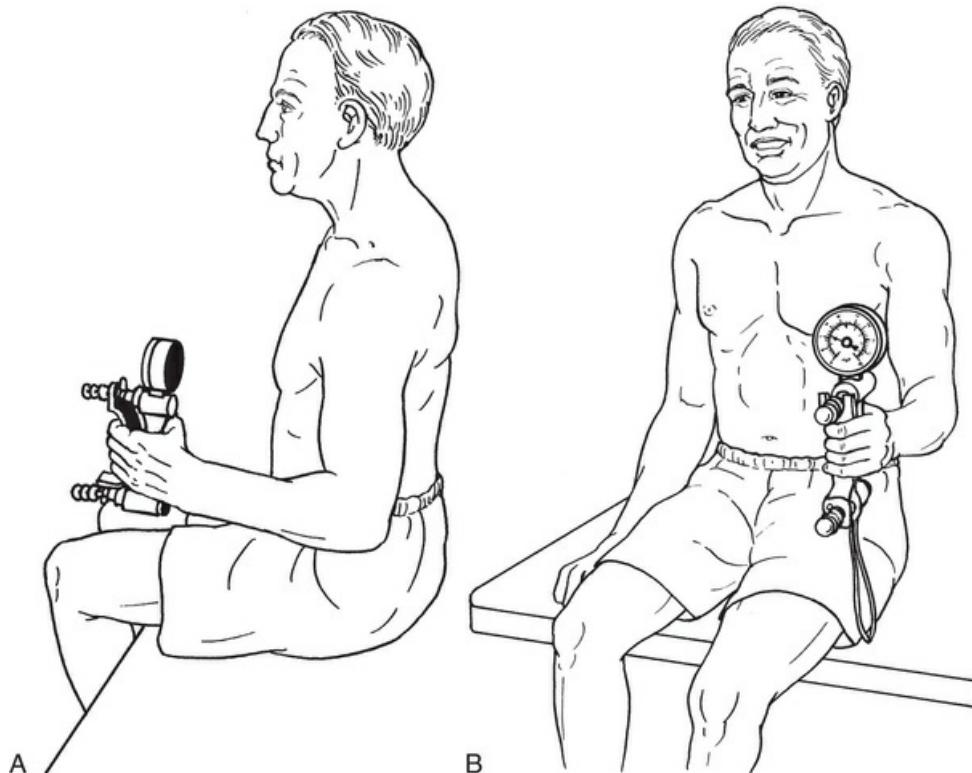


FIGURE 5.228A AND B

### Instructions to Therapist:

Both hands are tested, one at a time. Record which hand is dominant as it will be most often stronger. Stand in front of the patient to be able to see the dial. Place the dynamometer in the patient's hand with the dial facing away from patient (see Fig. 5.228B). Adjust the position of the dynamometer handle so that the patient's fingers can comfortably grasp and squeeze it. Most often this is in the second position. Repeat three times. Alternate hands with each trial.

### Instructions to Patient:

"When I say go, squeeze as hard as you can, in a smooth manner. Do not jerk the tool while you are gripping. Stop immediately if you experience any unusual pain or discomfort." See Fig. 5.228.

### Scoring

Three trials are recorded for each hand, averaging the three for the final score. Scores are compared with the appropriate age and sex categories for accurate interpretation (see Tables 5.28 and 5.29).<sup>74</sup>

## Helpful Hints

- Grip strength of 9 kg (20 pounds) is commonly considered functional and is necessary to perform most daily activities.<sup>72</sup> A maximal grip strength of 5 kg (11 pounds) was found to be associated with a high risk of death in elderly women admitted to geriatric wards after acute illness.<sup>73,74</sup>
- A possible explanation for the relationship between weak grip strength and mortality is the fact that grip strength seems to be an indicator of nutritional status.<sup>75</sup> Protein deficiency may result in generalized muscle weakness and decreased cell-mediated immunity. Thus, severe weakness of grip may identify older patients at risk for dying as a result of protein malnutrition.<sup>75</sup>
- Grip strength is correlated significantly with upper limb function in older adults and in people with certain disorders, but not in young, healthy patients.<sup>76,77</sup>
- Grip strength is affected by certain disorders that impair results, such as carpal tunnel syndrome, lateral epicondylitis, dementia, arthritis, and stroke.
- The interossei can be tested by hand grip using a hand-grip dynamometer. Use the smallest distance between handle positions because the intrinsics are most active in this position.<sup>78</sup>
- The average decrease in grip strength after an ulnar nerve block is 38%.<sup>79</sup>

**Table 5.29**  
**MEAN NORMATIVE HAND GRIP STRENGTH (KG)<sup>80</sup>**

Age	MEN			WOMEN		
	Right	Left	BMI	Right	Left	BMI
20–29	47 (9.5)	45 (8.8)	26.4 (5.1)	30 (7)	28 (6.1)	25.1 (5.8)
30–39	47 (9.7)	47 (9.8)	28.3 (5.2)	31 (6.4)	29 (6)	27.3 (6.8)
40–49	47 (9.5)	45 (9.3)	28.4 (4.6)	29 (5.7)	28 (5.7)	27.7 (7.7)
50–59	45 (8.4)	43 (8.3)	28.7 (4.3)	28 (6.3)	26 (5.7)	29.1 (6.4)
60–69	40 (8.3)	38 (8)	28.6 (4.4)	24 (5.3)	23 (5)	28.1 (5.1)
70+	33 (7.8)	32 (7.5)	27.2 (3.9)	20 (5.8)	19 (5.5)	27 (4.7)

Date collected using the position described in Fig. 5.224A and B.

BMI, Body mass index.

**Table 5.30**  
**GRIP STRENGTH VALUES FOR AGES 4–14 IN kg<sup>81</sup>**

AGE	BOYS			GIRLS		
	Dominant	Non-dominant	BMI	Dominant	Non-dominant	BMI
4	5.7 (2)	5.3 (2)	15.42	5.1 (2)	4.7 (2)	15.42
6	10.2 (3)	9.4 (3)	16	9.0 (3)	8.3 (3)	16
8	15.9 (4)	14.6 (3)	16.5	14.4 (3)	13.1 (3)	17.75
10	19.6 (2)	18.1 (3)	17.6	19.1 (4)	17.2 (4)	18.5
12	24.7 (5)	22.9 (5)	19	24.2 (5)	22.3 (4)	18.75
14	36.0 (7)	33.5 (7)	19.6	29.1 (5)	26.6 (5)	19.3

BMI, Body mass index.

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\*The coracobrachialis muscle cannot be isolated, nor is it really palpable. It has no unique function. It is included here because classically it is considered a shoulder flexor and adductor.