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## Upper Extremity Nerve Entrapments


Scott P. Olvey, MD

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## Compression Neuropathies: Pathophysiology


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## Goals

- ☞ Understand peripheral nerve histology
- ☞ Understand the pathophysiology of peripheral nerve compression
- ☞ Identify the crucial elements necessary to establish an appropriate clinical diagnosis


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## Introduction

- ☞ Carpal Tunnel Syndrome (CTS) most common form of compressive neuropathy
- ☞ Electrodiagnostics provide objective data regarding compression (but not 100% sensitive)
- ☞ Compression causes vascular insult and mechanical impedance


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## Background

- ☞ Compression neuropathy: Nerve compression resulting in nerve dysfunction
  - ☞ Dysfunction may be symptomatic (numbness, tingling, pain) or asymptomatic (EMG/NCS findings only)
  - ☞ Mechanical compression may cause axonal occlusion
  - ☞ Compression may cause occlusion of microvascular inflow/outflow

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## Background

- ☞ Nerve compression may occur at several locations
  - ☞ Most commonly involves median nerve
    - ☞ Ulnar, radial, lateral antebrachial cutaneous nerves also to be considered
  - ☞ Compression usually emanates from extrinsic factors (swelling, unforgiving fascia, masses)
  - ☞ Compression may occur intrinsically (neural tumor)

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## Background: Neurons and Axons

- Neuron: Basic unit of peripheral nerve
  - Cell body with outreaching cytoplasmic extension (dendrites and axon) ending in synaptic terminals
- Axon provides:
  - Nerve conduction (impulse)
  - Axonal transport (cellular products/proteins)
- Multiple neurons grouped in fascicles create a peripheral nerve

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## Epineurium

- External epineurium
  - Outer most layer of peripheral nerve
  - Anchors blood vessels entering from tissue
- Internal epineurium
  - Fills spaces between fascicles
  - Provides cushioning and protection

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## Perineurium

- Encircles each fascicle
- Creates a diffusion barrier
  - An extension of the blood-brain barrier
  - Maintains a positive pressure within fascicles
  - Pressure difference important for axon functions (transport and conduction)
- Strongest component of peripheral nerve withstanding stretch/traction injury

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## Endoneurium

- Innermost collagen layer surrounding individual axons
- Single or double layer of endoneurium
- Vessels penetrate endoneurium
  - Longitudinal vessel network interconnected in epi-, peri-, & endoneurium
  - Allows nerves to mobilize over long distances
  - Allows excursion over joints

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## Epidemiology

- Up to 10% of the general population will suffer from compressive neuropathy
  - Most commonly carpal tunnel syndrome
- Multiple risk factors identified

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## Risk Factors

- Obesity
- Hypothyroidism
- Diabetes
- Pregnancy
- Renal disease
- Inflammatory arthritis
- Acromegaly
- Mucopolysaccharidosis
- Gender (women > men)
- Genetic predisposition
- Age (> 50 years of age)
- Smoking
- Occupational exposure

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## Pathophysiology: Multifactorial

- ☞ Systemic disease creates □ at risk □ environment
  - ☞ Diabetes, hypothyroidism, smoking
  - ☞ Microvascular disease
- ☞ Symptoms develop when pressure exceeds nerve threshold

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## Pathophysiology: Multifactorial

- ☞ Diabetes and microvascular disease may result in peripheral neuropathy

	Peripheral	Compressive
Location	Stocking/glove	Anatomic (peripheral nerve)
Bilateral?	Usually bilateral, symmetric	May be unilateral, asymmetric
Onset	Slow, progressive	Slow, progressive
Tinel's	Usually negative	Often positive
Injection response	None	Often relieved (+/- transient)

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## Pathophysiology: Multifactorial

- ☞ Long standing changes may not reverse due to vascular insult and fibrosis
- ☞ Traction: Compression may inhibit glide and contribute to neuropathy
  - ☞ Poor glide leads to poor microvascular inflow/outflow
  - ☞ Nerve may glide up to 15 mm at wrist or elbow

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## Double Crush

- ☞ Double crush: Proteins and cell body products travel distally, while breakdown products travel proximally
  - ☞ Disruption at one level decreases threshold elsewhere
  - ☞ Either site may be asymptomatic without second insult
  - ☞ Brachial plexus or thoracic outlet may put distal nerve at risk

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## General Principles of Diagnosis

- ☞ History, physical examination and laboratory data help determine presence of specific lesion
- ☞ Testing: No test is 100% specific and sensitive
  - ☞ EMG/NCS
  - ☞ Hand diagrams
  - ☞ Static 2-point discrimination
  - ☞ Semmes-Weinstein
  - ☞ Provocative maneuvers
  - ☞ Physical findings (atrophy, clawing, etc.)

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## General Principles: Electrodiagnostics

- ☞ Often only objective measure available
- ☞ Not always positive in early stages
- ☞ False negative results may occur
- ☞ Operator dependent
- ☞ Allows localization of lesion with inching technique
- ☞ Allows measure of progression/resolution
- ☞ Normal values may vary between laboratories
- ☞ Conduction velocities are temperature dependent

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## Summary



- ☞ Compression leads to vascular insult and blocks axonal transport and conduction
- ☞ Multiple sites of potential compression
- ☞ Localization and correct diagnosis allows appropriate treatment
  - ☞ Consider effect of systemic disease
- ☞ EMG/NCS assists in diagnosis
- ☞ CTS most common

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## Compression Neuropathies: Carpal Canal and Pronator

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## Goals

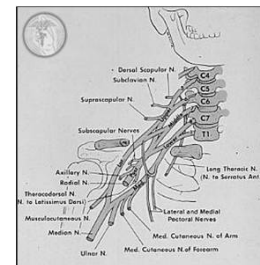
- ☞ Know criterion for diagnosis of Carpal Tunnel Syndrome, Anterior Interosseous Syndrome and Pronator Syndrome.
- ☞ Understand specific examination and tests used to diagnosis median nerve compression syndromes
- ☞ Know options for non operative and operative treatment of median nerve compression syndromes

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## Median Nerve Anatomy

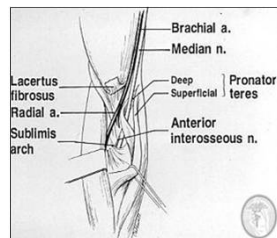
- ☞ Originates from lateral and medial cords of the Brachial Plexus
- ☞ Contains fibers from the C6, C7, C8 and T1 nerve roots and sometimes from C5.



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## Median Nerve Anatomy

- ☞ Travels down medial arm to the cubital fossa
- ☞ Enters forearm medial to the brachial artery
- ☞ Passes through the two heads of the pronator teres
- ☞ Gives off no branches in the upper arm.
- ☞ Give anterior interosseus branch as it passes under the pronator



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## Median Nerve Anatomy Muscles Supplied in Forearm

- ☞ Median Nerve Proper
  - ☞ Pronator Teres (PT) Muscle
  - ☞ Flexor Carpi Radialis (FCR)
  - ☞ Palmaris Longus (PL)
  - ☞ Flexor Digitorum Superficialis (FDS)
- ☞ Anterior Interosseous N
  - ☞ Flexor Digitorum Profundus (FDP) to index and long fingers
  - ☞ Flexor Pollicis Longus (FPL)
  - ☞ Pronator Quadratus (PQ)

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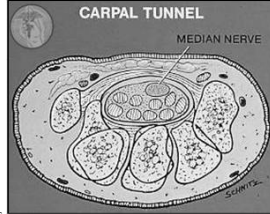
## Carpal Tunnel Anatomy

### Contents

- ☞ median nerve
- ☞ FDP index-small
- ☞ FDS index-small
- ☞ FPL

### Borders

- ☞ transverse carpal ligament (TCL)
  - ☞ roof of carpal tunnel
  - ☞ connects from the pisiform and hook of the hamate to the scaphoid tuberosity and trapezial beak.
  - ☞ ligament is confluent with antebrachial fascia of forearm
- ☞ carpus forms radial and ulnar borders and floor



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### Idiopathic Carpal Tunnel Syndrome

- 3:1 Female : Male
- 4th-5th decade and beyond
- Correlates most with increased Body mass index (BMI)

### Other Risk Factors

- Diabetes, hypothyroidism, rheumatoid arthritis and pregnancy

## Epidemiology

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## Symptoms Carpal Tunnel Syndrome

The symptoms of carpal tunnel are those caused by dysfunction of the sensory and motor components of the median nerve.

Sensory symptoms include decreased sensation (numbness), tingling in the median nerve sensory distribution and pain radiating both in the distribution of the median nerve and more proximally up the arm.



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## Aggravators of Symptoms

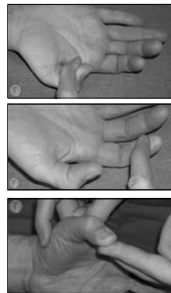
Patients will report the symptoms as worse with activities which increase the pressure on the median nerve in the carpal tunnel such as driving a car, grasping vigorously, operating heavy/vibrating equipment or sleeping (when a flexed wrist posture can increase pressure).



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## Specific Motor Functions

- ☞ Testing of FPL for anterior interosseous nerve lesion
- ☞ Testing of Index FDP for anterior interosseous nerve lesion
- ☞ Testing of Abductor Pollicis Brevis via palpation of APB with resisted opposition



Courtesy of Andrew P. Gutler, MD

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## Clinical Evaluation

- ☞ Observation for thenar atrophy
- ☞ Sensory testing
- ☞ Motor testing (APB)
- ☞ Provocative testing via median nerve compression
- ☞ Electrodiagnostic testing

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## Observed Signs

The primary visible sign of carpal tunnel syndrome is isolated thenar atrophy

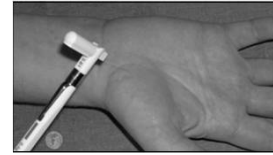


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## Sensory Testing

- ↳ Can help determine the level of the lesion
  - ☞ No sensory deficits: Pure motor lesion
    - ↳ Anterior Interosseous Nerve Syndrome
  - ☞ A sensory deficit in dermatomal pattern
    - ↳ cervical radiculopathy (e.g. C6 nerve root compression)
  - ☞ Absence of palmar cutaneous sensation suggests lesions above carpal tunnel



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Courtesy of Andrew P. Gutw, MD

## Phalen's Test

Phalen's test of wrist flexion is positive if it recreates the symptoms of numbness or tingling within 60 seconds. Helpful to reconfirm diagnosis with clinical history (sensitivity 0.75) but has high incidence of false positive (specificity 0.47).



The test is gravity assisted without extreme flexion of the elbow, which can cause ulnar nerve symptoms from stretching of the ulnar nerve in the cubital tunnel in the elbow.

Courtesy of Andrew P. Gutw, MD

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## Tinel's (Sign) Test

Direct tapping of an irritated nerve can recreate tingling in the sensory distribution of the nerve. For the median nerve tapping at the proximal aspect of the carpal tunnel over the median nerve is confirmatory (sensitivity 0.60) but not absolute (specificity 0.67).



The median nerve enters the carpal tunnel just radial to the palmaris longus at the ulnar side of the thenar eminence.

Courtesy of Andrew P. Gutw, MD

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## Compression Test (Durkan's)

Median nerve compression test

- Most sensitive (0.87) and specific (0.90) provocative test
- Direct pressure is placed over the median nerve at the carpal tunnel.
- Positive test recreates within 30 seconds the patient's sense of tingling or numbness in the median nerve distribution.



Courtesy of Andrew P. Gutw, MD

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## Electro diagnostic Testing

- ↳ Nerve Conduction Velocity (NCV) and Electromyography (EMG). These studies can help confirm the diagnosis of carpal tunnel syndrome, but do not in themselves give a diagnosis which requires treatment without co occurring symptoms.
- ↳ NCV/EMG can be helpful in confirming the anatomic level of compression of a nerve and in looking for more proximal lesions or generalized neuropathies.

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## Electro diagnostic Testing

- ↳ NCV testing measures both conduction velocity as well as the amplitude of action potentials.
- ↳ NCV can show slowing of conduction latencies (distal latency) across the carpal tunnel and decreased action potential amplitude.
- ↳ Sensory conduction latencies (distal sensory latency) increase first in mild cases before motor conduction latencies increase.
- ↳ Decreased amplitude of the compound motor action potential (CMAP) is a finding in more severe disease.

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## Electromyogram (EMG)

- ↳ Needle EMG study requires direct recording from a muscle and is used to assess for denervation or to measure severity of the nerve dysfunction.
- ↳ Denervated muscles show increased insertional activity, abnormal fibrillation potentials at rest and poor recruitment of motor units.
- ↳ EMG can be helpful in separating proximal from distal nerve compression if muscles proximal to the carpal tunnel are tested and also show evidence of denervation.

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## Prevention

- ↳ Control of contributing diseases
  - ✦ Control sugar in DM
  - ✦ Medically control tenosynovitis in RA
  - ✦ Correct Hypothyroidism
- ↳ No strong evidence of prevention from work modification.
  - ✦ Some suggestion of benefit to avoidance of continual strenuous grasping and extreme wrist positions

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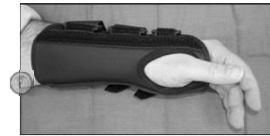
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## Treatment

- ↳ Decreasing the pressure in the carpal tunnel thereby improving the blood flow
- ↳ Non operative treatment decrease the volume of structures in the carpal tunnel by treating tendon enlargement or improve median nerve nourishment by using night time neutral wrist splinting to provide a daily period of improved blood flow.

Courtesy of Andrew P. Gutw, MD

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## Cortisone Injection

Injection of corticosteroid has been shown to improve symptoms, although at one year follow up only 20-50% of patients injected were symptom free.



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## Surgical Treatment

- ↳ Increases space available for the median nerve by sectioning transverse carpal ligament opening up the volar aspect of the carpal tunnel.
- ↳ Slight increase risk of nerve or tendon injury with minimal incision methods, with long term outcome and complication similar for all techniques with > 90% success and patient satisfaction rates.

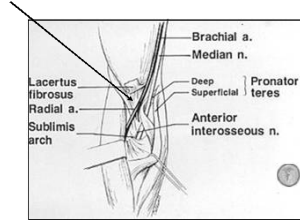
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## Anterior Interosseous Syndrome Definition

↳ Anterior Interosseous : pressure on nerve in proximal forearm or neuritis (Parsonage-Turner)

↳ The symptoms and signs : weakness of AIN innervated FDP, FPL, PQ muscles and vague sensory pain

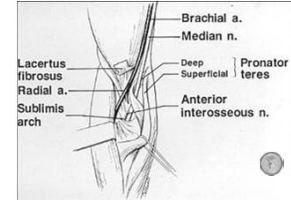


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## Anterior Interosseous Syndrome Treatment

↳ Anterior Interosseous Syndrome often spontaneously resolves.

↳ Surgical treatment is directed at release of the compression on the AIN in the forearm with fibrous bands of the pronator teres most frequently the site.

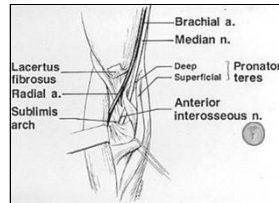


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## Pronator Syndrome Definition

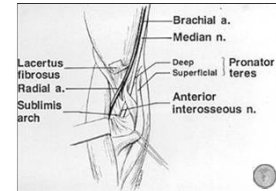
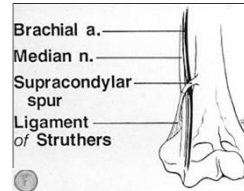
↳ Pronator Syndrome is a disorder caused by pressure induced dysfunction of the median nerve in the distal arm and proximal forearm.

↳ The symptoms and signs of pronator syndrome are the symptoms and signs of proximal median nerve dysfunction with both motor and sensory deficits



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## Pronator Syndrome Points of Compression



In Pronator Syndrome, from proximal to distal, the median nerve can be compressed in the arm beneath the ligament of struthers, under the lacertus fibrosus, between the heads of the pronator teres muscle and finally under the proximal arch of the FDS muscle.

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## Pronator Syndrome Diagnosis and Treatment

↳ Diagnosis of pronator syndrome requires recognition of median nerve motor and sensory deficits proximal to the wrist.

↳ Non operative treatment with rest, activity modification frequently successful

↳ Surgical treatment of pronator syndrome, requires identification of the point of compression and then surgical release of the offending structures.

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## Diagnosis of Median Nerve Compression Syndromes

Diagnosis is founded on:

- A clear history of specific symptoms.
- Clinically apparent signs.
- Clinically measurable sensory and motor deficits.
- Reproducible provocative diagnostic tests
- And, if needed, electro diagnostic tests.

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## Compressive Neuropathies: Cubital Tunnel

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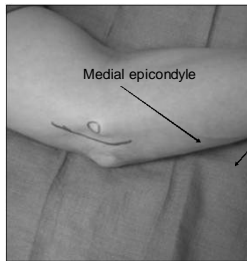
## Goals

- ⌘ Understand:
  - ⌘ Anatomy of the ulnar nerve at the elbow
  - ⌘ Pathophysiology of cubital tunnel syndrome
  - ⌘ Symptoms of patients with cubital tunnel syndrome
  - ⌘ Key points in the physical examination
  - ⌘ The role of electrodiagnostic studies
  - ⌘ Options for treatment
  - ⌘ Post operative management
  - ⌘ Expectations after surgery

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Cubital Tunnel Syndrome Describes the Symptom Complex Associated With Compression of the Ulnar Nerve at the Elbow.



Medial epicondyle

Path of ulnar nerve passing posterior to the medial epicondyle through the cubital tunnel

Courtesy of S. Houston Payne, MD

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## Cubital Tunnel Review Key Points of the Presentation

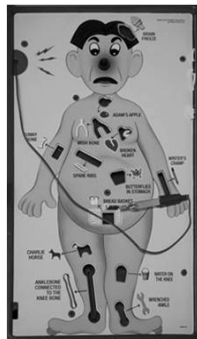
- ⌘ Initial symptoms in cubital tunnel can be non-specific (weakness, decreased coordination, or clumsiness).
- ⌘ Consider compression at other levels.
- ⌘ Educate the patient in non-operative management.
- ⌘ Pay attention to all possible points of compression in surgical treatment.

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## Anatomy of the Ulnar Nerve

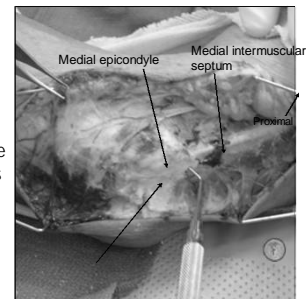
- ⌘ The ulnar nerve is a continuation of the medial cord of the brachial plexus and contains nerve fibers from the eight cervical (C8) and first thoracic (T1) roots.
- ⌘ It descends in the medial brachium posterior to the medial intermuscular septum.



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## Anatomy of the Ulnar Nerve

- ⌘ The cubital tunnel is a fibro osseous tunnel bordered medially by the elbow joint. It maintains the nerve in the ulnar groove posterior to the medial epicondyle.



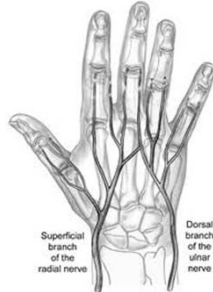
Courtesy of John G. Selzer, MD

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Cubital tunnel containing ulnar nerve, posterior to the medial epicondyle

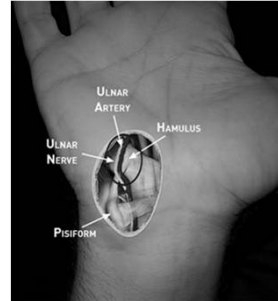
## Anatomy of the Ulnar Nerve

- ↳ Innervation to the flexor carpi ulnaris and the flexor digitorum profundus (FDP) of the ring and small finger.
- ↳ Above the wrist the dorsal cutaneous branch passes dorsally on the ulnar margin of the forearm to provide sensation to the dorso-ulnar aspect of the hand.



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## Anatomy of the Ulnar Nerve

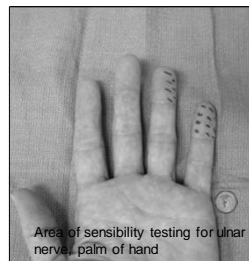


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- ↳ Below the wrist the nerve enters the hand through the canal of Guyon.
- ↳ It provides sensation to the ulnar border of the ring finger and both borders of the small finger.
- ↳ Motor fibers extend to the hypothenar musculature, ulnar two lumbricals, and the interosseous muscles.

## Anatomy of the Ulnar Nerve

- ↳ This innervation pattern is the "classic" description. However, as in all anatomy variations of sensory and motor innervation exist.



Courtesy of S. Houston Payne, MD

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## Clinical Presentation of Cubital Tunnel Syndrome

- ↳ classic presentation:
  - ⌘ a complaint of paresthesias or numbness in the ulnar two digits
  - ⌘ pain or soreness in the medial elbow and/or forearm
  - ⌘ the patient may note that the symptoms are worsened with elbow flexion and may awaken them at night.

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## Clinical Presentation of Cubital Tunnel Syndrome

- ↳ In severe cases muscle atrophy will be present.
- ↳ This is most easily appreciated in the first dorsal interosseous muscle.



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## Clinical Presentation of Cubital Tunnel Syndrome

- ↳ Cubital tunnel may present with more vague or subtle symptoms. These include:
  - ⌘ easy fatigue ability in the hand
  - ⌘ a subtle sense of clumsiness
  - ⌘ weakness or "dropping things"

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## Pathophysiology of Cubital Tunnel Syndrome

- ↳ With elbow flexion, the ulnar nerve is placed under the traction and is compressed by the changing shape of the cubital tunnel.
- ↳ Previous trauma may cause nerve adherence which decreases longitudinal excursion of the nerve and increases traction forces.

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## Pathophysiology of Cubital Tunnel Syndrome

- ↳ This traction and compression force produces local nerve ischemia.
- ↳ Initially these changes may cause transient symptoms without any long term changes in the nerve.
- ↳ However, if the situation persists or worsens, permanent changes can occur in the nerve

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## Examination of the Patient with Cubital Tunnel Syndrome

- ↳ Compression of the ulnar nerve at the wrist (Guyon's canal) can produce symptoms suggesting cubital tunnel syndrome.
- ↳ There are at least two clinical findings to differentiate this level of compression:
  - ↳ Sensation on the dorsum of the hand should be unaffected by compression at the the wrist level.
  - ↳ Compression at the wrist will not effect the strength of the flexor digitorum profundus of the ring and small fingers.

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## Examination of the Patient with Cubital Tunnel Syndrome

- ↳ Palpation along the course of the nerve at the elbow is important.
- ↳ Tenderness at some point along the nerve at the elbow is expected and may further localize the point of compression.
- ↳ A " Tinel's" sign may be present over the nerve at a precise location.

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## Examination of the Patient with Cubital Tunnel Syndrome

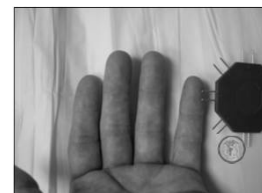
- ↳ The elbow flexion test is a helpful provocative test.
  - ↳ The patient flexes his/her elbow fully with the wrist maintained in a neutral position for up to 1 minute
  - ↳ A positive test occurs if this produces numbness and tingling in the ulnar distribution

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## Examination of the Patient with Cubital Tunnel Syndrome

- ↳ Sensory evaluation may include
  - ↳ two point discrimination
  - ↳ Semmes-Weinstein monofilament evaluation
  - ↳ subjective evaluation of light touch sensibility



Courtesy of S. Houston Payne, MD

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## Examination of the Patient with Cubital Tunnel Syndrome

- ↳ Muscle testing should include inspection for muscle atrophy in the hand.
- ↳ Ulnar innervated intrinsic muscle strength can be compared to the opposite side.
- ↳ Strength of the FDP of the ring and small finger is evaluated



Small finger FDP strength check

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## Electrodiagnostic Studies in the Evaluation of Cubital Tunnel Syndrome

- ↳ Both nerve conduction studies and electromyography (EMG) can be helpful in evaluating the patient with cubital tunnel syndrome.
- ↳ Decreased motor conduction velocity at the elbow indicates nerve compression.
- ↳ EMG abnormalities in ulnarly innervated muscles indicate more significant nerve compression
- ↳ Cervical paraspinal EMG abnormalities may be suggestive of a proximal level of compression

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## Electrodiagnostic Studies in the Evaluation of Cubital Tunnel Syndrome

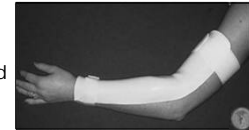
- ↳ As with any compressive neuropathy, the electrodiagnostic studies are to be used as an adjunctive test.
- ↳ This is particularly true in cubital tunnel syndrome as patients may have normal studies but significant symptoms.

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## Non-operative treatment of the patient with Cubital Tunnel Syndrome

- ↳ Non-operative treatment is directed towards limiting prolonged elbow flexion and preventing direct compression of the nerve at the elbow.



Fabricated splint to prevent excessive elbow flexion.

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## Non-operative treatment of the patient with Cubital Tunnel Syndrome

- ↳ Patient education is very useful in non-operative treatment. Once the patient understands the diagnosis, they can frequently identify daily activities which may be contributing to their symptoms.

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## Non-operative treatment of the patient with Cubital Tunnel Syndrome

- ↳ Either rigid or soft, padded elbow splints may be used effectively to protect the nerve from direct compression and limit elbow flexion.
- ↳ Splinting at night is particularly important as prolonged extreme elbow flexion is common during sleep.
- ↳ Up to three months of non-operative treatment in mild compression is reasonable before considering surgical treatment.

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## Operative treatment of Cubital Tunnel Syndrome

- ↳ Patients with unchanged or worsening symptoms after a trial of non-operative treatment should be considered for surgical management.
- ↳ The goal of surgical treatment is to decrease pressure on the nerve

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## Operative treatment of Cubital Tunnel Syndrome

- ↳ Many procedures have been described for the treatment of cubital tunnel syndrome.
- ↳ These include:
  - ↳ in-situ decompression
  - ↳ medial epicondylectomy
  - ↳ anterior transposition with the nerve placed in the subcutaneous tissue, below the flexor pronator mass, or in the muscle

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## Operative treatment of Cubital Tunnel Syndrome

- ↳ The many procedures available indicate both surgeon preference and some degree of continuing dissatisfaction with each procedure.

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## Operative treatment of Cubital Tunnel Syndrome

- ↳ In situ decompression involves a release of the cubital tunnel and proximal fascia of the flexor carpi ulnaris muscle.
- ↳ It is only indicated in a patient with no history or exam to indicate nerve subluxation.

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## Operative treatment of Cubital Tunnel Syndrome

- ↳ Transposition of the nerve after decompression is/was more common.
- ↳ Once the nerve is transposed, it may be placed in the subcutaneous tissue, flexor muscle mass, or below the flexor muscle mass.

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## Complications after Surgical Treatment.

- ↳ Incomplete decompression at the time of surgical treatment may allow symptoms to persist.
- ↳ Injury to branches of the medial antebrachial cutaneous nerve can produce painful neuromas which are much more symptomatic than the area of sensory loss.
- ↳ Recurrent posterior subluxation of the nerve can occur

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## Outcomes after surgical treatment.

- ↳ In patients with mild to moderate symptoms, outcomes are similar regardless of the specific operative procedure.
- ↳ Failure of improvement in clinical symptoms may occur in spite of appropriate operative treatment.
- ↳ Patients with significant muscle atrophy preoperatively, do not commonly recover full muscle strength even if other symptoms are improved.

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## Summary

- ↳ Initial symptoms in cubital tunnel can be non-specific (weakness, decreased coordination, or clumsiness).
- ↳ Consider compression at other levels.
- ↳ Educate the patient in non-operative management.
- ↳ Pay attention to all possible points of compression in surgical treatment.
- ↳ Protect branches of the medial antebrachial cutaneous nerve in the surgical approach.

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## Compressive Neuropathies: Brachial Plexus (Thoracic Outlet Syndrome)

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## Goals

- ↳ To review the anatomy of the brachial plexus
- ↳ To understand potential sites of compression in the thoracic outlet
- ↳ To become familiar with appropriate physical examination and diagnostic evaluation
- ↳ To understand the conservative and operative treatment options

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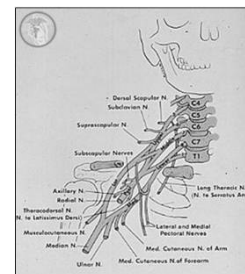
## Brachial plexus anatomy

- ↳ Derived from spinal levels C5 to T1
- ↳ Spinal cord
  - ↳ Motor axons originate in ventral horn
- ↳ Merge with dorsal sensory ganglion to form roots
- ↳ Roots C5 to T1 exit their spinal foramen to form the brachial plexus

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## Brachial plexus anatomy



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## Thoracic Outlet Syndrome: Etiology

- ☞ Three-dimensional dynamic compression involving the first rib, clavicle, scapula, and trapezius muscle
- ☞ Abnormal insertions of scalene muscles
- ☞ Results in compression of a combination of the brachial plexus, subclavian artery, and subclavian vein
- ☞ These structures are affected in varying degrees

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## Thoracic Outlet Syndrome

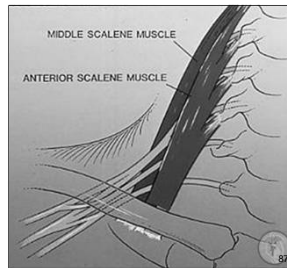
- ☞ Three potential compression sites
  - ☞ 1. Interscalene triangle
  - ☞ 2. Costoclavicular space
  - ☞ 3. Retro-pectoralis minor space

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## 1. Interscalene triangle

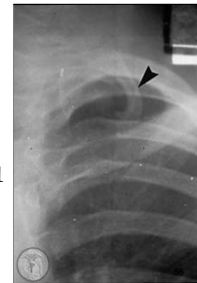
- ☞ Borders
  - ☞ Anterior: Anterior scalene muscle
  - ☞ Posterior: Middle scalene muscle
  - ☞ Inferior: First rib



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## 1. Interscalene triangle

- ☞ Compressive structures:
  - ☞ Scalenus muscle
  - ☞ Cervical rib
    - ☞ Incidence: 1%
    - ☞ Bilaterality: 50 - 80%
    - ☞ female to male ratio: 2:1
  - ☞ Tumors
  - ☞ C7 transverse process



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## 2. Costoclavicular space

- ☞ Borders
  - ☞ Anterior: medial 1/2 clavicle, costocoracoid ligament, subclavius muscle
  - ☞ Posteromedial: first rib, insertions of anterior and middle scalene muscles
  - ☞ Posterolateral: superior border of scapula

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## 2. Costoclavicular space:

- ☞ Compressive structures:
  - ☞ Clavicle/first rib/subclavius abnormalities
  - ☞ Trauma
    - ☞ Clavicle fracture with hematoma or callous
  - ☞ Abnormal shoulder position

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### 3. Retro-pectoralis minor space

- ☞ Anterior border: pectoralis minor
- ☞ Hyper-abduction leads to taut pectoralis minor and compression
- ☞ Clavicle motion in hyper-abduction increases compression

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### Thoracic Outlet Syndrome: Incidence

- ☞ 0.3-2% of population
- ☞ Female to male: 4:1
- ☞ Mean age 35 years old
- ☞ Increased incidence in heavy, overweight, or muscular individuals
- ☞ 60% of patients are post-traumatic

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### Thoracic Outlet Syndrome: Diagnosis

- ☞ History:
  - ☞ Vague complaints
  - ☞ Nocturnal paresthesias
  - ☞ Numbness involving medial forearm, ring and small fingers
  - ☞ May not have motor deficit
  - ☞ Anterior chest, upper arm discomfort
  - ☞ Worsening symptoms with overhead use of arms
  - ☞ Symptoms of arterial compression or venous occlusion with exercise

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### Thoracic Outlet Syndrome: Diagnosis

- ☞ Provocative maneuvers:
  - ☞ Roos Test
    - ☞ Abduct and externally rotate shoulders
    - ☞ Flex elbows to 90 degrees
    - ☞ Open and close hand repeatedly for up to 2 minutes
    - ☞ Activity reproduces symptoms

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### Thoracic Outlet Syndrome: Diagnosis

#### ☞ Provocative maneuvers:

- ☞ Adson's Test
  - ☞ Palpate radial artery
  - ☞ Extend neck and rotates head to affected side
  - ☞ Patient inhales deeply
  - ☞ Positive if radial pulse decreases & symptoms occur



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### Thoracic Outlet Syndrome: Diagnosis

#### ☞ Provocative maneuvers:

- ☞ Wright's Test:
  - ☞ Palpate radial artery
  - ☞ Abduct arm (overhead) and externally rotate arm
  - ☞ Patient rotates head away from affected side
  - ☞ Positive if radial pulse decreases & symptoms occur



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## Thoracic Outlet Syndrome: Diagnosis

### ☞ Diagnostic tests:

- ☞ Radiographs of cervical spine and chest
- ☞ Angiography or venography if there is a significant vascular component
- ☞ MRI if tumor or nerve root compression is suspected
- ☞ Positive electrodiagnostic studies can confirm clinical suspicion, but negative tests do not exclude diagnosis

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## Thoracic Outlet Syndrome: Treatment

### ☞ Non-surgical:

- ☞ Initial treatment choice
- ☞ Goal is to increase thoracic outlet space
- ☞ Physical therapy
  - ☞ Postural training
  - ☞ Manipulation and mobilization of first rib and surrounding muscles
  - ☞ Strengthening of shoulder muscles
  - ☞ Stretching of scalene muscles

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## Thoracic Outlet Syndrome: Treatment

### ☞ Non-surgical:

- ☞ Medication:
  - ☞ Anti-inflammatories, Oral Steroids
  - ☞ Analgesics, Sedatives
  - ☞ Muscle relaxants
- ☞ Ergonomic evaluation:
  - ☞ Avoidance of repetitive activity
  - ☞ Possible job restrictions or changes
  - ☞ Decreased overhead motions
- ☞ Weight loss if necessary

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## Thoracic Outlet Syndrome: Treatment

### ☞ Surgical Indications:

- ☞ Failure of dedicated exercise & postural program
- ☞ Intractable pain
- ☞ Significant neurological deficit
- ☞ Vascular compromise

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## Thoracic Outlet Syndrome: Treatment

### ☞ Types of surgical procedures:

- ☞ Cervical or first rib resection
- ☞ Scalenotomy/Scalenectomy
- ☞ Partial claviculectomy
- ☞ Pectoralis minor tenotomy

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## Thoracic Outlet Syndrome: Treatment

### ☞ Current preferred procedures:

- ☞ Transaxillary first rib resection
  - ☞ Difficult in obese/muscular patients
  - ☞ Can be combined with scalenectomy
- ☞ Scalenectomy
  - ☞ Muscular or obese patients because of difficult rib resection
  - ☞ For recurrence of symptoms after first rib resection

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# Summary



- ☞ We reviewed the following:
  - ☞ Anatomy of the brachial plexus
  - ☞ Potential sites of compression in the thoracic outlet
  - ☞ Appropriate physical examination and diagnostic evaluation
  - ☞ Conservative and operative treatment options