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# Anatomy, Shoulder and Upper Limb, Hand Compartments

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## Introduction

The upper extremity (UE) is comprised of its associated muscles, nerves, and vessels, organized into anatomical compartments.[1] The muscles cross joints to provide tone, maintain dynamic joint stability, and perform dynamic functions of the entire extremity. In addition, the arteries and veins provide nourishment and remove waste, and the nerves provide the motor and sensory innervations.[1]

## Structure and Function

The muscles of the shoulder originate from both the axial skeleton and the scapula, inserting onto the humerus. The muscles that originate from the anterior compartment of the brachium act to flex the forearm while the muscles with their origins from the posterior compartment of the brachium act to extend the forearm. Much like the brachium, the anterior muscles of the forearm act to flex the wrist joint, and the posterior muscles act to extend the wrist joint.[1]

The hand is comprised of eleven separate compartments. These are the four dorsal interossei, three volar interossei, the thenar, the hypothenar, the adductor, and the mid-palm compartments, respectively.[2] The dorsal interossei act to abduct the digits, and the volar interossei act to adduct the digits. The thenar and adductor compartment muscles exert activity on the thumb, while the muscles of the hypothenar compartment act on the small finger.

## Embryology

The embryology of the muscles in the upper extremity is a step-wise process. The first step is where myogenic progenitor cells present in somites give rise to the primary myotomes.[3] The second wave of myogenic progenitors arises from dermomyotomes that give rise embryonic myoblasts.[3] The myoblasts then proliferate, fuse and ultimately give rise to the primary muscle fibers.[3]

## Blood Supply and Lymphatics

The anatomical components of the UE receive vascular supply via the subclavian artery and its branches. It first transitions into the axillary artery to supply the shoulder. The axillary artery then transitions into the brachial artery to supply the brachium. The brachial artery splits distally into the radial and ulnar arteries to supply the forearm and hand. The deoxygenated blood of the upper extremity drains via the cephalic, basilic, and the brachial veins, which then flow into the subclavian vein and ultimately to the heart. The extracellular fluid is cleared by the lymphatic system. The right upper extremity feeds the right lymphatic duct, and the left upper extremity empties into the thoracic duct.[1]

## Nerves

Innervation to the upper extremity derives from the brachial plexus. It is comprised of the ventral rami from C5 to T1 nerve roots. The anterior muscles of the upper extremity receive innervation from the musculocutaneous, the median

and the ulnar nerves. The posterior muscles are innervated by the axillary and the radial nerves.[4]

The musculocutaneous nerve is composed of the C5 and C6 nerve roots, the median nerve arises from the C5 to T1 nerve roots, and the ulnar nerve is composed of the C8 and T1 nerve roots. The axillary nerve forms from the C5 and C6 nerve roots, and the radial nerve is composed of the C5 to T1 nerve roots.[4]

The collateral nerves of the brachial plexus are listed as follows:

- The dorsal scapular nerve.
- The long thoracic nerve.
- The suprascapular nerve.
- The lateral pectoral nerve.
- The medial pectoral nerve.
- The upper subscapular nerve.
- The lower subscapular nerve.
- The thoracodorsal nerve.
- The medial brachial cutaneous nerve.
- The medial antebrachial cutaneous nerve.

## Muscles

### Anterior Axioappendicular Muscles

#### Pectoralis major

- Function: flexion, adduction, medial rotation of the humerus.
- Origin: clavicular head: medial clavicle, anterior sternum, costal cartilages of ribs 1 to 6 and external oblique aponeurosis.
- Insertion: the lateral edge of the intertubercular groove of the humerus.
- Nerve: medial pectoral nerve (C8, T1) lateral pectoral nerve (C5, C6, C7)

#### Pectoralis minor

- Function: depression of shoulder and protraction of scapula.
- Origin: third, fourth, and fifth ribs.
- Insertion: coracoid process.
- Nerve: medial pectoral nerve (C8, T1)

#### Subclavius

- Function: depression and stabilization of clavicle.
- Origin: medial side of the first rib.
- Insertion: the inferior-middle part of the clavicle.
- Nerve: nerve to subclavius (C5, C6)

## **Serratus anterior**

- Function: protraction of scapula and rotation of the scapula.
- Origin: first through eighth ribs.
- Insertion: medial part of the anterior scapula.
- Nerve: long thoracic nerve (C5, C6, C7)

## **Posterior Axioappendicular Muscles**

### **Superficial Layer**

#### **Latissimus dorsi**

- Function: adduction, medial rotation, and extension of the humerus.
- Origin: spinous process of the seventh to twelfth thoracic vertebrae, the iliac crest, the thoracolumbar fascia, and the inferior third and fourth rib.
- Insertion: intertubercular groove of the humerus.
- Nerve: thoracodorsal nerve (C5, C6, C7)

#### **Trapezius**

- Function: elevation, depression, and retraction of the scapula and rotation of the glenoid cavity.
- Origin: superior nuchal line, nuchal ligament, occipital protuberance, and the spinous process of C7- T12.
- Insertion: spine of the scapula, the acromion, and the lateral clavicle.
- Nerve: cranial nerve 11 (spinal accessory nerve)

### **Deep Layer**

#### **Levator scapulae**

- Function: adduction, medial rotation, and extension of the humerus.
- Origin: transverse process of C1 through the C4 vertebrae.
- Insertion: medial border of the scapula.
- Nerve: dorsal scapular nerve (C4, C5)

#### **Rhomboid major**

- Function: retraction of scapula and depression of the glenoid cavity.
- Origin: spinous processes of T2 through the T5 vertebrae.
- Insertion: inferior aspect of medial scapula.
- Nerve: dorsal scapular nerve (C4, C5)

#### **Rhomboid minor**

- Function: retraction of scapula and depression of the glenoid cavity.

- Origin: nuchal ligament and the spine of C7 and the T1 vertebrae.
- Insertion: the superior aspect of the medial scapula.
- Nerve: dorsal scapular nerve (C4, C5)

## **Intrinsic Muscles of the Shoulder**

### **Deltoid**

- Function: anterior portion; flexion and medial rotation of the arm, middle portion; arm abduction, posterior portion; extension and lateral rotation of the arm.
- Origin: lateral clavicle, acromion, and the scapular spine.
- Insertion: deltoid tuberosity.
- Nerve: axillary nerve (C5, C6)

### **Teres major**

- Function: adduction and medial rotation of the brachium.
- Origin: posterior aspect of the scapula at the inferior angle.
- Insertion: intertubercular groove on the medial aspect.
- Nerve: lower scapular nerve (C5, C6)

### **Teres minor**

- Function: lateral rotation of the brachium.
- Origin: posterior aspect of the scapula at the inferior angle.
- Insertion: the inferior aspect of the greater tubercle
- Nerve: axillary nerve (C5, C6)

### **Supraspinatus**

- Function: initiation of arm abduction.
- Origin: posterior scapula, superior to the scapular spine.
- Insertion: the superior aspect of the greater tubercle.
- Nerve: suprascapular nerve (C5, C6)

### **Infraspinatus**

- Function: lateral rotation of the brachium.
- Origin: posterior scapula, inferior to the scapular spine.
- Insertion: greater tubercle of humerus, between supraspinatus and teres minor insertion.
- Nerve: suprascapular nerve (C5, C6)

### **Subscapularis**

- Function: adduction and medial rotation of the brachium.
- Origin: anterior aspect of the scapula.
- Insertion: lesser tubercle of the humerus.
- Nerve: subscapular nerves (C5, C6, C7)

## **Muscles of the Anterior Compartment of the Brachium**

### **Biceps brachii**

- Function: flexion and supination of the forearm.
- Origin: short head originates from the coracoid process and the long head from the supraglenoid tubercle of scapula.
- Insertion: radial tuberosity and forearm fascia (as bicipital aponeurosis)
- Nerve: musculocutaneous nerve (C5, C6, small contribution C7)

### **Brachialis**

- Function: flexion of the forearm.
- Origin: distal anterior humerus.
- Insertion: coronoid process and the ulnar tuberosity.
- Nerve: musculocutaneous nerve (C5, C6, C7)

### **Coracobrachialis**

- Function: flexion and adduction of the brachium.
- Origin: coracoid process.
- Insertion: medial aspect of the middle of the humerus.
- Nerve: musculocutaneous nerve (C5, C6, C7)

## **Muscles of Posterior Compartment of the Brachium**

### **Triceps brachii**

- Function: extensor of the forearm.
- Origin: lateral head, above the radial groove, medial head, below the radial groove, and the long head, infraglenoid tubercle of scapula.
- Insertion: olecranon process of the ulna and the forearm fascia.
- Nerve: radial nerve (C6, C7, C8)

### **Anconeus**

- Function: extension of the forearm.
- Origin: lateral epicondyle of the humerus.
- Insertion: olecranon process and the posterior aspect of the ulna.

- Nerve: radial nerve (C7, C8, T1)

## **Muscles of Anterior Compartment of Antebrachium**

### **Superficial Layer**

#### **Pronator teres**

- Function: pronation of the radio-ulnar joint.
- Origin: coronoid process and the medial epicondyle of the humerus.
- Insertion: lateral aspect of the radius.
- Nerve: median nerve (C6, C7)

#### **Flexor carpi radialis**

- Function: flexion and adduction of the wrist.
- Origin: medial epicondyle of the humerus.
- Insertion: base of the second metacarpal.
- Nerve: median nerve (C6, C7)

#### **Palmaris longus (inconsistent; absent in approximately 15% of the population)**

- Function: flexion at the wrist.
- Origin: medial epicondyle of the humerus.
- Insertion: flexor retinaculum.
- Nerve: median nerve (C7, C8)

#### **Flexor carpi ulnaris**

- Function: flexion and adduction of the wrist.
- Origin: medial epicondyle of the humerus and the olecranon.
- Insertion: pisiform, the hook of hamate and the fifth metacarpal.
- Nerve: median nerve (C7, C8)

### **Intermediate Layer**

#### **Flexor digitorum superficialis**

- Function: flexion of the proximal interphalangeal joint of the second, third, fourth, and fifth finger.
- Origin: medial epicondyle, coronoid process, and the anterior radius.
- Insertion: second, third, fourth, and the fifth middle phalanges.
- Nerve: median nerve (C7, C8, T1)

### **Deep Layer**

#### **Flexor digitorum profundus**

- Function: flexion of the distal interphalangeal joint of the second, third, fourth, and the fifth finger.
- Origin: medial and anterior aspect of the proximal ulna and interosseous membrane.
- Insertion: second, third, fourth, and the fifth distal phalanges.
- Nerve: ulnar nerve (C8, T1) for the medial part, anterior interosseous nerve (C8, T1) for the lateral.

### **Flexor pollicis longus**

- Function: flexion of the interphalangeal joint of the thumb.
- Origin: anterior aspect of the radius and the interosseous membrane.
- Insertion: base of the distal phalanx of the thumb.
- Nerve: anterior interosseous nerve (C7, C8)

### **Pronator quadratus**

- Function: pronation of the forearm.
- Origin: anterior aspect of the distal ulna.
- Insertion: anterior aspect of the distal radius.
- Nerve: anterior interosseous nerve (C7, C8)

### **Brachioradialis**

- Function: flexor of the forearm.
- Origin: the proximal supracondylar ridge on the humerus.
- Insertion: lateral aspect of the distal end of the radius.
- Nerve: radial nerve (C5, C6, C7)

## **Muscles of Posterior Compartment of the Antebrachium**

### **Superficial Layer**

#### **Extensor carpi radialis longus**

- Function: extension and abduction of the wrist.
- Origin: the proximal supracondylar ridge on the humerus.
- Insertion: dorsal base of the second metacarpal.
- Nerve: radial nerve (C6, C7)

#### **Extensor carpi radialis brevis**

- Function: extension and abduction of the wrist.
- Origin: lateral epicondyle on the humerus.
- Insertion: dorsal base of the third metacarpal.
- Nerve: the deep branch of the radial nerve (C7, C8)

**Extensor digitorum**

- Function: extension of the proximal interphalangeal joint of the second, third, fourth, and fifth finger.
- Origin: lateral epicondyle of the humerus.
- Insertion: extensor expansions of the dorsal aspect of the second, third, fourth, and fifth phalanges.
- Nerve: posterior interosseous nerve (C7, C8)

**Extensor digiti minimi**

- Function: extension of the little finger at metacarpophalangeal joint and interphalangeal joint.
- Origin: lateral epicondyle on the humerus.
- Insertion: extensor expansion on the dorsal aspect of the fifth phalanx.
- Nerve: posterior interosseous nerve (C7, C8)

**Extensor carpi ulnaris**

- Function: extension and adduction of the wrist.
- Origin: lateral epicondyle of the humerus and the posterior ulna.
- Insertion: fifth metacarpal base.
- Nerve: posterior interosseous nerve (C7, C8)

**Deep Layer****Extensor indicis**

- Function: extension of the index finger.
- Origin: the dorsal aspect of the distal ulna and interosseous membrane.
- Insertion: extensor expansion of the second finger.
- Nerve: posterior interosseous nerve (C7, C8)

**Supinator**

- Function: supination of the forearm.
- Origin: lateral epicondyle and supinator crest of the ulna.
- Insertion: lateral aspect of the radius.
- Nerve: deep branch of the radial nerve (C7, C8)

**Abductor pollicis longus**

- Function: abduction of the thumb.
- Origin: dorsal aspects of the proximal radius, ulna, and interosseous membrane.
- Insertion: base of the first metacarpal.
- Nerve: posterior interosseous nerve (C7, C8)

**Extensor pollicis longus**

- Function: extension of the thumb.
- Origin: dorsal aspects of the middle ulna and interosseous membrane.
- Insertion: distal phalanx of the thumb.
- Nerve: posterior interosseous nerve (C7, C8)

**Extensor pollicis brevis**

- Function: extension of the thumb.
- Origin: dorsal aspects of the middle radius and interosseous membrane.
- Insertion: distal phalanx of the thumb.
- Nerve: posterior interosseous nerve (C7, C8)

**Intrinsic Muscles of Hand****Thenar Muscles****Opponens pollicis**

- Function: opposition of the thumb.
- Origin: flexor retinaculum and the tubercle of the trapezium.
- Insertion: lateral aspect of the thumb.
- Nerve: recurrent branch of median nerve (C8, T1)

**Abductor pollicis brevis**

- Function: abduction of the thumb.
- Origin: flexor retinaculum and the tubercle of the scaphoid.
- Insertion: lateral aspect of the proximal phalanx of the thumb.
- Nerve: recurrent branch of median nerve (C8, T1)

**Flexor pollicis brevis**

- Function: flexion of the thumb.
- Origin: flexor retinaculum and the tubercle of the trapezium.
- Insertion: lateral aspect of the proximal phalanx of the thumb.
- Nerve: recurrent branch of median nerve (C8, T1)

**Adductor Compartment****Adductor pollicis**

- Function: adduction of the thumb.
- Origin: second and third metacarpal, and the capitate.

- Insertion: proximal phalanx and extensor expansion of the thumb.
- Nerve: deep branch of ulnar nerve (C8, T1)

## **Hypothenar Muscles**

### **Abductor digiti minimi**

- Function: abduction of the little finger.
- Origin: pisiform.
- Insertion: medial aspect of proximal phalanx of the fifth finger.
- Nerve: deep branch of ulnar nerve (C8, T1)

### **Flexor digiti minimi brevis**

- Function: flexion of the little finger.
- Origin: flexor retinaculum and the hook of the hamate.
- Insertion: medial aspect of the proximal phalanx of the fifth finger.
- Nerve: deep branch of ulnar nerve (C8, T1)

### **Opponens digiti minimi**

- Function: opposition of the little finger.
- Origin: flexor retinaculum and the hook of the hamate.
- Insertion: medial aspect of the fifth metacarpal.
- Nerve: deep branch of ulnar nerve (C8, T1)

## **Short Muscles**

### **Lumbricals**

- Function: flexion of the metacarpophalangeal joints with the extension of the interphalangeal joints.
- Origin: arise from tendons of flexor digitorum profundus.
- Insertion: extensor expansions of the second, third, fourth, and fifth finger.
- Nerve: median nerve (C8, T1) for the lateral two lumbricals, deep branch of ulnar nerve (C8, T1) for the medial two lumbricals.

### **Dorsal interossei**

- Function: abduction of the second, third, and fourth finger.
- Origin: adjacent metacarpals.
- Insertion: extensor expansions and proximal phalanges of the second, third, and fourth fingers.
- Nerve: deep branch of ulnar nerve (C8, T1)

### **Palmar interossei**

- Function: adduction of the second, third, and fourth finger.
- Origin: palmar aspect of the second, fourth, and fifth metacarpals.
- Insertion: extensor expansions and proximal phalanges of the second, fourth, and fifth fingers.
- Nerve: deep branch of ulnar nerve (C8, T1)[1]

## Physiologic Variants

Many physiological variants may manifest in the UE. These variations are often a cause for concern because they may lead to a misdiagnosis. The following are a few that may occur.

Under normal anatomical pretenses, the extensor indicis (EI) arises from the dorsal aspect of the distal part of the ulna and interosseous membrane. It inserts into the expansion hood of the index finger. It may present as a double tendon, and lead to clinical symptoms within the hand.[5]

The flexor digitorum superficialis (FDS) typically originates from the medial epicondyle, coronoid process, and the anterior aspect of the radius. It inserts at the base of the middle phalanx of the second, third, fourth, and the fifth phalanges. There have been reports of the FDS with two muscle bellies, and it may lead to volar forearm compression and pain.[6]

The extensor digitorum brevis manus is a variant muscle located in the dorsum of the hand. It leads to a variation of the fourth extensor compartment within the hand.[7]

## Surgical Considerations

Surgical considerations need to evaluate anatomical variations of the UE.

The double tendon of the EI leads to an increased volume of the fourth dorsal tunnel that may lead to clinical symptoms. Surgical excision to equalize the thickness of the medial slips of the two tendons relieves mechanical stress and may correct the symptomatology.[5]

If the FDS has two muscle bellies, then the increased mass may lead to clinical symptoms in the anterior forearm. Many previously reported cases received surgical treatment but depending on the level of symptoms, it may be treated non-operatively.[6]

The extensor digitorum brevis manus anatomical variant can be treated with either decompression or an excision surgery. Recent studies have shown that the excisional method of complete removal of the anatomical variant proved to be beneficial because it is the most effective and has improved outcomes compared with decompression.[7]

## Clinical Significance

Compartment syndrome is an emergent clinical condition that is well-documented in the literature. It is a clinical diagnosis that is often difficult to determine because it must be assessed in a timely manner. Although the lower leg and the forearm have the most common incidence, it may occur in any muscle compartment in the body.

Even though compartment syndrome of the hand is rare, it is important to have a high index of suspicion. The hallmark of diagnosis is pain with passive stretching, yet one may see pain and swelling as well. Determining the pressure in the compartment is a key in the diagnosis. Pressures above 30 mmHg warrant an emergent surgery. Failure to act may lead to debilitating consequences.[2][8]

## Other Issues

Neuropathies are a common manifestation in the hand compartments. Carpal tunnel syndrome (CTS) is the most common neuropathy of the hand compartments, and it affects 1 to 3 persons in 1000 per year. The specific cause is unknown, but it is a multifactorial syndrome.[9]

CTS diagnosis is via electromyography and nerve conduction testing. Treatment begins conservatively, usually starting with a reduction in provoking factors. The next step is to implement non-steroidal anti-inflammatory medications and a nightly wrist splint. The subsequent step is to use a local glucocorticoid injection to decrease the inflammation. The final intervention is to release the carpal tunnel surgically to decompress the components.[9]

## Questions

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