Anatomy and Physical Examination of the Hand

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Introduction

General Information

- The goal of any type of treatment of the hand is to restore function not only to the affected area but also to the whole upper extremity. Whether obtained for the acutely traumatized hand or the smallest most chronic condition, an accurate and complete history and physical examination are paramount to a successful outcome.
- The history should include information regarding the patient's age, occupation, hand dominance, and recreational activities. Although all of these data are routinely obtained in a standard orthopaedic history and physical examination, there are several important aspects of which the physician should be cognizant. For example, an injury that could be detrimental to something as simple as small finger abduction could severely compromise the capabilities of someone who plays the piano.
- The patient's past medical history is important. A history of diabetes mellitus can cause difficulties in the diagnosis of a compressive neuropathy and/or complicate wound healing in the surgical patient. One also must be aware of conditions in the upper extremity that exist concomitantly with the presenting problem. Does the patient with a hand problem have a prior history of shoulder or elbow problems? Every examination of the hand should begin at the shoulder, especially in patients who had long periods of disuse or who protected the hand with a sling. The skin, nerves, tendons, muscles, bones, and joints should be thoroughly examined. The size of the muscles is indicative of the amount of use of the hand, and the presence and/or amount of atrophy are indicative of a pathologic processes.

Nontraumatic Hand Conditions

- A hand with a disability of gradual onset and without any specific traumatic incident often presents a difficult diagnostic problem. In the nontraumatized patient, determine the chief complaint. Is the primary problem pain, stiffness, numbness, snapping, a painless mass, or a combination of these signs? When did the symptoms begin, what makes them better and worse, and have they been progressive? Are there associated problems at night, such as pain or numbness, and do these problems cause the patient to wake up or prevent sleep? Is the patient's function worse in the morning and improve throughout the day, or is there a constant problem? Knowing underlying medical conditions, such as gout, rheumatoid arthritis, or generalized osteoarthritis, can help in making the diagnosis and formulating a treatment strategy. A thorough history may reveal an unusual use of the hand that was a precipitating cause or the history of a degenerative process that reached a point where secondary injury occurred, as in an attritional tendon rupture.
The Traumatized Hand

- Some fractures and dislocations are readily obvious because of gross deformity and swelling. One of the most common pitfalls in treating hand injuries is overlooking the damage to the soft tissue structures or an additional injury because of an obvious fracture or dislocation. The history in acute injuries should include the time of injury, preliminary treatment by emergency medical technicians or emergency department staff, medications given (especially tetanus and antibiotics if there are open wounds), mechanism of injury (crushing vs. sharp), setting of the injury (i.e., barnyard, kitchen), and whether the injury was work related.

Physical Examination

- Observation of the resting hand should precede any physical examination. One should observe the attitude of the hand, posture of the digits, color of the skin, presence of atrophy (particularly of the thenar, hypothenar, and first dorsal interosseous regions), calluses, swelling, bruising, vascularity of all the digits, and prior scars. If swelling is present, is the cause trauma, obstruction of blood or lymphatic flow, a trophic condition resulting from injury to the nerves, vasomotor, or self-inflicted? The nails and nail folds should be inspected because they often show signs of undiagnosed systemic diseases, malnutrition, toxicity, and trauma. Additionally, an examination of the unaffected hand is helpful prior to an examination of the affected side. Always look for a second or third coexisting condition that may not be the primary complaint. For example, patients with arthritis of the carpometacarpal joint of the thumb can have coexisting carpal tunnel syndrome and the associated sequelae.

Embryology and Development

- Although it is beyond the scope of this chapter to go into extensive detail about the embryology and development of the hand, there are several key periods of development to keep in mind. The limb bud generally forms during 4 weeks of gestation. By 33 days of gestation, the hand forms into a paddle without individual digits. Digital separation usually begins at 7 weeks and progresses over the course of week 7. The condensation that will give rise to each of the bones of the hand also occurs at week 7.
- Ossification of the carpal bones begins at the capitate and proceeds in a clockwise direction. Ossification of the capitate usually is present at age 1 year. The hamate is the second carpal bone to ossify at approximately 1 to 2 years, followed by the triquetrum at 3 years, the lunate at 4 to 5 years, the scaphoid at 5 years, the trapezius at 6 years, the trapezoid at 7 years, and the pisiform at 9 years.

Terminology

- In true anatomic description, the palm is the anterior surface of the hand; however, this descriptive term is seldom used. The hand and digits have a dorsal surface, a palmar or volar surface, and radial and ulnar borders. The palm is subdivided into the thenar, midpalmar, and hypothenar areas. The thenar mass or eminence is the muscular area overlying the palmar surface of the thumb metacarpal. Atrophy of this muscle may be noted in pathologic conditions such as chronic carpal tunnel syndrome. The hypothenar musculature is located overlaying the small finger metacarpal. The digits are referred to as the thumb, index finger, long (middle) finger, ring finger, and small finger. Each finger possesses three joints: the metacarpophalangeal (MCP) joint, the proximal interphalangeal (PIP) joint, and the distal interphalangeal (DIP) joint. The MCP joints of the fingers are located at a line drawn from the radial extent of the proximal palmar crease to the ulnar extent of the distal palmar crease. This is important to bear in mind when placing a splint or cast that requires flexion of the MCP joints. The level of the finger webs correlates to the middle third of the proximal phalanges. The thumb has an MCP joint and only one interphalangeal (IP) joint. The carpometacarpal (CMC) or basal joint of the thumb is a unique structure in the hand and is important for thumb mobility.

Motion

- Active and passive measurements should be taken for each motion of the entire upper extremity, and any discrepancies noted. Pronation and supination of the forearm are measured with the elbow firmly at the side and at a right angle. In pathologic conditions, the amount of forearm rotation should be measured at the forearm because the radiocarpal joint may allow 10 to 20 degrees of motion without forearm rotation. Wrist motion is measured as degrees of dorsiflexion and palmar or volar flexion and radial or ulnar deviation. Ulnar deviation is determined by the angle between the midline of the forearm and the line from the center of the wrist to the third metacarpal. Radial deviation should be measured with the hand in the plane of the forearm because abnormal values can be obtained as the wrist goes into dorsiflexion. Finger motion is measured in degrees of maximal extension and degrees of maximal flexion. Hyperextension is documented as a negative number for calculations of total active motion (TAM) and total passive motion (TPM).
- Motion of the thumb has flexion and extension at the MCP and IP joints but becomes more complex when measuring motion of the CMC joint. Thumb CMC joint motions include palmar and radial abduction, opposition, and retrusion (Figure 1–1). The thumb should be examined through the full range of circumduction, from
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the back of the hand to opposition and to touch of the fifth metacarpal head. It also should be fully extended and fully flexed, and it should be able to make the OK sign with the index finger. Abduction of the thumb is measured by the angle between the first and second metacarpals with the thumb spread at right angles to the palm. Opposition is a combination of flexion, adduction, and pronation. Thumb adduction can be measured as the distance between the tip of the thumb and the head of the fifth metacarpal.

By knowing the normal range of motion of these joints, one can quickly determine what the patient cannot do and where the disability may lie (Table 1–1). Examination of the contralateral limb is particularly important if the patient has hypermobility of the other joints.

Table 1–1: Approximate Normal Ranges of Motion

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Active range of motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow</td>
<td>Flexion: 135°</td>
</tr>
<tr>
<td></td>
<td>Extension: 0 to −5°</td>
</tr>
<tr>
<td></td>
<td>Supination: 90°</td>
</tr>
<tr>
<td></td>
<td>Pronation: 90°</td>
</tr>
<tr>
<td>Wrist</td>
<td>Flexion: 80°</td>
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<tr>
<td></td>
<td>Extension: 70°</td>
</tr>
<tr>
<td></td>
<td>Ulnar deviation: 30°</td>
</tr>
<tr>
<td></td>
<td>Radial deviation: 20°</td>
</tr>
<tr>
<td>Finger</td>
<td>Flexion: 90°</td>
</tr>
<tr>
<td></td>
<td>Extension: 30–45°</td>
</tr>
<tr>
<td></td>
<td>Flexion: 100°</td>
</tr>
<tr>
<td></td>
<td>Extension: 0°</td>
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<tr>
<td></td>
<td>Flexion: 90°</td>
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<tr>
<td></td>
<td>Extension: 20°</td>
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<tr>
<td></td>
<td>Finger abduction and adduction</td>
</tr>
<tr>
<td></td>
<td>Abduction: 20°</td>
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<tr>
<td></td>
<td>Adduction: 0°</td>
</tr>
<tr>
<td></td>
<td>Thumb abduction and adduction</td>
</tr>
<tr>
<td></td>
<td>Abduction (palmar abduction): 70°</td>
</tr>
<tr>
<td></td>
<td>Adduction (dorsal adduction): 0°</td>
</tr>
</tbody>
</table>

Figure 1–1: The biconcave surfaces of the thumb carpometacarpal joint allow thumb rotation, flexion/extension, and abduction/adduction. MCl, Thumb metacarpal; Tz, trapezium. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)

Hand and Forearm Anatomy

Skin

- The skin on the volar aspect of the palm and fingers is tough and thick and possesses no hair follicles (glabrous). It covers a layer of fat with many fibrous septa that hold the skin firmly to the deeper tissues. The septa allow traction when gripping but necessitate a system of creases to prevent the skin from bunching as the hand is closed (Figure 1–2). The skin on the dorsal surface is thin, soft, and pliable, permitting motion of the joints. Because the veins are located dorsally, the dorsum of the hand is a common site for edema, which can limit flexion. The skin on the fingers is fixed to the bone by small ligaments along the radial and ulnar sides of the fingers. The ligaments dorsal to the neurovascular bundles are called Cleland’s ligaments and those volar to the neurovascular bundles are called Grayson’s ligaments.

Nail Bed and Fingertip

- The nail bed complex, also called the perionychium, consists of the paronychium and the nail bed itself (Figure 1–3). Proximally the nail fits into a depression called the nail fold. The eponychium is the thin membrane that extends onto the dorsum of the nail. Just distal to the eponychium beneath the nail is the lunula,
curved white opacity at the junction of the proximal germinal and distal sterile matrixes on the nail floor. Bacterial infections (paronychia) of the nail most commonly involve the paronychium and can be diagnosed easily on physical examination.

- The fingertip is the area of the digit distal to the insertion of the flexor and extensor tendons on the distal phalanx. The tuft of the distal phalanx is covered by adipose tissue and highly innervated skin tethered to the distal phalanx by numerous fibro septa. The tuft and the fibro septa are implicated in infections of the pulp of the distal phalanx called a felon.

**Motor Units of the Hand and Wrist**

- Motion of the hand and wrist is facilitated through the intrinsic and extrinsic motor units. The tendons and muscles originating proximal to the wrist are extrinsic and those that originate within the hand are intrinsic.

**Osseous Anatomy of the Hand and Wrist**

- The radiocarpal joint is an ellipsoid joint composed of the distal radius and its two articular facets for the scaphoid and lunate, respectively. Between the radius and the ulna is the sigmoid notch of the radius, which allows an
articulation with the distal ulna and 270 degrees of rotation. The ulnar styloid is the attachment of the triangular fibrocartilage complex. In the normal intact forearm with neutral ulnar variance and neutral rotation 80% of the forces are transmitted through the distal radius (50% across the scaphoid fossa and 30% across the lunate fossa) and 20% through the distal ulna. These numbers change with wrist and forearm motion and ulnar variance.

Intercarpal Joints

- The proximal carpal row is composed of the scaphoid, lunate, and triquetrum. The pisiform is a sesamoid bone within the flexor carpi ulnaris (FCU) tendon that articulates with the triquetrum. This articulation can become a source of ulnar-sided wrist pain that is often overlooked. The joints of the proximal row are primarily gliding joints. The scaphoid bone is the link between the proximal and distal rows and is the reason why pathology originating from the scaphoid can cause problems with almost all of the articulations in the wrist. The distal carpal row is made up of the trapezium, trapezoid, capitate, and hamate. With the exception of the trapezium, the bones of the distal carpal row are strongly anchored by their attachments with the metacarpals.

Metacarpals and Metacarpophalangeal Joints

- The MCP joints are condyloid joints and, unlike the IP joints, allow not only flexion and extension but also abduction and adduction of the proximal phalanx on the metacarpal head. The collateral ligaments of the MCP joints provide stability, where the volar plate prevents hyperextension. All of the volar plates are connected by the strong intermetacarpal ligaments, which help maintain longitudinal and rotational alignment in the case of many metacarpal fractures. Because of the camlike shape of the metacarpal head, the collateral ligaments are lax in extension and taut in flexion. When the MCP joints are included in a cast, they should be flexed to maintain the length of the ligaments, preventing permanent shortening and stiffness.
- Although index and long finger CMC joints are relatively immobile, there is 5 to 10 degrees of flexion at the ring finger CMC joint and 15 to 20 degrees of flexion of the small finger CMC joint. Because of their articulations with the distal hamate facets, the ring and small finger metacarpals rotate toward the middle of the palm with flexion to enhance gripping. However, because of the shape of the articulations with the hamate, subluxations and/or dislocations can occur easily in a fracture situation of the fourth and fifth metacarpal bases.

Phalanges and Interphalangeal Joints

- The PIP and DIP joints are bicondylar ginglymus (hinge) joints where the collateral ligaments and the volar plate allow only flexion and extension (Figure 1–4).

Metacarpophalangeal and Basal Joints of the Thumb

- The thumb MCP joint is much more complex than the MCP joints of the other digits. Its complexity is compounded by the presence of the sesamoid bones and the thenar musculature. At the ulnar side, a collateral ligament injury can become “complex” if the adductor aponeurosis becomes interposed between the torn ligament and its bony insertion. This forms a “Stener lesion,” where the avulsed ligament end cannot heal back to the bone, requiring operative reduction and fixation.
- The basal joint or CMC joint of the thumb is a complex structure, which allows 360 degrees of motion. The thumb metacarpal articulates with the trapezium on biconcave saddle-shaped joints and the trapezium articulates with the scaphoid, trapezoid, and the radial facet of the index finger (see Figure 1–1). This joint is supported by the capsule and the radial, volar, and dorsal CMC ligaments. Perhaps one of the more important ligaments of the basal joint is the volar oblique or “beak” ligament, named for its attachment to the articular margin of the ulnar side of the metacarpal beak. Its origin is the palmar tubercle of the trapezium. The volar oblique ligament is implicated in pathologic conditions of the CMC joint, such as osteoarthritis.
Ligaments of the Wrist

- The ligaments of the wrist are divided into three groups: the volar radiocarpal, the interosseous, and the dorsal intercapsular, although there is much diversity in the nomenclature of these ligaments. The volar wrist ligaments provide the majority of stability of the radiocarpal joint and maintenance of position of the individual carpal bones. Although there are numerous intercarpal ligaments, the two most important are the scapholunate (SL) interosseous ligament and the lunotriquetral (LT) interosseous ligaments. Tearing of the SL interosseous ligament is implicated in the formation of dorsal intercalated segment instability (DISI), where the SL angle on the lateral radiograph is greater than 60 degrees. Usually, there is also an associated disruption of the volar radiocarpal ligament. Volar intercalated segment instability (VISI) usually results as a disruption of the LT interosseous ligament and the dorsal radiocarpal (DRC) and ulnolunate (UL) ligaments. In DISI the lunate assumes an extended posture, whereas in VISI the lunate assumes a flexed posture.
- The volar radiocarpal ligaments include the radioscapoholunate (RSC), long and short radiolunate (LRL and SRL), radioscapholunate (RSL) (ligament of Tuet), lunotriquetral (UT), UC, and ulnolunate (UL) (Figure 1–5). With some exceptions, most of these ligaments can be visualized during wrist arthroscopy. These ligaments are arranged in a double chevron pattern that allows them to adjust the carpal rotation and the ulnar and radial heights of the carpus during ulnar and radial deviation. Between the RSC and LRL ligaments is an area of potential weakness over the capitate-lunate articulation known as the space of Poirier, where the capitate can dislocate during a perilunate dislocation.
- The dorsal intercarpal (DIC) and DRC ligaments are important thickenings in the dorsal joint capsule (Figure 1–6). These structures provide important stabilization of the carpal bones. The DRC originates from the dorsal margin of the distal radius, and its radial fibers attach at the lunate and LT interosseous ligament before inserting on the dorsal tubercle of the triquetrum. The DIC originates from the triquetrum and attaches onto the lunate before inserting into the dorsal groove of the scaphoid with extension of the insertion to the trapezium. Because of the importance of these ligaments, some authors recommend a ligament-sparing technique when performing a dorsal capsulotomy.

Fibroosseous Tunnels of the Wrist

- On the palmar side of the wrist, the carpal tunnel and the Guyon's canal allow the tendons, nerves, and arteries to enter the hand. The bony pillars of the carpal tunnel are made up of the bony ridges of the trapezium and the scaphoid on the radial side and the hook of the hamate and the pisiform on the ulnar side. The roof of the carpal tunnel is the transverse carpal ligament. The contents of the carpal tunnel include the eight extrinsic flexor tendons to the fingers, the flexor pollicis longus (FPL), and the median nerve. The Guyon's canal is located ulnar to the carpal tunnel and contains the ulnar nerve and artery (Figure 1–7). The bony boundaries of the Guyon's canal are the pisiform and the hook of the hamate. The volar carpal ligament forms the roof of Guyon's canal.

Innervation

- The sensation on the palmar aspect of the hand is provided by the median and ulnar nerves. On the dorsal aspect of the hand, the radial and ulnar nerves provide sensation. The ulnar nerve is the major motor innervation to the intrinsic
musculature of the hand, except for the muscles supplied by the motor branch of the median nerve.

**Extrinsic Tendons of the Wrist**

- On the dorsal aspect of the wrist are six discrete compartments for the extrinsic extensor tendons (Figure 1–8). The compartments prevent bowstringing and provide reliable landmarks for surgical approaches. Additionally, each compartment can have its own unique pathologic process. On the volar aspect of the wrist, the tendons are not arranged as discretely.

**Anatomy of the Extrinsic Extensor Tendons**

- Knowledge of the surface anatomy and location of the extensor tendons is crucial for understanding pathologic conditions of the tendons themselves. In addition, the extensor tendon compartments are important intervals for open surgical approaches to the wrist and forearm and for placement of arthroscopy portals.

**First Dorsal Compartment**

- The first dorsal compartment contains the abductor pollicis longus (APL) and the extensor pollicis brevis (EPB) tendons. These tendons represent the radial border of the anatomic snuffbox. As the thumb is brought into radial abduction, the individual tendons can be palpated as they exit distal to the retinaculum. Toward the insertion of these tendons on the thumb metacarpal, the EPB lies on the ulnar side of the APL. The APL can possess two to five separate tendon slips. In up to 60% of the population, there is a separate subcompartment for the EPB or one of the slips of the APL. If all of the compartments are not released during surgery for tenosynovitis, surgical failure may result. Tenosynovitis of the wrist is most commonly seen at the first dorsal compartment and is referred to as de Quervain’s disease. The provocative maneuver for diagnosis of de Quervain’s disease is the Finkelstein test. The Finkelstein test is performed by tucking the patient’s thumb inside the closed fingers of a fist (Figure 1–9). The wrist then is brought into ulnar deviation as the forearm is stabilized. Sharp pain in the area of the first dorsal compartment is strong evidence for de Quervain’s disease.

- **Pathologic Condition**—de Quervain’s disease

**Second Dorsal Compartment**

- The second dorsal compartment is located on the radial side of the Lister’s tubercle and contains the extensor carpi radialis longus (ECRL) and the extensor carpi radialis brevis (ECRB). The ECRL inserts on the base of the second metacarpal, and the ECRB inserts on the base of the third metacarpal. To examine the tendons, ask the patient to make a clenched fist. The tendons will be palpable on the radial side of the Lister’s tubercle (Figure 1–10). The two tendons are powerful wrist
extensors that also cause radial deviation because of their insertions on the radial aspects of the metacarpal bases. However, the ECRB remains the primary location for transfer of a tendon to provide wrist extension because of its more central location causing less radial deviation. Intersection syndrome is tenosynovitis of the second dorsal compartment. Symptoms of intersection syndrome are pain and swelling where the APL and EPB tendons cross the ECRL and the ECRB, approximately 4 cm proximal to the wrist joint.

Pathologic Condition—Intersection syndrome

Third Dorsal Compartment

- The third dorsal compartment contains the extensor pollicis longus tendon (EPL) (Figure 1–11). The EPL tendon defines the ulnar border of the anatomic snuffbox.
At Lister’s tubercle, the EPL tendon takes a 45-degree turn before attaching on the base of the distal phalanx of the thumb. Placing the patient’s hand flat on a table and then asking the patient to lift only the thumb can allow evaluation of the EPL tendon. Pain and crepitus over the EPL tendon, especially at the Lister’s tubercle, can represent impending rupture of the tendon, especially after a fracture of the distal radius. Another cause of attritional rupture of the EPL tendon is rheumatoid arthritis.

**Pathologic Condition**—Attritional tendon rupture

**Fourth Dorsal Compartment**

- The fourth dorsal compartment contains the extensor digitorum communis (EDC) and the extensor indicis proprius (EIP). The EDC inserts on the extensor hoods of all four fingers, and the EIP inserts on the ulnar aspect of the extensor tendon to the index. The ulnar location of the EIP is important for identifying the tendon for transfers. Additionally, the EIP allows full independent extension of the index finger, whereas the EDC provides combined extension of all four fingers (Figure 1–12). The juncturae tendineae are links that typically occur between the extensor of the middle finger and the index and ring finger. For 80% of the population, the EDC of the small finger consists of only a slip of junctura from the ring finger. The EDC causes MCP joint extension and can be evaluated by asking the patient to extend the fingers. The EIP can be tested by asking the patient to extend the index finger while making a fist. Except in cases of rheumatoid arthritis, primary symptomatic tenosynovitis of the fourth compartment is rare.

- **Pathologic Condition**—Rheumatoid synovitis

**Fifth Dorsal Compartment**

- The fifth dorsal compartment contains the extensor digiti minimi (EDM) or extensor digiti quinti (EDQ) tendon and overlies the dorsal radioulnar articulation. The EDQ tendon attaches to the extensor hood on the ulnar side of EDC. The EDQ, similar to the EIP, allows independent extension of the small finger. Because of its location near the radioulnar joint, the tendon can become involved.
from rheumatoid arthritis of the joint or can rupture because of attritional wear resulting from a dorsally dislocated ulnar head.

- **Pathologic Condition**—Rheumatoid synovitis, attritional rupture

**Sixth Dorsal Compartment**

- The sixth dorsal compartment contains the extensor carpi ulnaris (ECU), which lies in a groove between the ulnar styloid process and the ulnar head. With the wrist extended and ulnarly deviated, the ECU tendon can be palpated before its insertion onto the ulnar side of the fifth metacarpal base. A traumatic event can rupture the dorsal carpal ligament, which normally prevents subluxation of the tendon during pronation. Subluxation of the tendon usually is accompanied by pain and an audible snap. Patients with rheumatoid arthritis can similarly have displacement of the tendon or even rupture.

- **Pathologic Condition**—Posttraumatic dislocation, attritional rupture in rheumatoid patients

**Anatomy of the Extrinsic Flexor Tendons**

**Wrist Flexor Tendons**

- The two major extrinsic flexor tendons of the wrist are the flexor carpi radialis (FCR) and the FCU. To examine the FCR, wrist flexion and radial deviation make the tendon prominent, as it lies radial to the palmaris longus tendon. The FCR (innervated by the median nerve) originates at the medial epicondyle and crosses the scaphoid before inserting distally on the base of the second metacarpal and trapezium. Localized tenosynovitis of the FCR at the wrist level can become severe, necessitating release of the distal extent of the tendon from its sheath. The FCU lies ulnar to the palmaris longus and can be palpated when the wrist is flexed against resistance. The FCU (innervated by the ulnar nerve) also originates from the medial epicondyle and encloses the pisiform at its insertion. Occasionally, the insertion of the FCU can be the site of severe pain when calcific deposits form. The palmaris longus tendon bisects the volar aspect of the wrist. The palmaris tendon also originates from the medial epicondyle and inserts distally on the palmar fascia. The palmaris longus is one of the most commonly used tendons for a variety of upper extremity reconstructions. However, it is crucial to examine for the presence of a palmaris longus tendon prior to surgery because this tendon is absent in 7% to 20% of the population. To examine for the presence of a palmaris longus tendon, the patient should flex the wrist and oppose the tips of the thumb and small finger.

**Digital Flexor Tendons**

- The flexor digitorum superficialis (FDS) and the flexor digitorum profundus (FDP) are the major extrinsic flexors of the digits, as the fingers themselves do not possess any muscle bellies. The FDS originates from the medial epicondyle and the radial shaft and inserts on the on the palmar middle phalanx to produce flexion of the PIP joint. Proximal to the insertion onto the middle phalanx, the FDS divides into two slips to form Camper’s chiasma (Figure 1–13). Anatomically, Camper’s chiasma is a long area located over most of the proximal phalanx and is not just a discrete point. The FDP tendon passes between these two slips before attaching on the distal phalanx. As the FDS tendons pass through the carpal tunnel, they are organized in two reproducible layers. The FDSs to the ring and middle fingers are always located palmar to the FDS of the index and small fingers. This anatomic relationship is of particular importance when performing flexor tendon repairs located at this level. A commonly taught way of remembering this relationship is that “34” in reference to the third and fourth digits is greater than “25” corresponding to the second and fifth digits (Figure 1–14). Each muscle of the FDS can function independently. However, absence of the FDS to small finger, seen in up to 30% of the population, prevents isolated flexion of the PIP joint of the small finger. Because the FDP shares a common muscle belly, only the FDS can cause active flexion of the middle, ring, and small fingers while the adjacent digits are held in extension (Figure 1–15).

- The FDP originates from the ulna and inserts on the distal phalanx, promoting flexion of the DIP joint. In contrast to the FDS, the FDP possesses only a single muscle to the long, ring, and small fingers, which prevents independent flexion. The index finger FDP usually has independent function. To test for FDP function, the PIP joint should be held in extension while active flexion of the DIP joint is attempted (Figure 1–16).

**Figure 1–13:**
The flexor digitorum profundus (FDP) passes through the Camper’s chiasma. The vincula provide the blood supply to the flexor tendons. FDS, Flexor digitorum superficialis. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)
The FPL originates from the volar surface of the radius and inserts into the base of the distal phalanx of the thumb, allowing for IP joint flexion (Figure 1–17). Between the FPL and the pronator quadratus at the level of the distal radius is the space of Parona. This is the area where infection can spread from the thumb flexor tendon sheath to the small finger, causing a horseshoe abscess.

**Flexor Tendon Sheath**

- At the level of the MCP joints, the digital flexors enter a fibroosseous tunnel also referred to as the flexor tendon sheath. The flexor tendon sheath keeps the flexor tendons close to bone, improving the biomechanics of digital flexion and preventing the tendons from bowstringing. The tendon sheath is composed of annular (A) and...
cruciate (C) pulleys. There are five annular pulleys: A1 to A5 (Figure 1–18). The two most important of the five annular pulleys are A2 and A4, which are located over the proximal and middles phalanges, respectively. Injury to these pulleys are responsible for bowstringing of the flexor tendons. The A1 pulley is frequently implicated in the pathology of flexor tendon stenosing tenosynovitis or trigger finger. Except in the case of rheumatoid arthritis, the A1 pulley can be released with little biomechanical compromise. In addition to the annular pulleys are three cruciate pulleys: C1 to C3, which are collapsible pulleys that allow finger flexion without impingement of the adjacent pulleys.

Anatomy of the Extensor Hood and the Intrinsic Muscles of the Hand

Extensor Hood Mechanism

- The extensor mechanism of the finger is much more complex than the flexor mechanism. The extensor hood mechanism is where the extrinsic tendons and intrinsic tendons merge to control PIP and MCP motion (Figures 1–19 and 1–20). For each digit, the extensor hood has attachments from the interosseous muscles and a lumbrical muscle. These intrinsic muscles make up the lateral bands, which join distally and insert at the distal phalanx to allow DIP joint extension. Spanning between the two conjoined lateral bands is the triangular ligament, which prevents their volar subluxation. Also stabilizing the lateral bands is the transverse retinacular ligament (located at the level of the PIP joint), which prevents dorsal subluxation. The central slip is the part of the extensor tendon that inserts on the base of the middle phalanx, allowing PIP joint extension.
- Swan-neck deformity is characterized by hyperextension of the PIP joint and flexion of the DIP joint. Common causes of swan-neck deformity include rheumatoid arthritis, mallet finger, laceration of the FDS, and intrinsic contracture. Except in the case of mallet finger (where the terminal extensor tendon is disrupted), the pathophysiology of swan-neck deformity arises from
CHAPTER 1  Anatomy and Physical Examination of the Hand

Figure 1–18:
The flexor tendon sheath is composed of annular pulleys and cruciate pulleys. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)

Figure 1–19:

Figure 1–20:
stretching of the transverse retinacular ligaments, which allows the lateral bands to sublux dorsal to the axis of the PIP joint. When combined with laxity of the volar plate, hyperextension of the PIP joint and subsequent swan-neck deformity occur.

- **Boutonnière deformity** is the opposite posture of swan-neck deformity, exhibiting PIP flexion and DIP extension. Rheumatoid arthritis, laceration, or traumatic injury can cause a problem with central slip and subsequent volar subluxation (in contrast to the dorsal subluxation seen in swan-neck deformity) of the lateral bands as a result of incompetence or injury to the triangular ligament. As the lateral bands translate in a palmar direction, they become a flexor at the PIP joint and an extensor at the DIP joint.

- The sagittal band is the most proximal portion of the extensor hood and centralizes the extensor mechanism over the metacarpal head. It is a unique structure in that it encircles the proximal phalanx and attaches to the flexor tendon sheath, which allows extension of the proximal phalanx on the metacarpal head. MCP joint flexion and extension is a complex motion because there are no attachments of either flexor or extensor tendons at the proximal phalanx. Primary extension of the MCP joint is accomplished when the extensor tendon pulls on the sagittal bands, lifting the proximal phalanx from below (Figures 1–21 and 1–22). Located distal to the sagittal band are the transverse and oblique bands of the dorsal hood (see Figure 1–20).

### Intrinsic Muscles

- The intrinsic muscles assist with MCP joint flexion via their attachments to the extensor mechanism. The lumbrical muscles cross the MCP joint palmar to its axis and dorsal to the axis of the PIP joint before attaching on the middle phalanx. This line of force allows the intrinsic muscles to cause MCP joint flexion and PIP joint extension.

- There are four dorsal interosseous muscles and three palmar interossei (Figure 1–23). The dorsal interossei are responsible for abduction of the digits. The insertions of the dorsal interossei are on both the radial and ulnar sides of the index, long, and ring fingers. The palmar interossei adduct the index, ring, and small fingers. A way to remember the function of the interossei are the words **DAB** and **PAD**, which represent dorsal-abduction and palmar-adduction, respectively.

- The lumbrical muscles originate on each of the FDP tendons and insert on the radial lateral band of the extensor expansion. The lumbrical muscle is the only muscle in the body that originates and inserts on a tendon (Figure 1–24). Another unique attribute of the lumbrical muscle is its ability to relax its own antagonist, the FDP. Innervation of the lumbrical muscles is the ulnar nerve for the ulnar two lumbricals and the median nerve for the radial two lumbricals.

- The intrinsic tightness test is used to examine for contracture of the intrinsic muscles. To perform the intrinsic tightness test, the amount of passive PIP joint flexion is tested with the MCP joints held in extension. Next, the MCP joints are flexed (relaxing the intrinsic muscles) and amount of passive PIP flexion reevaluated. The intrinsic tightness test is positive when there is less passive PIP flexion when the MCP joint is extended (Figure 1–25). Clinically, intrinsic tightness hampers the grasp of large objects, in contrast to extrinsic tightness, which prevents closure of the fist and the grasp of small objects.
Oblique Retinacular Ligament
(of Landsmeer)

• The oblique retinacular ligament (ORL) links the PIP joint and DIP joint extension. Its line of force is analogous to the intrinsic muscles but is applied more distally in the finger. The ORL originates from the periosteum of the proximal phalanx and the A1 and C1 pulleys and inserts on the terminal tendon. With extension of the PIP joint, the ORL, which is palmar at this level, tightens. This tension is transmitted distally, pulling on the terminal tendon as the ORL travels dorsally at the level of the DIP joint. The ORL becomes contracted in chronic boutonnière deformity. Because of the ORL, Fowler terminal tendon tenotomy can be performed to correct this deformity, with preservation of DIP extension.

Thenar Muscles

• The muscles of the thenar eminence are the abductor pollicis brevis (APB), flexor pollicis brevis (FPB), opponens pollicis, and adductor pollicis. Muscles located

Figure 1–23:
Four dorsal interossei provide abduction and three volar interossei provide adduction of the fingers. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)

Figure 1–24:
The lumbrical muscles function to flex the metacarpophalangeal joint and extend the proximal interphalangeal joint. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)

Figure 1–25:
When the intrinsic tightness test is positive, the proximal interphalangeal joint has less passive flexion with metacarpophalangeal extension because the contracted intrinsic muscles are under greater stretch. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)
on the radial side of the FPL are innervated by the median nerve; muscles on the ulnar side are innervated by the ulnar nerve (Figure 1–26). The APB (innervated by the median nerve) originates from the transverse carpal ligament and the trapezium and inserts on the radial aspect of the proximal phalanx. Thumb flexion, pronation, and palmar abduction all are caused by action of the APB. The FPB originates from the transverse carpal ligament and trapezium and inserts on the radial sesamoid. There is a dual innervation of the FPB: the median nerve innervates the superficial head and the ulnar nerve innervates the deep head. The APB and FPB obtain opposition and thumb rotation by a combination of action. Located deep to the APB and FPB is the opponens pollicis brevis (OPB). It also arises from the transverse carpal ligament and inserts on the radial aspect of the thumb metacarpal, causing flexion of the thumb metacarpal at the CMC joint. The adductor pollicis (innervated by the ulnar nerve) originates from the third metacarpal and capitate and inserts onto both sesamoids, providing major strength during pinch.

**Hypothenar Muscles**
- All of the hypothenar muscles are innervated by the ulnar nerve. These muscles are the abductor digiti quinti (ADQ), flexor digiti quinti (FDQ), and opponens digiti quinti (ODQ). The ADQ originates on the pisiform and inserts on the ulnar aspect of the proximal phalanx of the small finger, providing for abduction of the small finger (see Figure 1–26). The FDQ originates on the hook of the hamate and inserts on the palmar base of the small finger proximal phalanx, causing flexion at the small finger CMC joint. The ODQ is deep to the ADQ and FDQ, originates from the hamate, and inserts on the fifth metacarpal.

**Innervation of the Hand**
- Although it is beyond the scope of this chapter to describe the brachial plexus in its entirety, understanding the contributions of the cervical spine to each nerve of the hand is crucial. Sensation and motor innervation in

![Image: The muscles of the thenar eminence include the abductor pollicis brevis (APB), flexor pollicis brevis (FPB), opponens, and adductor pollicis. FCR, Flexor carpi radialis; FCU, flexor carpi ulnaris; FDS, flexor digitorum superficialis; FPL, flexor pollicis longus. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)](image-url)
the hand are mediated through the median, radial, and ulnar nerves and their branches. When assessing an injury to one or more of the nerves of the hand, key aspects of the physical examination are indicative of the area of injury (Table 1–2).

**Radial Nerve**

- The radial nerve originates from the posterior cord of the brachial plexus (receiving innervation from C5 through T1) and then spirals distally from medial to lateral before emerging between the brachialis and brachioradialis anterior to the lateral epicondyle. Proximal to the elbow the nerve innervates, in order, the anconeus, brachioradialis, and ECRL, before dividing into its posterior interosseous and sensory branch. The radial sensory nerve proceeds distally deep to the brachioradialis until approximately 4 cm proximal to the tip of the radial styloid, where the nerve becomes superficial and passes between the ECRL and the brachioradialis. At this level, the nerve can be injured during placement of an external fixator. As the sensory nerve proceeds distally, it provides for sensation on the dorsum of the thumb and dorsal radial web space (Figures 1–27 and 1–28). At the radial aspect of the wrist, the superficial branch of the radial sensory nerve and the lateral antebrachial cutaneous nerve (the terminal branch of the musculocutaneous nerve) overlap the same sensory territories in 75% of the population. Because of this overlap, treatment of injury or neuroma at this level is fraught with mediocre results.

- After branching from the radial nerve, the posterior interosseous nerve (PIN) dives deep to the fascia of the proximal edge of the supinator (also known as the arcade of Froste), one of the potential sites of compression in radial tunnel syndrome. The PIN innervates the supinator at this level and then all of the extensor muscles of the forearm (see Table 1–3 for the order of innervation).

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**Table 1–2: Physical Examination Points Indicative of Nerve Injury**

<table>
<thead>
<tr>
<th>Sensory Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial nerve: Dorsal radial hand near the first web space</td>
</tr>
<tr>
<td>Median nerve: Pulp of the thumb and index finger</td>
</tr>
<tr>
<td>Ulnar nerve: Pulp of the small finger</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motor Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median nerve</td>
</tr>
<tr>
<td>Intrinsic: Thumb palmar abduction</td>
</tr>
<tr>
<td>Extrinsic: All flexor digitorum superficialis tendons</td>
</tr>
<tr>
<td>Flexor digitorum profundus to index</td>
</tr>
<tr>
<td>Flexor pollicis longus</td>
</tr>
<tr>
<td>Flexor carpi radialis</td>
</tr>
<tr>
<td>Ulnar nerve</td>
</tr>
<tr>
<td>Intrinsic: Hypothenar muscles, first dorsal interosseus (FDIO)</td>
</tr>
<tr>
<td>Extrinsic: Flexor digitorum profundus to the small finger</td>
</tr>
<tr>
<td>Flexor carpi ulnaris</td>
</tr>
<tr>
<td>Radial nerve</td>
</tr>
<tr>
<td>Extrinsic: Wrist extension</td>
</tr>
<tr>
<td>Finger extension at the metacarpophalangeal joint</td>
</tr>
<tr>
<td>Thumb extension</td>
</tr>
</tbody>
</table>

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Figure 1–27:
Sensory patterns of the median ulnar and radial nerves for the palm (left view) and dorsum (right view) of the hand. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)
Median Nerve

- The median nerve originates from both the medial and lateral cords of the brachial plexus (receiving fibers from C6, C7, C8, and T1 and sometimes C5) and travels with the brachial artery before entering the forearm medial to the biceps tendon. The nerve then passes between the two heads of the pronator teres. At the level of the pronator teres, the median nerve gives off its anterior interosseous nerve (AIN) branch, providing innervation to the FDP muscle of the index and middle fingers, the FPL, and pronator quadratus. To test for function of the AIN, ask the patient to make the "OK" sign with the index finger and thumb. Because of the location of the AIN in the deep flexor compartment of the forearm, the AIN can become injured in compartment syndrome and/or fractures of the forearm or elbow. In the volar forearm, all of the forearm flexor muscles are innervated by the median nerve, except for the FDP to the ring and small fingers and the FCU, which are innervated by the ulnar nerve. The nerve continues distally between the FDS and FDP (innervating the entire FDS). Approximately 5 cm proximal to the wrist flexion crease, the palmar cutaneous branch splits off of the radial side of the nerve and runs between the palmaris longus and the FCR, innervating the skin at the base of the thenar eminence.

- Beneath the transverse carpal ligament, the median nerve enters the hand and gives off its motor branch from the radial side. The motor branch provides innervation to the APB, opponens pollicis, and superficial head of the FPB. There are three variations of the motor branch. The most common (occurring in approximately 50% of the population) is the extraligamentous and recurrent, where the motor branch comes off of the median nerve distal to the transverse carpal ligament before innervating the thenar musculature. In 30% of the population the nerve branches beneath the transverse carpal ligament (subligamentous), and in 20% the nerve is transligamentous, piercing the transverse carpal ligament after branching below. To examine the motor branch of the median nerve, ask the patient to oppose the thumb to the small finger while the APB muscle is palpated for contraction.

- The median nerve provides sensation to the palmar aspects of the radial 3½ digits and the dorsum of these digits from the DIP joint to the fingertips (see Figures 1–27 and 1–28). The four sensory nerves begin deep to the superficial palmar arch but become superficial to the arteries in the distal palm. The nerve always lies superficial to the artery within the finger. Innervation of the radial two lumbricals is provided by the common digital nerves.
Ulnar Nerve

- The ulnar nerve is composed of fibers from the C8 and T1 nerve roots and sometimes a minor contribution from C7. Nearly all of the fibers arise from the lower trunk of the brachial plexus and pass through the medial cord before forming the ulnar nerve. It is important to remember that a large portion of the median nerve and medial antebrachial cutaneous nerve also originate from the medial cord. From the brachial plexus, the ulnar nerve runs along the medial aspect of the arm. At the elbow, the nerve passes in the groove between the medial epicondyle and olecranon process, the cubital tunnel. The ulnar nerve continues distally, enters the forearm between the two heads of the FCU, which it supplies, and then runs between the FCU and the FDP. At this level, the nerve gives off motor branches to the FDP to the ring and small fingers. In the distal third of the forearm, the ulnar nerve gives off the ulnar sensory nerve. Approximately 4 cm proximal to the wrist crease, the ulnar sensory branch exits dorsal to the FCU, providing sensation to the dorsum of the ring and small fingers.

- The ulnar nerve enters the wrist via Guyon's canal. The motor branch of the ulnar nerve innervates the hypothenar muscles (ADQ, FDQ, ODQ) and all of the interossei. The motor branch to the interossei takes an acute turn just distal to the hook of the hamate and usually is visualized during removal of the hook for a fracture (see Figure 1–7). The sensory portion of the ulnar nerve supplies the palmar small finger and the ulnar half of the ring finger (see Figures 1–27 and 1–28). Sensory abnormalities on the dorsum of the hand help distinguish between a lesion of the nerve located proximal versus distal to the branch of the ulnar sensory nerve. Testing for motor function of the ulnar nerve is accomplished through pinch strength. Froment's sign is hyperflexion of the thumb IP joint as a patient with deficient ulnar innervation applies a firm key pinch. When the adductor pollicis is paralyzed, the patient compensates by using the FPL, which causes hyperflexion of the IP joint (Figure 1–29). Other tests of ulnar nerve function include examination of digital abduction to test the interossei.

Arterial Anatomy

- The arterial anatomy of the hand is one of the greatest areas of variability among patients. There are three main arches for blood supply to the hand: the superficial palmar arch, the deep palmar arch, and the dorsal carpal arch. These three arches are formed by the radial and ulnar arteries and provide a rich collateral circulation to the hand. The main blood supply to the superficial palmar arch is the ulnar artery. This arch is located at Kaplan’s cardinal line at the distal extent of the transverse carpal ligament and is superficial to the median nerve and the long finger flexors. The common digital arteries to the second, third, and fourth web spaces arise from the superficial palmar arch.

- Deep to the median nerve and the long finger flexors is the deep palmar arch. The main blood supply of the deep palmar arch is the radial artery, which also gives a branch to the dorsal carpal arch. The princeps pollicis is a branch of the radial artery just distal to the deep palmar arch. It runs on the palmar aspect of the adductor pollicis before emerging into the subcutaneous tissue at the MCP flexion crease of the thumb. It then branches into the two collateral palmar arteries of the thumb, which run along the flexor sheath, before anastomosing at the fingertip. Other branches, given off while still at the level of the adductor pollicis, include the radialis indicis artery, which supplies the radial digital artery to the index finger, and a branch to the deep palmar arch.

- The dorsal carpal arch is formed by the radial and ulnar dorsal carpal branches. This arch is an important blood supply to the carpal bones, especially the scaphoid. The scaphoid receives its blood supply proximally along the dorsal carpal ridge via the dorsal carpal branch of the radial artery and distally from the volar tuberosity. The dorsal carpal arch extends distally with the dorsodigital arteries, which are important for performing local dorsal hand flaps.
The patency of the palmar arch can be determined by the Allen test (Figure 1–30). To perform the test, the radial and ulnar arteries are occluded with manual pressure while the patient makes a fist several times. Pressure is released from one artery, and capillary refill should be noted in the fingertips within 5 seconds. Failure to provide rapid capillary refill to all the digits after releasing pressure from one of the arteries indicates the patient has a vessel occlusion or an incomplete arch. Similarly, a digital Allen test can be performed at the finger level to assess the digital arteries.

References


Three palmar radiocarpal ligaments are described: radioscaphocapitate, long radiolunate, and short radiolunate.


This study examined the anatomy and mechanical properties of the dorsal radiocarpal and dorsal intercarpal ligaments of the wrist.


A classic description of the intrinsic mechanism.


A detailed discussion, with drawings, of the anatomy and function of the hand.


Figure 1–30: The Allen test to evaluate patency of the radial and ulnar arteries. (From Trumble TE, editor: Principles of hand surgery and therapy. Philadelphia, 2000, WB Saunders Company.)
A discussion of the tensions of the palmar radiocarpal ligaments.

A classic textbook on the physical examination of the entire musculoskeletal system and the provocative maneuvers for common pathologic conditions.


