Imaging of Peripheral Neuropathies
Involvement of the Upper Limb

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Objectives

• Illustrate the peripheral nerve anatomy at common sites of neural entrapment in the upper extremity
• Highlight clinically important sites of peripheral nerve pathology and their associated clinical syndromes
• Identify ultrasound and MR imaging features of upper limb peripheral neuropathies
Objectives
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• musculocutaneous nerve
• axillary nerve
• suprascapular nerve
• radial nerve
• ulnar nerve
• median nerve
Nerves

- parallel bundles of nerve fibers grouped together in fasciculi
  - endoneurium
    - fibers
  - perineurium
    - fasciculi
  - epineurium
    - nerve trunk
Entrapment Neuropathies

- compression of a short segment of a single nerve at a specific site
  - fibro-osseous tunnel
  - opening in fibrous tissue or muscle
- injured structures
  - nerve fibers
  - Schwann cells
  - endoneurium
  - perineurium
  - epineurium
  - intraneural microvessels
Peripheral Neuropathies

- **traditional diagnosis**
  - clinical history
  - physical examination
  - electrophysiologic studies
    - able to determine location & severity of underlying nerve injury
    - mildly invasive
    - operator dependent

- **limitations**
  - inability to determine structural causes
  - inability to assess spatial information
Peripheral Neuropathies

• imaging
  – US
    • quick, low-cost, noninvasive
    • dynamic evaluation
    • high spatial resolution
    • capacity to explore long nerve segments
    • limitations: operator dependence, confined use for assessment of superficial nerves
  – MRI
    • depiction of deeper nerves
    • high contrast resolution
    • identify specific muscle denervation patterns
      – muscle edema within 24-48 hours
      – fatty atrophy within several months
Musculocutaneous Nerve

- lateral cord of brachial plexus
  - between brachialis & biceps branchii muscles
  - lateral to biceps branchii tendon
  - through antebrachial fascia
Musculocutaneous Nerve

- lateral cord of brachial plexus
  - between brachialis & biceps branchii muscles
  - lateral to biceps branchii tendon
  - through antebrachial fascia
- lateral antebrachial cutaneous nerve
  - lateral forearm
Musculocutaneous Nerve

- muscle supply
  - coracobrachialis
  - brachialis
  - biceps branchii

The muscle stretch reflex was absent in the left biceps but was normal in the right biceps. Elsewhere, muscle power, bulk, tone, and reflexes were normal. He had a reduced sensation to pinprick, light touch, and temperature over the lateral aspect of the left forearm. Sensation elsewhere was normal to all sensory modalities. The remainder of the physical examination was normal.

The patient underwent electromyography (EMG) and nerve conduction velocity testing. The needle examination showed increased insertional activity and 2+ positive sharp waves in the left biceps brachii muscle, but was normal in all other tested muscles of the left upper extremity, including the first dorsal interosseous, abductor pollicis brevis, flexor digitorum profundus I, extensor digitorum, triceps, pronator teres, deltoid, supraspinatus, and paraspinals. The coracobrachialis and brachialis muscles were not tested. Motor and sensory conduction studies of the left median, ulnar, and radial nerves were all normal.

Diagnosed with an isolated musculocutaneous nerve injury, the patient was advised to forego competitive baseball for the duration of the season and to receive graduated physical therapy. Over the course of several months, his condition improved markedly. He returned to baseball the following season and performed at a very high level. Among his team’s contingent of pitchers, he had the most wins, lowest earned run average, and highest number of pickoffs at first base. As of this writing, 22 months after the injury, the patient has no clinically evident weakness but has some residual numbness in the left lateral forearm.

Discussion

There are few case reports of isolated musculocutaneous nerve injury in the literature. Several cases have been iatrogenic injuries, incurred as a result of prolonged intraoperative positioning of the arm in abduction and external rotation during surgery. However, most reports describe injury in adult athletes or laborers, where the primary mechanism of injury has been aggressive forearm extension or repetitive, forceful lifting or throwing.

Figure 1. Course and innervation of the musculocutaneous nerve.

- (A) The nerve is derived from the fifth and sixth cervical roots, and its initial branches are motor in function. From proximal to distal, the motor branches innervate the coracobrachialis, biceps, and brachialis muscles. At the cubital fossa, the remaining fibers are sensory in function and the nerve acquires the new name of the lateral cutaneous nerve of the forearm. Because the nerve is anchored as it pierces the coracobrachialis muscle, this is the most likely site of injury in an isolated musculocutaneous neuropathy. An injury at this site would explain the motor weakness and sensory loss observed in our patient.

- (B) Distribution of sensory loss in an isolated musculocutaneous neuropathy. As its name implies, the lateral cutaneous nerve of the forearm supplies cutaneous innervation to the lateral forearm. As observed in our patient, injury to the musculocutaneous nerve will produce loss of sensation to all sensory modalities in the lateral forearm (shaded area).

Figure 2. Photograph of the patient 3 weeks after the pitching injury. At this time, the patient still had substantial weakness in flexion of the left elbow. Note that the normal contour of the biceps muscle on the right (arrow) and the normal shadow produced by biceps muscular definition on the right (arrowhead) are both absent in the atrophied left biceps.
Musculocutaneous Nerve

- entrapment is uncommon; posttraumatic
- sites of entrapment
  - coracobrachialis muscle
  - antebrachial fascia in cubital fossa
    - external compression against biceps tendon
    - repetitive & vigorous arm exercise
- clinical features
  - muscle weakness
    - at/distal to coracobrachialis muscle
      - brachialis & biceps branchii muscles
  - sensory abnormalities mimicking lateral epicondylitis

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Musculocutaneous Nerve

• MR imaging
  – nerve may not be well visualized
  – muscle edema
    • coracobrachialis muscle
    • brachialis muscle
    • biceps branchii muscle

• US
  – point of emergence of lateral antebrachial cutaneous nerve
Musculocutaneous Nerve

43-year-old patient with laceration to the upper arm and biceps weakness

Axillary Nerve
The axillary nerve originates from the posterior cord of the brachial plexus. Proximally, it runs below the coracoid process and along the anterior surface of the subscapularis muscle. It then turns toward the inferior aspect of the shoulder joint and courses through the quadrilateral space, traveling around the posterolateral humeral surgical neck and dividing into anterior and posterior branches. The anterior branch innervates the anterior and middle portions of the deltoid muscle. The posterior branch divides into the upper lateral brachial cutaneous nerve and the nerve to the teres minor muscle. The quadrilateral space is bounded laterally by the medial aspect of the humerus, medially by the long head of the triceps muscle, superiorly by the teres minor muscle, and inferiorly by the teres major muscle (Fig 7).

Sites of Entrapment.— Sites of entrapment include the quadrilateral space and the area posteroinferior to the glenohumeral joint.

Causes.— Most axillary nerve injuries are secondary to brachial plexus impairment (17). A common cause of isolated injury is open surgical intervention with a deltoid muscle–splitting approach (17). Entrapment can occur while one is exercising or is maintaining the arm in a prolonged abducted and externally rotated position, such as during sleep. Posttraumatic nerve injury may occur in up to 45% of shoulder dislocations, since the nerve is stretched over the dislocated humeral head (17). This injury occurs just proximal to the quadrilateral space.

Quadrilateral space syndrome involves axillary nerve compression within the quadrilateral space, has both traumatic and atraumatic causes, and typically affects young, active individuals (17). The nerve can be affected by mass lesions such as tumors, posteroinferior paralabral cysts (Fig 8; see also Fig E2 [online]), or fibrous bands (10,18–20), with fibrous bands being the most frequently implicated (17). Osteoarthritis of the glenohumeral joint may cause compression or traction of the nerve resulting from large osteophytes (Fig 9).

Clinical Features.— The clinical diagnosis of axillary nerve injury is challenging because signs and symptoms are vague (10). Pain is poorly localized over the anterior aspect of the shoulder, with potential radiation to the arm and forearm (21). Paresthesia of the skin over the upper lateral brachial cutaneous nerve or weakness of the deltoid muscle can be expected (see Fig E2 [online]) (22). Posttraumatic nerve injury secondary to shoulder dislocation may be masked clinically by pain (17). Athletes may experience fatigue, particularly with heavy weight lifting and overhead activities (17). Atrophy of the teres minor and deltoid muscles may be visualized later in the course of the disease (17). In the absence of a space-occupying lesion, symptoms of quadrilateral space syndrome may remit with nonsurgical management; however, the natural history of this syndrome is unknown.

Radiologic and Electrodiagnostic Findings.— Radiographs are useful in ruling out a proximal humeral fracture or severe degenerative changes, and in evaluating the adequacy of shoulder reduction following dislocation.

Figure 6. Musculocutaneous nerve injury in a 43-year-old man with a history of upper arm injury and weakness of the biceps muscle. MR imaging was requested to rule out a distal biceps tear. Fat-saturated T2-weighted MR image through the elbow in the FABS (flexed elbow, abducted shoulder, forearm supinated) position shows edema in both the biceps muscle (arrows) and the brachialis muscle (arrowheads). The distal biceps tendon (not shown) was intact. The absence of edema in any other muscle suggested injury to the musculocutaneous nerve. Subsequent electromyographic findings confirmed axonal injury to this nerve.

AX T2 FS
biceps muscle
brachialis muscle
AX T2 FS
brachialis muscle
FABS T2 FS
biceps muscle
Axillary Nerve

- posterior cord of brachial plexus
  - below coracoid process along anterior surface of subscapularis muscle
  - toward inferior aspect of shoulder, through quadrilateral space
  - divides
    - anterior branch
      - anterior & middle deltoid muscle
    - posterior branch
      - upper lateral brachial cutaneous nerve
      - teres minor muscle

Linda et. al. RadioGraphics 2010
Axillary Nerve

- quadrilateral space
  - teres minor muscle
  - teres major muscle
  - long head of the triceps muscle
  - humerus
Axillary Nerve

• sites of entrapment
  – quadrilateral space
  – anteroinferior to glenohumeral joint

• causes
  – usually secondary to brachial plexus impairment
  – open surgical intervention
  – posttraumatic in up to 45% of shoulder dislocations
  – quadrilateral space syndrome
    • fibrous bands (most common)
    • tumors
    • paralabral cysts
    • osteophytes
Axillary Nerve

- clinical features
  - vague
  - poorly localized pain over anterior shoulder with potential radiation to arm & forearm
  - paresthesias
  - weakness of deltoid
  - fatigue in athletes
  - atrophy of teres minor & deltoid muscles
Axillary Nerve

- radiography
  - proximal humeral fracture
  - severe osteoarthritis
  - adequacy of shoulder reduction
- MR imaging
  - masses
  - edema involving teres minor & deltoid muscles
Quadrilateral Space Syndrome

60-year-old patient with shoulder pain and weakness
Suprascapular Nerve

- upper trunk of brachial plexus
  - obliquely across posterior triangle of neck toward coracoid process
  - through suprascapular foramen
    - suprascapular notch
    - transverse scapular ligament
- supraspinatus fossa
  - supraspinatus muscle
- spinoglenoid notch
  - infraspinatus muscle
Suprascapular Nerve

• sites of entrapment
  – suprascapular notch
  – spinoglenoid notch

• causes
  – thickened transverse scapular ligament
    • repetitive strain on abducted externally rotated shoulder
  – paralabral cysts
  – tumors
  – iatrogenic surgical injury
  – enlarged varicosities
Suprascapular Nerve

- **clinical features**
  - insidious onset of deep, generalized, dull posterior shoulder pain
  - minimal functional motor loss
  - atrophy of supraspinatus &/or infraspinatus muscles
Suprascapular Nerve

• MR imaging
  – muscle edema & atrophy
    • suprascapular notch syndrome
      – supraspinatus & infraspinatus muscles
    • spinoglenoid notch syndrome
      – infraspinatus muscle only

• US
  – distinguishing paralabral cysts from a varix
  – guiding aspiration of large paralabral cysts at spinoglenoid notch
Suprascapular Nerve

22-year-old patient with muscle pain about the shoulder and EMG findings suggesting mild suprascapular nerve compression likely at the spinoglenoid notch.
Radial Nerve

- posterior cord of brachial plexus
  - around posterolateral humeral shaft
  - dorsally along spiral groove between lateral & medial heads of triceps muscle
  - enters anterior compartment by piercing lateral intermuscular septum ~10cm proximal to lateral epicondyle
    - superficial branch
    - deep branch
Radial Nerve

• muscle supply
  – triceps
  – brachioradialis
  – anconeus
  – extensor carpi radialis longus

• cutaneous innervation to posterior upper arm
Radial Nerve

- muscle supply
  - triceps
  - brachioradialis
  - anconeus
  - extensor carpi radialis longus

- cutaneous innervation to posterior upper arm
Radial Nerve

- sites of entrapment at arm & elbow
  - spiral groove
  - lateral head of triceps muscle
- causes
  - Saturday night palsy
    - classic radial neuropathy secondary to intoxication
  - humeral shaft fracture
  - misuse of crutches
  - deep intramuscular injections
  - fibrous arch of lateral head of triceps muscle
    - weight lifters

www.martii.blogg.no
Radial Nerve

• clinical features (spiral groove)
  – functional loss
    • accessory forearm supination
    • elbow flexion
    • wrist & digital extension
    • thumb abduction
  – sensory loss
dorsolateral hand
  – elbow extension is spared
    • triceps muscle branch proximal to spiral groove

www.cambridgeorthopaedics.com
Radial Nerve

• **MR imaging**
  - muscle edema in some or all muscles
    • spiral groove entrapment
      - most except for triceps muscle
    • proximal muscles = high radial nerve entrapment
      - triceps muscle
      - extensor carpi radialis longus muscle
      - anconeus muscle

• **US**
  - neuroma
    • focal swelling
    • hypoechogenicity
    • loss of normal fascicular pattern
56-year-old patient with possible history of trauma, numbness of arm and weakness of extensor muscles

Saturday Night Palsy

AX T2 FS

radial nerve

brachioradialis muscle

supinator muscle

spiral groove

AX T2 FS
Saturday Night Palsy

50-year-old patient with history of trauma and a flaccid right arm following shoulder subluxation.

- Radial nerve
- Dorsal forearm muscles
- Humerus
- Radius
- Ulna

Images of ultrasound scans showing the location of the radial nerve and dorsal forearm muscles.
Radial Nerve

- radial tunnel
  - mobile wad
  - elbow joint capsule
  - radiocapitellar joint
  - arcade of Frohse
    - fibrous arch at proximal superficial head supinator muscle

- divides
  - deep motor branch
    - posterior interosseous nerve
    - between superficial & deep portions of supinator muscle
    - along dorsal surface of interosseous membrane
  - superficial sensory branch
    - deep to brachioradialis muscle

Linda et. al. RadioGraphics 2010
Radial Nerve

- **muscle supply (PIN)**
  - supinator
  - abductor pollicis longus
  - extensor carpi ulnaris
  - extensor digitorum communis
  - extensor indicis
  - extensor digiti minimi
  - extensor pollicis longus
  - extensor pollicis brevis
  - extensor carpi radialis brevis

- **cutaneous innervation to dorsolateral hand** (superficial branch)

Boles, et. al. AJR 2000
Radial Nerve

- muscle supply (PIN)
  - supinator
  - abductor pollicis longus
  - extensor carpi ulnaris
  - extensor digitorum communis
  - extensor indicis
  - extensor digiti minimi
  - extensor pollicis longus
  - extensor pollicis brevis
  - extensor carpi radialis brevis

- cutaneous innervation to dorsolateral hand (superficial branch)
Posterior Interosseous Nerve

- sites of entrapment at elbow
  - radiocapitellar joint & radial tunnel
  - arcade of Frohse
  - leash of Henry
    - vessels arising from recurrent radial artery

- causes
  - involvement of posterior interosseous nerve (PIN) with two distinct syndromes
    - differentiation based on presence or absence of neurologic deficits
    - radial tunnel syndrome
      - pain involving dorsolateral forearm
    - PIN syndrome
      - pain & paresis of extensor muscles
  - speculation: different nerve fibers are affected
    - PIN also carries sensory afferent fibers from wrist & innervated muscles
Posterior Interosseous Nerve

- **causes**
  - forceful supination & pronation
    - athletes & workers
  - trauma
  - fibrous bands
  - thickened arcade of Frohse or margin of ECRB tendon
  - space-occupying lesions
    - ganglia, bursae, lipomas, recurrent pulsating radial vessels, synovitis, neurogenic tumors
Posterior Interosseous Nerve

• clinical features
  – radial tunnel syndrome
    • pain over anterolateral proximal forearm
    • clinically similar to lateral epicondylitis
      – both are simultaneously present in 7%
      – 5% of patients with recurrent “tennis elbow” may have radial tunnel syndrome
  – PIN syndrome
    • inability to extend metacarpophalangeal joints of thumb & fingers
    • pain over supinator muscle, exacerbated by forced extension of fingers & supination of forearm
Posterior Interosseous Nerve

- **MR imaging**
  - exclude mass lesion
  - muscle signal alterations

- **US**
  - exclude lateral epicondylitis
  - focal nerve swelling & loss of normal fascicular pattern
    - adjacent & proximal to compression
Radial Tunnel Syndrome

46-year-old patient with history of lateral elbow pain diagnosed as lateral epicondylitis
59-year-old patient with a lump and vague weakness of forearm, without sensory symptoms.
Radial Nerve

• superficial branch of radial nerve
  – deep to the brachioradialis tendon to pierce fascia & become subcutaneous
  – around radial aspect of wrist
    • dorsum of wrist, hand & two-and-a-half radial fingers to level of PIP joints
    • crosses 1st extensor compartment
Superficial Branch of Radial Nerve

- clinical features
  - Wartenburg syndrome or cheiralgia paresthetica
    - nerve involvement at wrist causing paresthesia over dorsal thumb
  - causes
    - de Quervain tenosynovitis
    - injury during venipuncture
    - compression: handcuffs, casts, wristbands
  - entrapment at distal third of forearm
    - pain over distal radial forearm with associated paresthesia
    - positive Tinel sign
Superficial Branch of Radial Nerve

- US
  - comparison with asymptomatic contralateral side
  - identification of swollen nerve
    - de Quervain disease prior to surgical release
      - avoid incomplete relief of symptoms
      - aggravation of neuritis symptoms
Wartenburg Syndrome

49-year-old patient with paresthesia over dorsal radial hand and vague pain along radial side of forearm radiating both proximally and distally
Ulnar Nerve

- medial cord of brachial plexus
  - midhumerus level
    - pierces intermuscular septum
    - enters posterior compartment
  - under arcade of Struthers
    - 8cm proximal to medial epicondyle
    - 70% of individuals
  - follows groove in medial head of triceps muscle
  - cubital tunnel
    - medial epicondyle
    - olecranon
    - joint capsule & ulnar collateral ligament
    - cubital tunnel retinaculum
  - between humeral & ulnar heads of flexor carpi ulnaris muscle
  - pierces flexor pronator aponeurosis
Ulnar Nerve

- **muscle supply**
  - flexor carpi ulnaris
  - flexor digitorum profundus
    - 4th & 5th fingers

- **cutaneous innervation**
  - palmar cutaneous nerve
    - hypothenar eminence
  - dorsal ulnar cutaneous nerve
    - 5th & half of 4th fingers
Ulnar Nerve

• sites of entrapment at elbow
  – arcade of Struthers
  – medial intermuscular septum
  – cubital tunnel
  – between two heads of flexor carpi ulnaris muscle
  – flexor pronator aponeurosis
Ulnar Nerve

• cubital tunnel syndrome
  – 2\textsuperscript{nd} most common neuropathy in upper limb
  – volume change during elbow flexion
    • tightening arcuate ligament
    • bulging medial head triceps muscle
  – causes
    • blunt trauma
    • compression
      – anconeus epitrochlearis muscle
      – osteophytes
      – ganglia
      – synovitis
    • lax ulnar collateral ligament
    • tardy ulnar nerve palsy
      – delayed neuropathy
    • valgus instability
    • ulnar nerve subluxation
      – 10-16% of individuals
      – may be associated with symptoms of neuritis
Ulnar Nerve

- clinical features
  - medial elbow pain radiating to hand
    - exacerbated by elbow flexion
  - pain or numbness at ulnar aspect of hand & fingers
  - weakness of finger abduction, thumb adduction, pinching of thumb & forefinger
  - muscle atrophy
  - flexion contractures
Ulnar Nerve

• US
  – assess entire course of nerve to determine site of compression (when EMG nonlocalizing)
  – hypoechoic & swollen nerve proximal to compression or “hourglass” constriction
  – dynamic evaluation throughout elbow flexion & appreciation of “snapping” sensation
  • ulnar nerve
  • triceps muscle
Ulnar Nerve

- MR imaging
  - comprehensive assessment
  - appearance of normal ulnar nerve
    - round, hypointense surrounded by fat
    - may be hyperintense in asymptomatic individuals
      - focal nerve thickening & fascicular distortion is pathologic
  - anconeus epitrochlearis
    - 4-34% of individuals
  - muscle edema or atrophy
Anconeus Epitrochlearis

31-year-old patient with constant tingling and numbness in ring & little fingers
35-year-old patient with hand weakness

Anconeus Epitrochlearis

Figure 17. Compression of the ulnar nerve by an anconeus epitrochlearis muscle in a 35-year-old man with weakness of the hand. There was electrophysiologic evidence of severe ulnar nerve conduction block at the elbow and active denervation of the abductor digiti minimi and first dorsal interosseous muscles.

(a) Axial fat-saturated T2-weighted MR image through the elbow shows a prominent anconeus epitrochlearis muscle (arrowheads) filling the cubital tunnel superficial to the ulnar nerve (arrow).

(b) Transverse US image obtained through the cubital tunnel with the elbow in flexion shows flattening of the ulnar nerve (arrowheads) against the medial epicondyle (open arrow) compounded by compression from the anconeus epitrochlearis muscle (solid arrows), which occupies the majority of the cubital tunnel.

Ulnar Nerve

The ulnar nerve arises from the medial cord of the brachial plexus. At the midhumerus level, it pierces the intermuscular septum and enters the posterior compartment (Fig 16). The ulnar nerve may pass under the arcade of Struthers, which is present in 70% of individuals and is situated 8 cm proximal to the medial epicondyle (10). The nerve follows a groove in the medial head of the triceps muscle, arriving at the cubital tunnel (16). This fibro-osseous interval is formed anteriorly by the medial epicondyle and laterally by the olecranon. The roof is formed by the arcuate ligament (10). The ulnar nerve then travels between...
59-year-old patient with two year history of ulnar nerve symptoms

Intraneural Ganglion Cyst

PANORAMIC PROXIMAL TO ELBOW

ulnar nerve

proximal
distal

ganglion cyst

ulnar nerve

distal

proximal

AX T2 FS

AX T2 FS

AX T2 FS

intraneural dissection
44-year-old patient with prior elbow fracture and new ulnar motor weakness

**Cubital Tunnel Syndrome**

Figure 21. Ulnar nerve constriction in a 45-year-old man who had sustained an elbow fracture 15 years earlier. The patient presented with progressive ulnar motor weakness. No electromyography was performed.

(a, b) Coronal fat-saturated T2-weighted MR images (a) obtained posterior to (b) demonstrate synovitis and osteoarthritis in the elbow. The ulnar nerve is hyperintense (arrowheads) but is difficult to see longitudinally on a single image. Denueration edema is evident in the FCU muscle (arrows).

(c) Longitudinal US image shows an hourglass constriction of the ulnar nerve (arrowheads) due to an adhesive band. The nerve is swollen and edematous proximally (black arrows) and returns to a normal caliber distally (white arrow).

#4 = cubital tunnel, U = ulna. Because the patient complained only of ulnar nerve symptoms and refused treatment for the osteoarthritis, the US image aided the surgeon by depicting local nerve constriction that could potentially be corrected surgically.

Figure 20. Ulnar neuropathy in a 19-year-old man who was referred for US with electrodiagnostic evidence of ulnar nerve conduction block in the elbow and axonal dropout in the first dorsal interosseous muscle.

(a) Transverse US image obtained at the level of the cubital tunnel shows the ulnar nerve (dashed circle) with a normal caliber and echotexture.

(b) On a transverse US image obtained at the level of the medial intermuscular septum, the ulnar nerve appears swollen and hypoechoic (arrows). Further reading of the entire electromyography report revealed that the ulnar nerve abnormality was localized 8–10 cm proximal to the medial epicondyle, which correlated with the US findings. This case illustrates the importance of careful correlation with electromyographic findings when available.
Ulnar Nerve

- forearm
  - deep to flexor carpi ulnaris muscle proximally & lateral to muscle distally
- wrist
  - through Guyon’s canal aka pisohamate tunnel
    - pisiform
    - hamate hook
    - flexor retinaculum
    - volar carpal ligament
  - divides
    - superficial sensory branch
    - deep motor branch
      - around hamate hook, posteriorly through hypothenar muscles, crossing deep palm to adductor pollicis muscle

Linda et. al. RadioGraphics 2010
Ulnar Nerve

• zones
  – 1: proximal to bifurcation
  – 2: deep motor branch
  – 3: superficial sensory branch
Ulnar Nerve

- muscle supply
  - hypothenar
  - palmaris brevis
  - 3rd & 4th lumbricals
  - interossei
    - palmar
    - dorsal
  - adductor pollicis
  - deep head of flexor pollicis brevis
Ulnar Nerve

- sites of entrapment at wrist
  - Guyon’s canal
  - tendinous arch of adductor pollicis muscle

- causes
  - ganglia from pisotriquetral joint
  - chronic repetitive trauma
    - use of tools (hypothenar hammer syndrome)
    - bicycle handlebars (cyclist’s palsy)
    - crutches
  - lipoma
  - pisotriquetral osteoarthritis
  - pisiform hamate coalition
  - os hamuli proprium
  - fractures
  - muscle anomalies
    - accessory abductor digiti minimi
    - accessory or reversed palmaris longus
    - hypertrophic flexor carpi ulnaris

Ulnar Nerve

- clinical features
  - depending on site of lesion relative to ulnar nerve bifurcation
    - type 1 syndrome (most common)
      - proximal to or within Guyon’s canal
        » weakness of all ulnar intrinsic hand muscles
        » sensory loss
        • without dorsal sensory deficit of hand
    - type 2 syndrome
      - deep motor branch in region of hook of hamate
        » weakness of ulnar intrinsic hand muscles
        • anatomic location determines which muscles
        » no sensory loss
    - type 3 syndrome
      - superficial sensory branch
        » sensory loss over volar aspect of the ulnar two fingers
        » no motor loss
Ulnar Nerve

• MR imaging
  – T1-weighted imaging
    • round, oval hypointense structure in Guyon’s canal
    • surrounded by fat
    • 3mm
  – anomalous or accessory muscles or fibrous bands
  – indirect evidence of entrapment
    • muscle edema or atrophy

• US
  – level of pisiform
    • thin, round structure medial to ulnar artery
    • bifurcation into sensory & motor branches
  – ganglia & space occupying lesions
29-year-old massage therapist with new onset ulnar dysesthesia and decreased grip strength
Ganglion Cyst

39-year-old patient with ulnar motor symptoms, without sensory abnormalities and negative US of Guyon’s canal.
Median Nerve

- medial & lateral cords of brachial plexus
- medial to biceps muscle & deep to bicipital aponeurosis
- between humeral & ulnar heads of pronator teres muscle
- deep to fibrous arch of flexor digitorum superficialis
- anterior interosseous nerve
  - 5cm proximal to medial epicondyle
- Martin-Gruber anastomosis
  - anomalous communication between median or anterior interosseous nerve & ulnar nerve
  - up to 40%

Linda et. al. RadioGraphics 2010
Median Nerve

- muscle supply
  - pronator teres
  - flexor carpi radialis
  - palmaris longus
  - flexor digitorum superficialis

- cutaneous innervation
  - palmar & distal dorsal aspects of 1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd} & half of 4\textsuperscript{th} digits

Boles, et. al. AJR 2000
Median Nerve

- muscle supply
  - pronator teres
  - flexor carpi radialis
  - palmaris longus
  - flexor digitorum superficialis

- cutaneous innervation
  - palmar & distal dorsal aspects of 1st, 2nd, 3rd & half of 4th digits
Anterior Interosseous Nerve

- muscle supply
  - flexor digitorum profundus to 2\textsuperscript{nd} & 3\textsuperscript{rd} digits
  - flexor pollicis longus
  - pronator quadratus

Boles, et. al. AJR 2000
Median Nerve

- sites of entrapment at elbow
  - supracondylar spur & Struthers ligament
  - between humeral & ulnar heads of pronator teres muscle (pronator syndrome)
  - lacertus fibrosus
  - fibrous arch of flexor digitorum superficialis muscle
Median Nerve

• causes
  – supracondylar fracture
  – elbow dislocation
  – injection injury
  – aberrant median artery
  – crossing branch of radial artery
  – soft tissue mass
Anterior Interosseous Nerve

• **causes**
  – anterior interosseous nerve syndrome or Kiloh-Nevin syndrome
  – direct trauma
  – compression
    • midshaft radial fracture
    • poorly applied casting
    • repetitive heavy lifting
    • soft tissue mass
    • tendinous origin of pronator teres muscle
    • enlarged bicipital bursa
    • varices
  – anatomical abnormalities
    • Gantzer muscle
    • vascular anomalies
Median Nerve

• clinical features
  – volar forearm pain
  – paresthesia & sensory loss of innervated digits
  – pronator muscle weakness
  – sensory loss over thenar eminence
  – exacerbated by forearm supination & elbow extension
  – pronator syndrome
    • pronator teres muscle is spared
Anterior Interosseous Nerve

• clinical features
  – motor dysfunction
    • flexor pollicis longus
    • flexor digitorum profundus (radial half)
    • pronator quadratus
  – unable to form an O
  – differential diagnosis
    • tendon rupture
Median Nerve

• radiography
  – supracondylar spur

• MR imaging
  – pronator syndrome
    • normal or altered nerve signal intensity
  – denervation pattern (edema & atrophy) is important
  – deeper course of median nerve between brachialis & pronator muscles
    • 17% asymptomatic elbows
Median Nerve

- US
  - dynamic compression deep to bicipital aponeurosis with pronation & supination
  - suspected median nerve laceration
Anterior Interosseous Nerve

- MR imaging
  - muscle edema or atrophy
  - most reliable sign of AIN lesion
    - edema with pronator quadratus muscle
  - edema within non-AIN-innervated muscles
    - flexor carpi radialis
    - flexor digitorum profundus to 3\textsuperscript{rd} & 4\textsuperscript{th} digits
Supracondylar Process

68-year-old patient with vague medial forearm pain

Sir John Struthers (1849)
Median Nerve & AIN

48-year-old weight lifter with burning and discomfort in the fingers & clinical exam suggesting AIN injury

**Median Nerve & AIN**

**SYMPTOMS**: Symptoms include volar tenderness, swelling,('$\overrightarrow{A}$') symptoms in the thumb, index, and middle fingers, and paresthesia in the innervated digits. Radial half of the ring finger may be present.

**Clinical Features**: Patients with AIN syndrome are unable to pinch the second and third fingers and thumb together to form an O. Symptoms may be exacerbated by supination and pronator weakness, and thenar sensory loss.

**Clinical Examination**: Results of clinical examination were suggestive of AIN injury. Symptoms include volar tenderness, swelling, ($'\overrightarrow{A}$') symptoms in the thumb, index, and middle fingers, and paresthesia in the innervated digits. Radial half of the ring finger may be present.

**Radiologic and Electrodiagnostic Findings**: Injury to the AIN is most commonly caused by direct trauma and external compression from elbow tendinous origins, pronator teres muscle, aberrant median artery, tissue mass, tendinous origin of the pronator teres muscle (black arrow in 2's6OLUME), and vascular abnormalities.

**Median Nerve Innervation**: median nerve innervation: flexor digitorum profundus, flexor pollicis longus, pronator teres muscle (an accessory head of the FPL muscle), flexor pollicis brevis, and vascular structures (arrowheads in 2's6OLUME).

**Surgical Management**: Surgical decompression revealed compression by a band deep to the pronator teres muscle and prominent pulsating vessels bordering the AIN. Electromyographic findings suggested partial high median nerve injury from stretch or traction injury. Electrodiagnostic test results can often be normal, but muscles and slowed nerve conduction. However, electromyography may reveal denervation in the forearm, ectatic varices (arrowhead in 2's6OLUME).

**Imaging Findings**: With involvement of the FPL and FDP muscles, a slightly deeper atypical passage of the median nerve is seen adjacent to the AIN. Surgical decompression may be necessary. In pronator syndrome, the pronator teres muscle itself may be spared, since its innervation originates more proximally.

**Diagnosis**: Although electrodiagnostic tests are less useful for the clinician, electrodiagnostic test results can often be normal, but muscles and slowed nerve conduction. However, electromyography may reveal denervation in the forearm, ectatic varices (arrowhead in 2's6OLUME).

**Figure 27**: Median Nerve & AIN innervation: flexor digitorum profundus, flexor pollicis longus, pronator teres muscle (an accessory head of the FPL muscle), and vascular structures (arrowheads in 2's6OLUME).
Median Nerve

34-year-old manual labourer with intermittent episode of shooting pain radiating from anterior elbow to wrist, particularly with pronation.
Anterior Interosseous Nerve (Kiloh-Nevin) Syndrome

39-year-old patient with weakness of wrist and forearm musculature

![Anterior Interosseous Nerve (Kiloh-Nevin) Syndrome](image)

- Median nerve
- Gantzer muscle
- AIN
- flexor pollicis longus
- flexor digitorum profundus
Median Nerve

- carpal tunnel – 6cm
  - carpal bones
  - tubercles of scaphoid & trapezium
  - pisiform & hamate hook
  - flexor retinaculum
    - proximally: thin & slack
    - distally: thick & taut

Linda et. al. RadioGraphics 2010
Median Nerve

- distal to carpal tunnel
  - terminal motor branches
    - opponens pollicis
    - abductor pollicis brevis
    - superficial head of flexor pollicis brevis
    - 1st & 2nd lumbricals
  - 4 terminal sensory branches
    - thumb, index, middle & half of ring fingers
Median Nerve

• sites of entrapment at wrist
  – carpal tunnel
  – recurrent branch of median nerve
    • pierces or wraps around flexor retinaculum
  – metacarpal tunnels

• causes
  – carpal tunnel syndrome
    • middle aged women
    • precise cause is often unknown
    • etiologies
      – diabetes, rheumatoid arthritis, gout, calcium pyrophosphate deposition, amyloid deposition, pregnancy, hypothyroidism
      – mass lesions: ganglia, lipomas, neurofibromas
      – postoperative: incomplete release, granulation tissue
Median Nerve

- clinical features
  - burning wrist pain radiating into fingers
  - paresthesia & numbness in median nerve distribution
  - symptoms worsening at night & exacerbated by repetitive wrist flexion/extension, strenuous gripping or vibration
  - clumsiness of hand
  - thenar eminence atrophy
Median Nerve

- imaging not required in majority
  - secondary cause
  - doubt about diagnosis
  - atypical presentation
  - recalcitrant symptoms postoperatively

- **MR imaging**
  - proximal & distal carpal tunnel nerve assessment
    - hyperintensity
    - volar bowing of flexor retinaculum at level of hamate hook (ratio 0.18)
    - increased caliber at level of pisiform
    - flattening at level of hamate hook
  - muscle edema & atrophy
    - chronic or severe
    - isolated recurrent branch at distal carpal tunnel
  - mass lesions
    - pathognomonic fibrolipomatous hamartoma
Median Nerve

• **US**
  – nerve flattening in distal tunnel
  – palmar bowing of flexor retinaculum
  – reduced nerve echogenicity & loss of normal fascicular pattern
  – nerve swelling & intraneural hypervascularity
    • good predictors
  – useful
    • tenosynovitis
    • ganglia
    • anomalous muscles
Patient with symptoms of carpal tunnel and bulkiness and swelling at the volar aspect of wrist

Fibrolipomatous Hamartoma
42-year-old patient with prior carpal tunnel release and persistent median nerve symptoms
57-year-old patient with 2 year history of soft, fluctuant mass at volar aspect of wrist, concerning for CTS due to ganglion cyst
Palmar Cutaneous Branch of Median Nerve

• final collateral branch from radial aspect of median nerve in distal forearm

• with median nerve between palmaris longus & flexor carpi radialis tendons

• “palmar cutaneous branch of median nerve tunnel”
  – 1.5cm proximal to wrist
  – 8mm fascial passage between superficial & deep layers of distal antebrachial fascia
  – supplies skin overlying thenar eminence

Linda et. al. RadioGraphics 2010
Palmar Cutaneous Branch of Median Nerve

• causes
  – ganglia of flexor carpi radialis tendon
  – antebrachial fascia
  – atypical palmaris longus muscle
  – entrapment concomitant with carpal tunnel syndrome
  – direct trauma
    • accidental
    • iatrogenic
      – resection of ganglia
      – carpal tunnel release
        » erroneous skin incisions
Palmar Cutaneous Branch of Median Nerve

- **clinical features**
  - overlying thenar eminence
    - new onset of painful discharges
    - sensory loss
    - local numbness
    - hyperesthesia
  - similar to sensory distribution of the median nerve
Palmar Cutaneous Branch of Median Nerve

- US
  - identify nerve in up to 83%
  - focal hypoechoic swelling
  - neuroma due to transection
49-year-old patient history of wrist laceration, retracted tear of palmaris longus and persistent hyperesthesia in region of laceration.

Palmar Cutaneous Branch of Median Nerve

carpal tunnel distally
carpal tunnel proximally

PCBMN neuroma
Summary

• numerous peripheral neuropathies affect the upper limb
• diagnostic mainstay
  – clinical examination
  – electrophysiologic studies
• MR imaging & US
  – useful spatial information
  – narrow differential diagnosis
  – guide treatment
  – valuable in complex cases with discrepant nerve function tests
• awareness of clinical features, relevant anatomy & most common sites & causes of entrapment
  – choice of diagnostic test
  – syndrome identification
  – appropriate case management
Imaging of Peripheral Neuropathies
Involvement of the Upper Limb

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