

Nerve Injury

- When injury or disease occurs to a neural structure in the upper extremity, there is a high likelihood that multiple areas of neural pathology will develop. This phenomenon is known as the double or multiple crush syndrome. Remembering this concept lessens the possibility of missing relevant clinical findings.
- The various mechanisms of nerve injury include acute or chronic compression, stretch ischemia, electrical shock, radiation, injection, and laceration. Compression and laceration, impairments that are commonly seen by hand therapists, are described next.



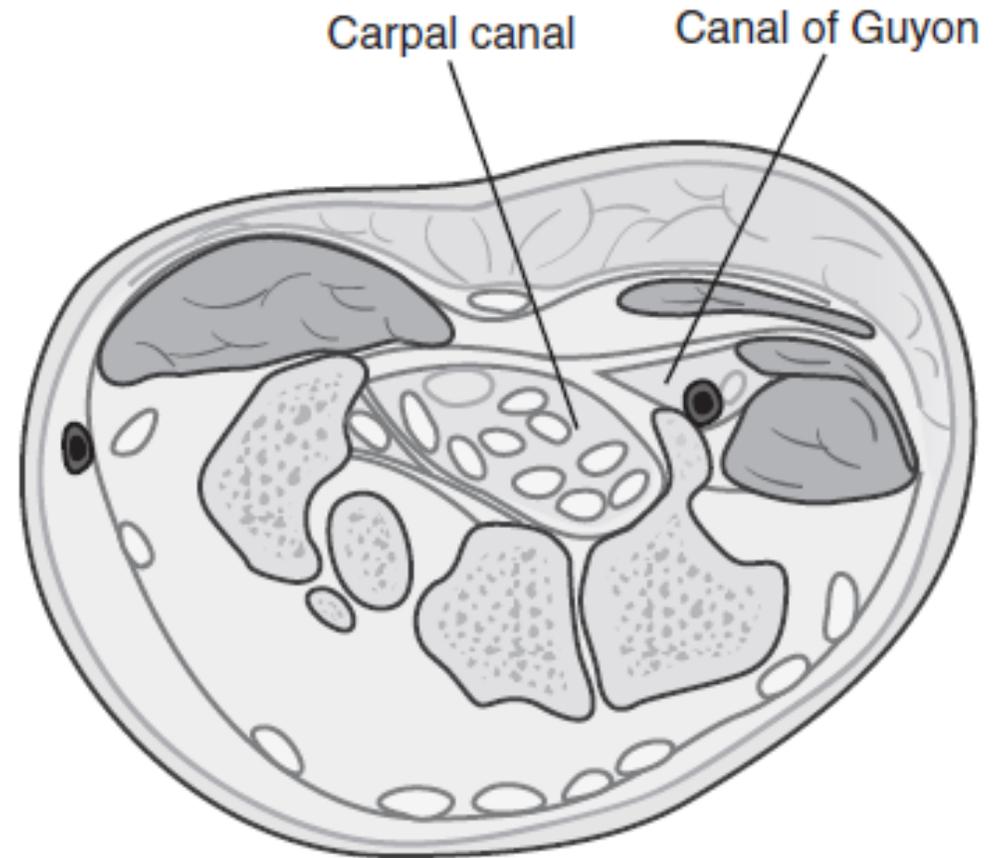
Nerve Compression

- **Median Nerve Compression at the Wrist, or Carpal Tunnel Syndrome**
Carpal tunnel syndrome is the most common upper extremity nerve entrapment. It results from compression of the median nerve at the wrist. The carpal bones form the floor of the carpal tunnel. The transverse carpal ligament, also called the flexor retinaculum, forms the roof of the tunnel and acts as a pulley for the flexor tendons during gripping. Inside the carpal canal are nine flexor tendons (four FDP, four flexor digitorum superficialis [FDS], and the flexor pollicis longus) and the median nerve, which is most superficial.





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- Swelling or thickening of the tendons can lead to pressure on the nerve, resulting in sensory symptoms in the distribution of the median nerve.
- Typical complaints include hand numbness, particularly at night or when driving a car, along with pain and paresthesia in the distribution of the median nerve (thumb through radial ring finger pads), and clumsiness or weakness



- Associated diagnoses include RA, Colles' fracture, diabetes, deconditioning, obesity, and thyroid disease. Transient carpal tunnel syndrome is fairly common in pregnancy. Carpal tunnel syndrome may be **associated with repetitive use or flexor tenosynovitis caused by increased friction between the tendons and nerve**. For these people, focus intervention on resolving the tendinitis.



- **Evaluation.** Perform a cervical screening, and evaluate posture, ROM, grip and pinch, and a manual muscle test looking for independent excursion of FDP and FDS. Also do Tinel's, Phalen's, Semmes-Weinstein Monofilament, and two-point discrimination tests. **Tapping at the volar wrist elicits Tinel's sign, which is a sensation of tingling or electric shock if the median nerve is compromised.**
- **Phalen's test provokes sensory symptoms in the median nerve distribution if positive, created by maintaining the wrist in flexion for 60 seconds.**



- Phalen's test should be **done with extended elbows** to avoid confusing these findings with a positive elbow flexion test (cubital tunnel syndrome).
- Advanced cases of carpal tunnel syndrome reveal thenar atrophy of the abductor pollicis brevis, which can be functionally debilitating



Carpal Tunnel Syndrome



Positive Phalen's Maneuver

Maintained flexion of the wrist at a 90° degree angle for 30-60 seconds reproduces CTS symptoms of tingling or pain.



- **Intervention** . Conservative medical management may include steroid injection. **Conservative therapy** for carpal tunnel syndrome includes **night splinting** with the wrist in neutral because this position minimizes pressure in the carpal tunnel, **exercises for median nerve gliding at the wrist**, differential flexor tendon gliding exercises, **aerobic exercise**, **proximal conditioning**, **ergonomic** modification, and **postural training**.
- **Teach patients to avoid extremes of forearm rotation or of wrist motions and to avoid sustained pinch or forceful grip. Provide padded gloves and built-up handles. Thick padded automobile steering wheel covers are helpful.**

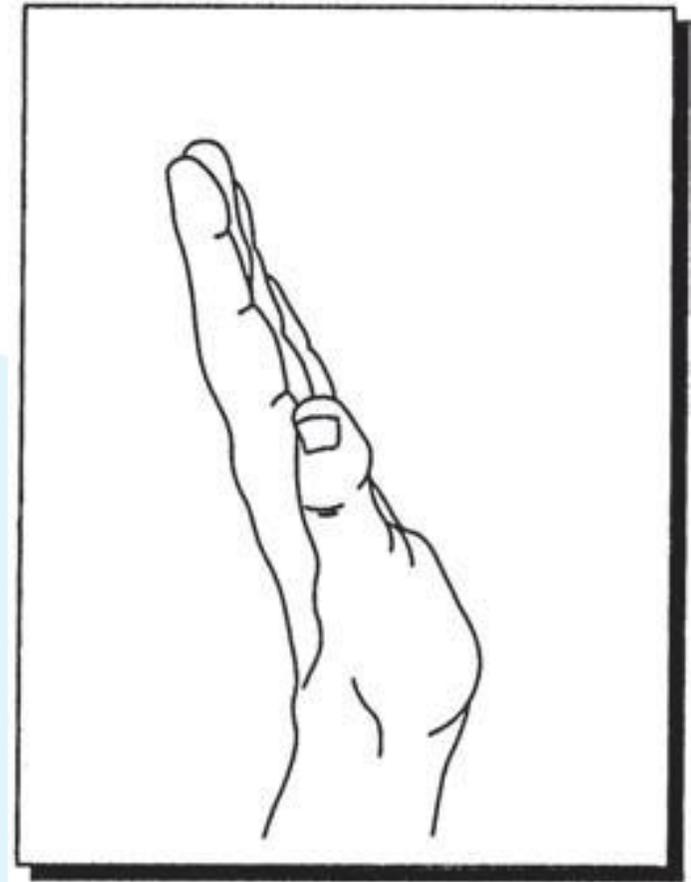
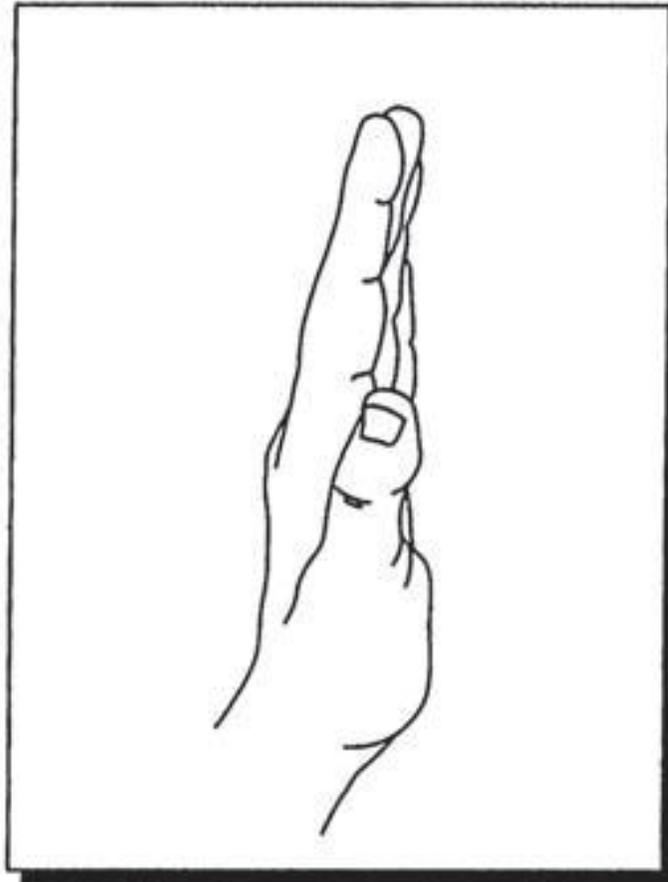
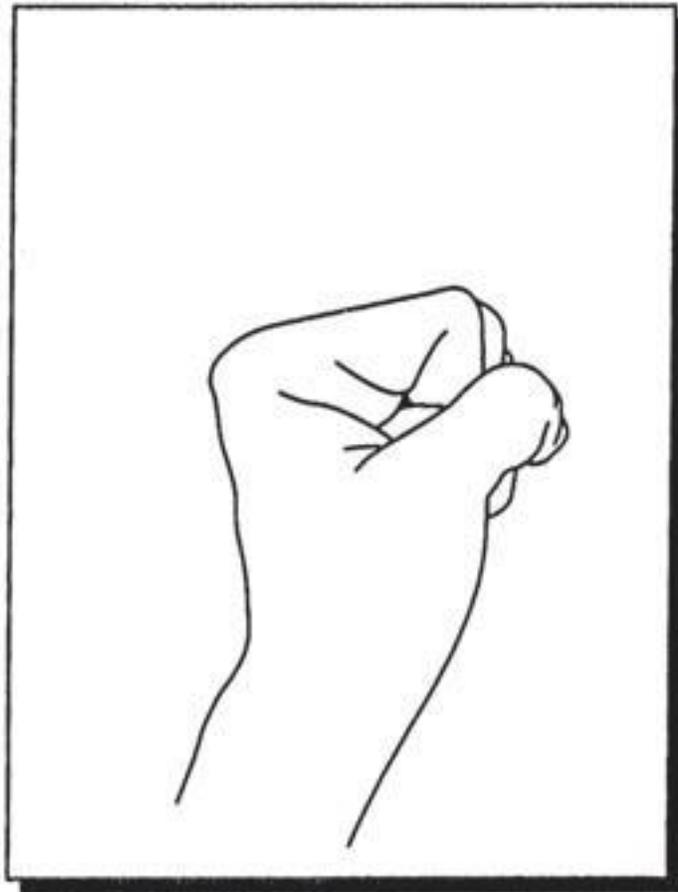


- Surgical intervention consists of decompression of the carpal tunnel by division of the transverse carpal ligament. Carpal tunnel release is one of the 10 most frequent surgeries performed in the United States.
- Postoperative therapy, when necessary, consists of edema control, scar management, desensitization as needed, nerve and tendon gliding exercises, and eventual strengthening. Many therapists postpone strengthening exercises until at least 6 weeks following carpal tunnel release to avoid inflammation. Patients with new and mild symptoms tend to recover best.

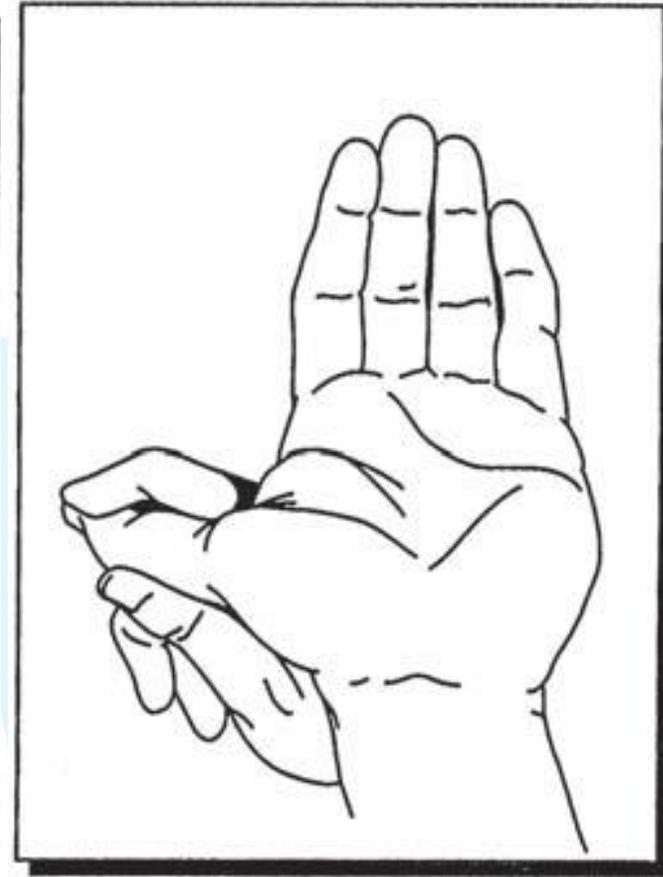
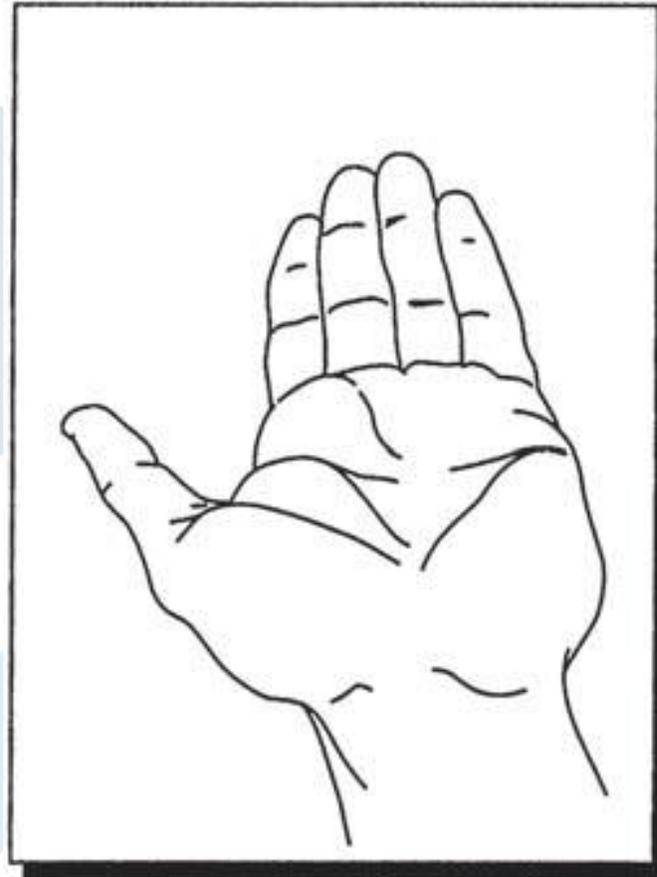
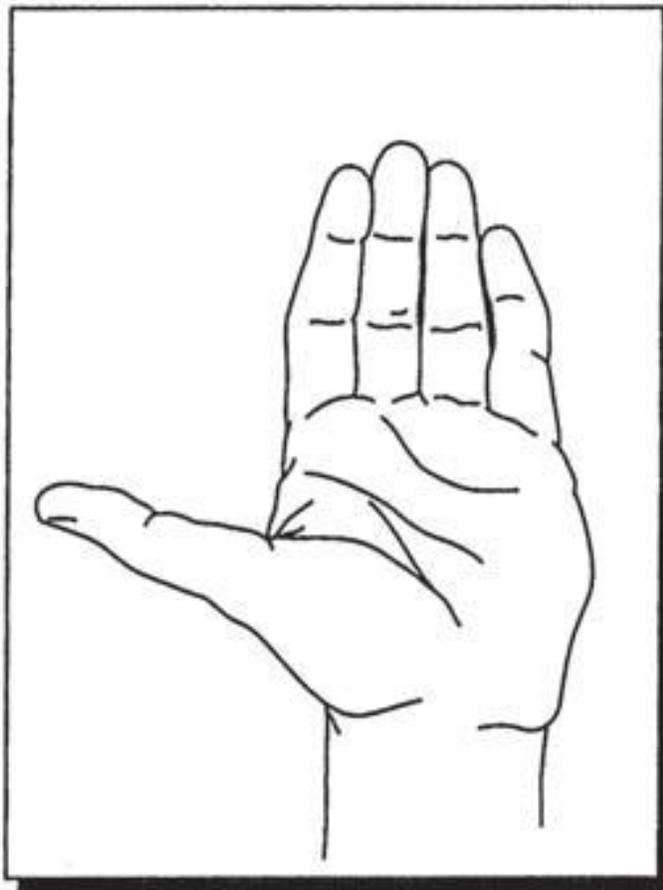


Median nerve gliding exercises at the wrist.

Positions: 1. Neutral wrist with finger and thumb flexion. 2. Fingers and thumb extended. 3. Wrist and fingers extended with thumb in neutral.



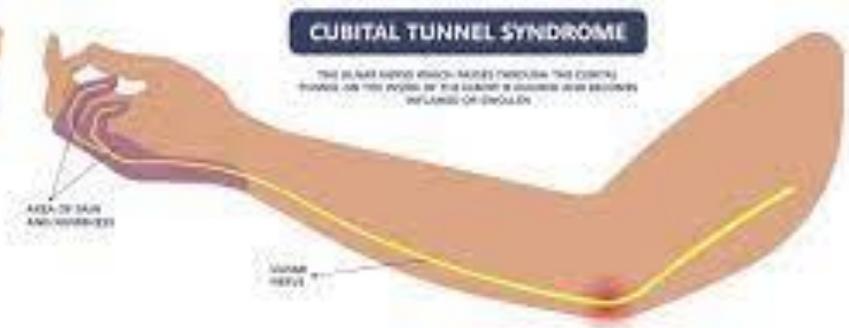
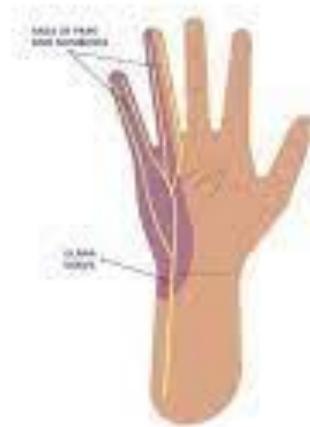
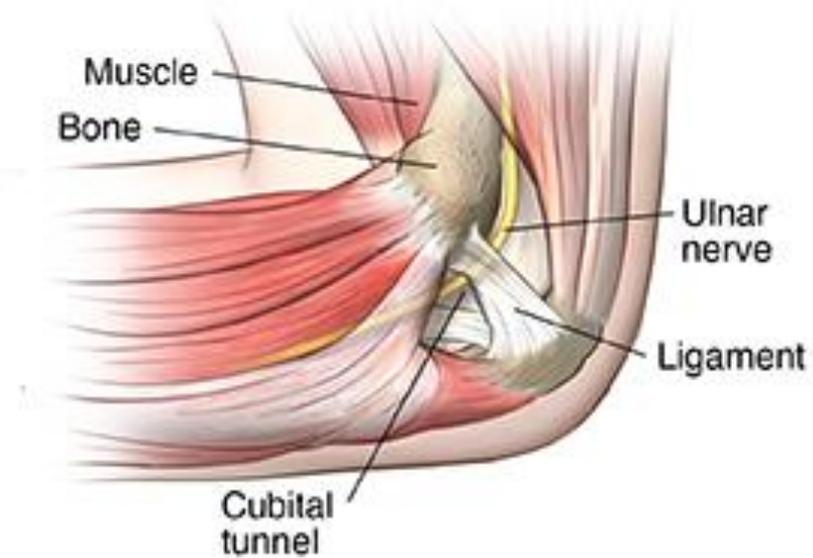
4. Thumb extended. 5. Forearm supinated. 6. Thumb gently stretched into extension.



Ulnar Nerve Compression at the Elbow, or Cubital Tunnel Syndrome.

- Cubital tunnel syndrome is the second most common upper extremity nerve entrapment and is the most commonly compressed site of the ulnar nerve, at its location between the medial epicondyle and the olecranon.
- Typical complaints include proximal and medial forearm pain that is aching or sharp; decreased sensation of the dorsal and palmar surfaces of the small finger and the ulnar half of the ring finger; and weakness of interossei, adductor pollicis (AP), FCU, and FDP of the ring and small fingers.



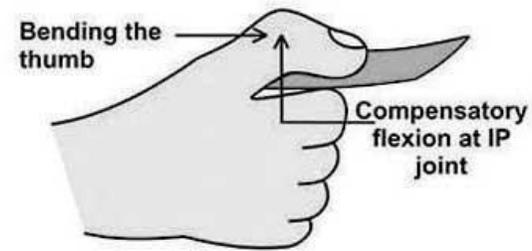


- Wartenberg's sign, the inability to adduct the small finger, and Froment's sign, in which effort at lateral pinch elicits thumb IP flexion because of weakness of the AP, may be seen. Grip and pinch strength are decreased, and patients complain of dropping things. Symptoms are worse when the elbow is flexed repeatedly or is kept in flexion because this position dramatically reduces the volume of the cubital tunnel. Understandably, symptoms may increase at night if the person sleeps with the elbow flexed.

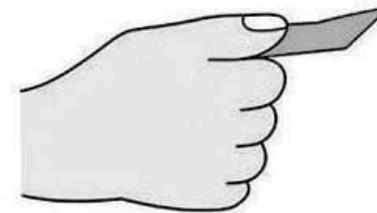




Froment's Sign



Positive
(Ulnar nerve palsy)



Negative
(Normal ulnar nerve)

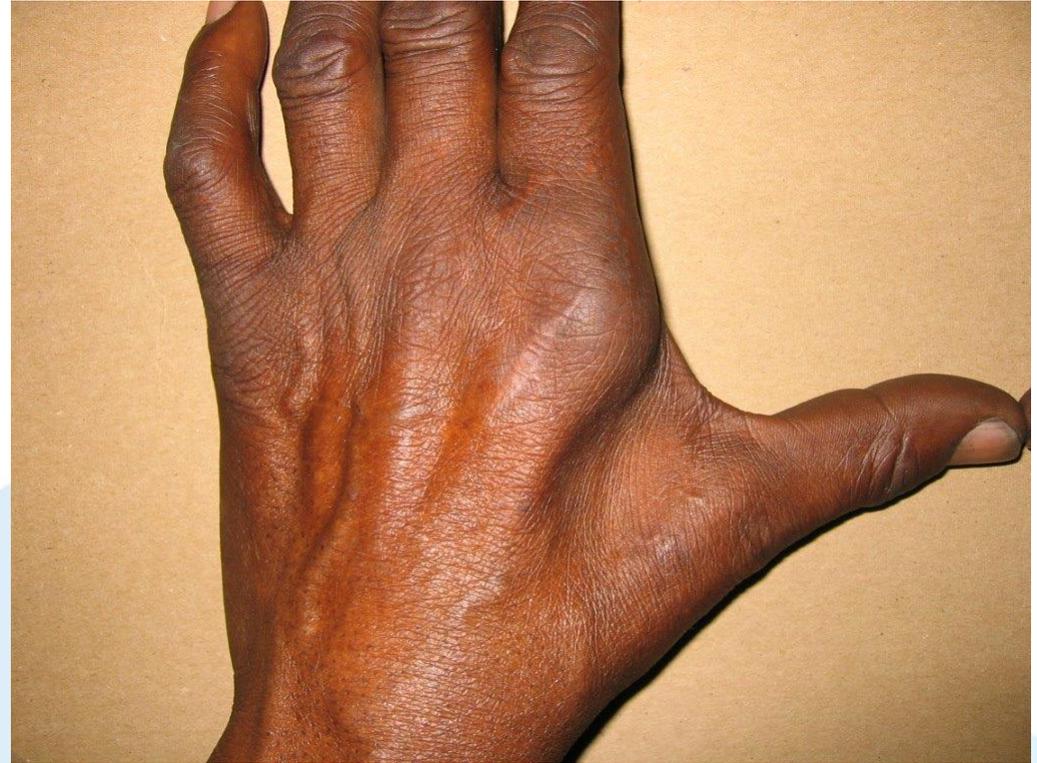


- Cubital tunnel syndrome may result from trauma, such as a blow to the elbow or fracture or dislocation of the supracondylar or medial epicondylar area, or it may be due to chronic mild pressure on the elbow. Associated diagnoses include osteoarthritis (OA), RA, diabetes, and Hansen's disease.



- Evaluation . Tapping over the cubital tunnel elicits a positive Tinel's sign. However, Tinel's sign may also be positive in 20% of normal people. **The elbow flexion test is positive if passively flexing the elbow and holding it flexed for 60 seconds produces sensory symptoms. Keep the wrist neutral** while performing the elbow flexion test so as not to confound the findings with Phalen's test.
- Look for **digital clawing and for muscle atrophy** in the first web space, hypothenar eminence, and medial forearm. Perform grip and pinch testing and manual muscle testing as appropriate, and test sensation.





- Intervention . Conservative therapy for cubital tunnel syndrome includes edema control; splinting or padding the elbow; and positioning guidelines to avoid leaning on the elbow, to avoid elbow-flexed postures, and to avoid elbow-intensive activity. An elbow orthosis helps prevent sleeping with the elbow flexed. Types of orthotics include elbow pads or soft splints, pillows, and anterior or posterior thermoplastic orthoses. The splinted elbow position for sleeping is usually about 30° of flexion. Additional therapy includes proximal conditioning, postural and ergonomic training, and ulnar nerve gliding exercises



Neural mobilization for cubital tunnel syndrome in highly irritable stage.

- A. Ipsilateral scapular elevation and cervical side-bending while the wrist, ring, and small fingers are extended with the forearm remaining supinated and the elbow extended.
- B. Return the scapula and cervical spine to neutral as the patient brings the wrist, ring, and small fingers into slight flexion.

Perform this in a slow and in rhythmic manner.



- **Radial Nerve Compression, or Posterior Interosseous Nerve Syndrome.**
- Posterior interosseous nerve syndrome **is purely motor**. It presents two clinical pictures. In one, paralysis affects all muscles innervated by the posterior interosseous nerve, with **inability to extend the MP joints of thumb, index, long, ring, or small fingers. Wrist extension occurs only radially** because of paralysis of extensor digitorum and ECU. In the other presentation of this syndrome, the person **cannot extend the MP joint of one or more digits. Paralysis may spread to other digits if it is not treated on a timely basis**



POSTERIOR INTEROSSEOUS NERVE INNervation

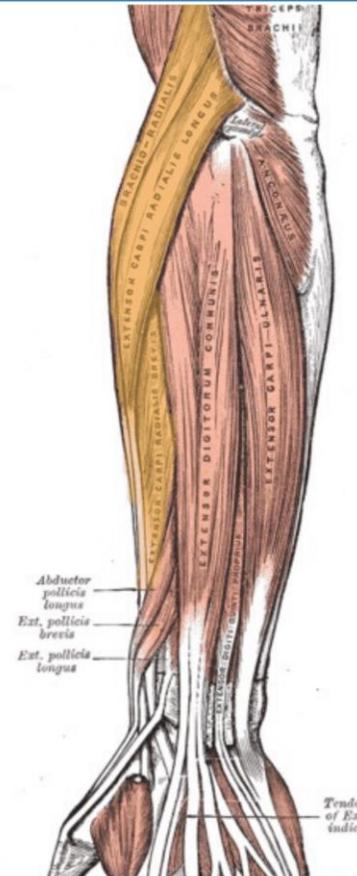
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PIN innervates all muscles in the extensor compartment, except those highlighted in yellow:

- Brachioradialis
- ERCL
- ERCB



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- A common **site** of entrapment of the posterior interosseous nerve is at the **supinator muscle**, where it pierces the two heads of this muscle. Other causes include **soft tissue tumors**, **RA** with synovial proliferation, and **radial head fractures or dislocations**. Therapy focuses on maintaining **PROM and orthotic selection** to prevent deformity and promote function.



Nerve Laceration

- Nerve lacerations are categorized as complete or partial. Stretching and contusion injuries can occur along with the laceration. Nerve reconstruction is termed primary if within 48 hours, early secondary if within 6 weeks, and late secondary after 3 months.
- The advantages associated with primary repair are that nerve stump retraction is limited, and electrical stimulation can be used to identify distal fascicles



- A **neuroma** , a disorganized mass of nerve fibers, can follow nerve injury. Significant nerve pain is elicited by tapping over the neuroma, with hypersensitivity limiting functional use of the hand.
- **Desensitization techniques are helpful, along with padding over the painful area to promote functional use.**



- Following nerve injury, therapy promotes functional performance in the areas of occupation with ADL training and adaptive equipment and assists in prevention of deformity with orthotics and appropriate PROM.
- Hand therapy provides valuable education to patients about their diagnosis and general recovery sequence and teaches protective guidelines to compensate for sensory loss. Hand therapy monitors changes in sensory and motor function and helps prevent joint contractures and imbalance by re-evaluating ROM, sensation, and muscle status. Orthotic modifications are based on clinical changes over time.



- **Low Median Nerve Lesion** . Median nerve laceration at the wrist results in low median nerve palsy, with denervation of the opponens pollicis and abductor pollicis brevis of the thumb and of the lumbricals to the index and long fingers. Clawing of the index and long fingers does not usually occur because the interossei remain ulnarly innervated.
- Loss of sensation of the radial side of the hand is present. With the absence of thumb abduction and opposition, the thumb rests in adduction, where it may become contracted. Fabricate a hand-based thumb abduction orthosis to maintain balance, to substitute for lost thumb opposition, and to prevent overstretching of denervated muscles.





Figure 37-12 Thenar wasting (atrophy of thumb muscles) caused by median nerve problem.



- Median nerve laceration creates serious functional loss of manipulation and sensibility of the thumb, index, and long fingers. Motor recovery usually occurs before sensory recovery. Be sure to teach compensatory strategies to avoid reinjury while sensibility is impaired. Instruct the patient to perform PROM to maintain joint mobility. Fabricate orthotics to sustain thumb abduction and digital MP flexion with IP extension to promote functional hand use and to counteract the deforming forces of the injury.



- **High Median Nerve Lesion** . Injury near or at the elbow is called a high median nerve injury. Along with the motor loss identified earlier, there is denervation of FDP to index and long fingers, FDS to all digits, pronator teres, and pronator quadratus.
- The median nerve is considered the most important sensory nerve, and its loss severely compromises hand function. In therapy, prepare patients for probable tendon transfers by preventing deformity with orthotics and by maintaining PROM of pronation, of digital MPs in flexion, of digital IPs in extension, and of thumb CMC abduction. Visual cues, adaptive devices, and modified handles may help compensate for the functional loss.



- **Low Ulnar Nerve Lesion.** Laceration of the ulnar nerve at the wrist level is called a low ulnar lesion. This injury results in loss of most of the hand intrinsics. Denervation of the abductor digiti minimi, flexor digiti minimi, and opponens digiti minimi results in flattening of the hand with loss of the ulnar transverse metacarpal arch; denervation of thumb AP and deep head of flexor pollicis brevis results in loss of thumb adduction and MP support; denervation of dorsal and volar interossei results in loss of digital abduction or adduction; and denervation of lumbricals to the ring and small fingers results in extrinsic imbalance.
- The ring and small fingers present a claw deformity , a position of MP hyperextension and PIP flexion associated with muscle imbalance in ulnar-innervated structures. Fine manipulation skills are compromised. Sensory loss involves the ulnar digits.



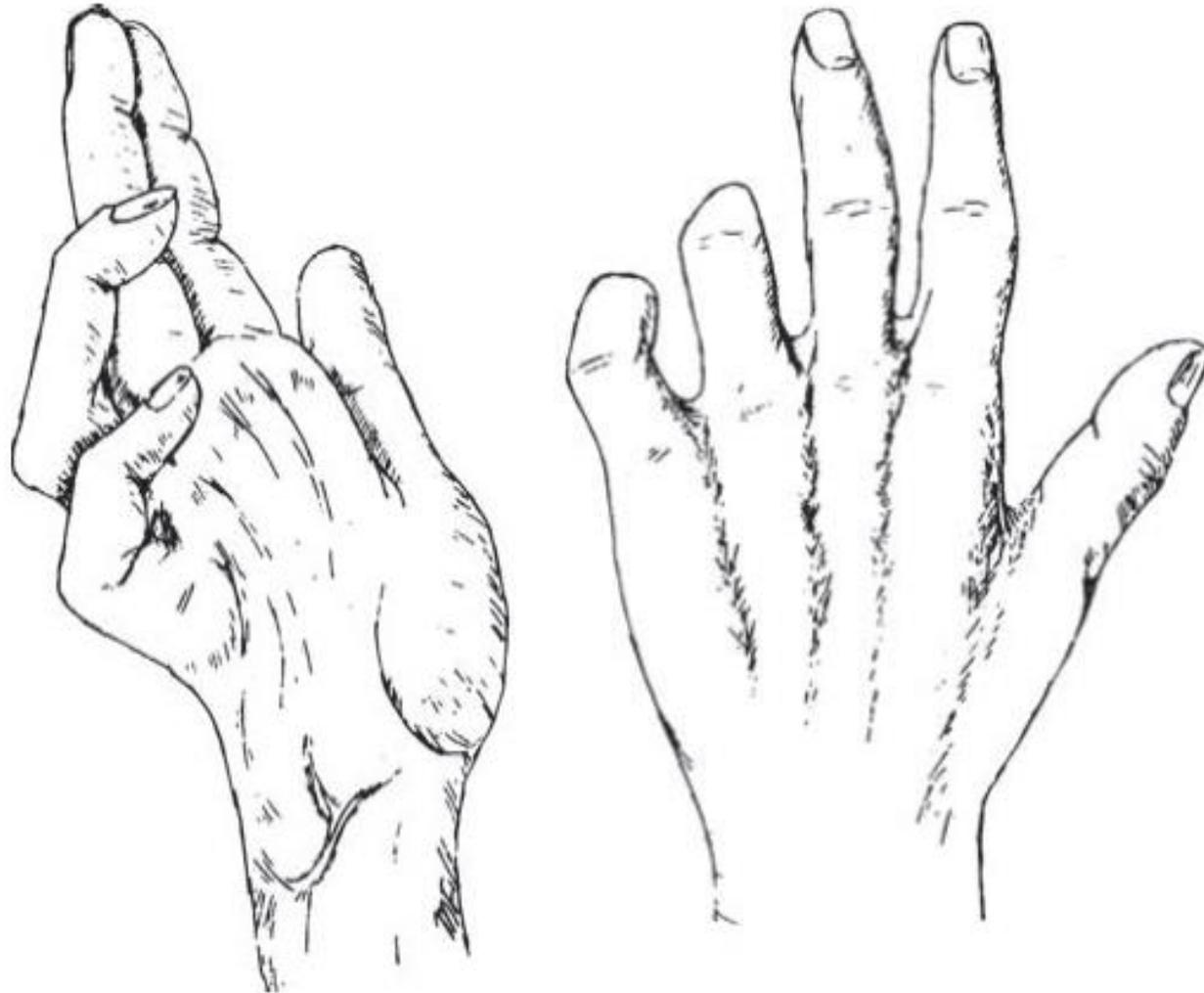


Figure 37-13 Clawing of digits seen with ulnar nerve problems. (From Snell, R. S. [2003]. *Clinical anatomy* [7th ed.]. Baltimore: Lippincott Williams & Wilkins.)



- Orthotic intervention for ulnar nerve palsy aims to prevent overstretching of the denervated ring and small finger intrinsics. An MP blocking orthosis that maintains slight MP flexion and prevents MP extension is recommended. Teach patients to compensate for sensory loss and to maintain passive range of the MPs in flexion and the IPs in extension. It is very important to prevent PIP flexion contractures. Built-up handles in conjunction with the MP blocking orthosis may be helpful.



- **High Ulnar Nerve Lesion** . A high ulnar nerve lesion is often identified with trauma at or proximal to the elbow. There is involvement of the muscles listed earlier and denervation of FDP of ring and small fingers and of FCU.
- Ring and small finger clawing is less apparent with the high lesion but becomes noticeable as the FDP are reinnervated and are unopposed by the still-absent intrinsics. Orthotic intervention and treatment are the same as for a low ulnar nerve lesion. If the FDP is absent, teach the patient to maintain full PROM of the IPs of the ring and small fingers to prevent contractures



- **Low Radial Nerve Lesion** . Low radial nerve injury of the deep motor branch is called posterior interosseous palsy.
- Presentations vary but brachioradialis and extensor carpi radialis longus function is usually present. Efforts to extend the wrist yield strong radial deviation. MP extension is affected.
- Sensation on the dorsal radial hand is affected. Therapy is similar to that described for radial nerve compression, with emphasis on maintaining PROM for wrist, thumb, and digital extension and orthotics to promote tenodesis for functional pinch, grip, and release.



- **High Radial Nerve Lesion** . A high radial nerve injury is seen commonly with humeral fractures because this nerve spirals around the humerus. Wrist and digital extensors are absent. Sensory loss occurs on the dorsal– radial hand, which interferes less with function than does sensory loss on the palmar hand. Triceps function remains, but the supinator and all wrist and finger extensors lose function. Tenodesis is lost.



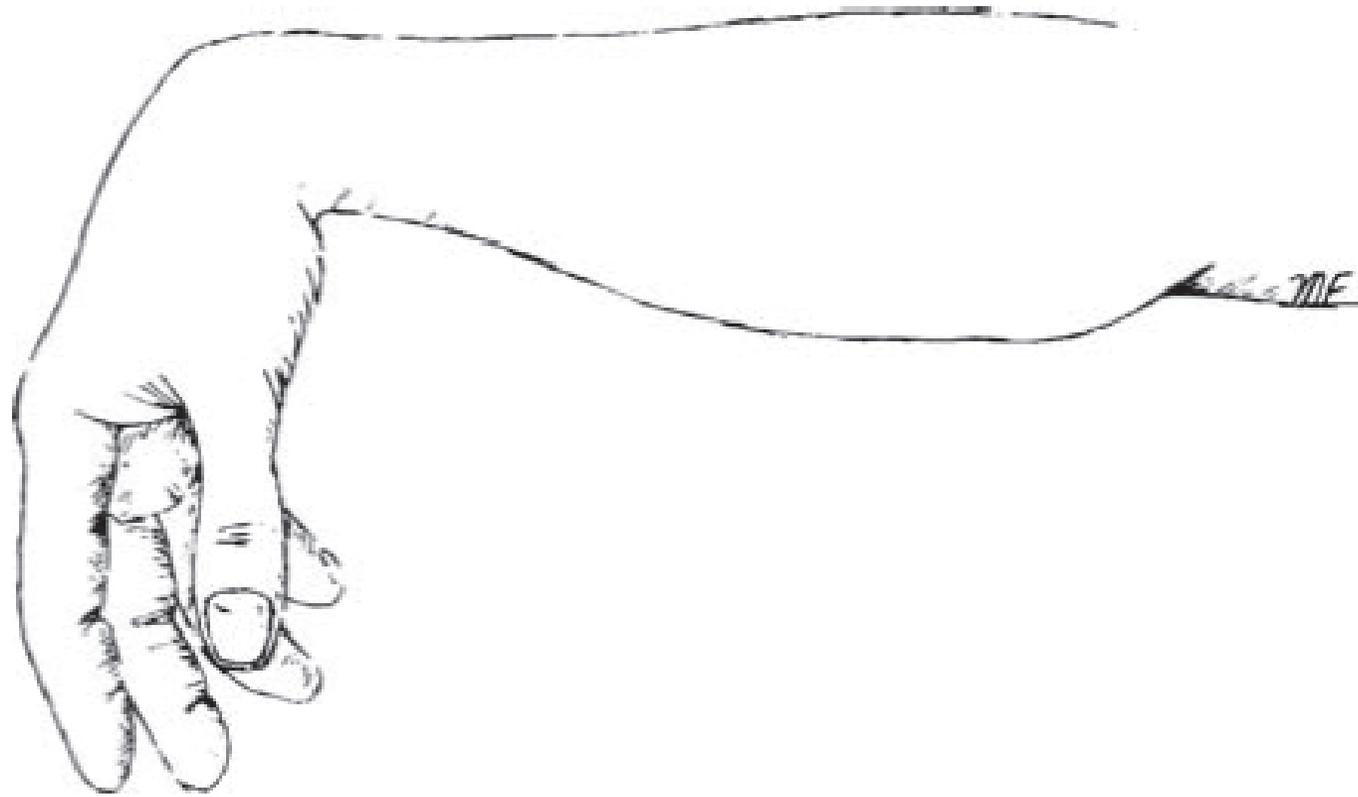


Figure 37-14 Wrist drop caused by radial nerve problem. (From Snell, R. S. [2003]. *Clinical anatomy* [7th ed.]. Baltimore: Lippincott Williams & Wilkins.)



- Splinting restores tenodesis and may be useful for the many months during the wait for reinnervation, which occurs at approximately 1 inch per month. Various static and dynamic orthoses are available; the dynamic orthotics are most useful functionally. Many patients make good use of both types of orthoses. Compliance tends to be good because of the functional value of these orthoses. It is important to maintain joint suppleness while awaiting reinnervation or reconstructive surgery.



Thank you

