# Peripheral Neuropathies of the upper limb: Magnetic Resonance Imaging Features In correlation to Neurophysiologic studies

Essay
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By


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# Abstract

**With advances in modern MR imaging, direct MR visualization of many peripheral nerves is now possible. MR nerve imaging can detect and delineate the extent of neural tumors, demonstrate nerve continuity in cases of traumatic injury, and demonstrate abnormal enlargement and abnormal signal in diseased peripheral nerves. This ability to image peripheral nerves has the potential to dramatically change the diagnosis and treatment of peripheral nerve disease.**



**Key words:-**

**Peripheral Neuropathy - Entrapment Neuropathies - Magnetic Resonance Imaging - Upper Limb**

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## List of abbreviations

| | |
|---|---|
| **AIN** | **Anterior interosseous nerve** |
| **AVFs** | **Arteriovenous fistulas** |
| **AVMs** | **Arteriovenous malformations** |
| **CIDP** | **Chronic inflammatory demyelinating polyradiculopathy** |
| **CMAP** | **Compound muscle action potential** |
| **CTS** | **Carpal tunnel syndrome** |
| **EMG** | **Electromyography** |
| **FOV** | **Field of view** |
| **GCTTS** | **Giant cell tumours of the tendon sheath** |
| **Gd-DTPA** | **Gadolinium diethylene triamine penta-acetic acid** |
| **LMs** | **Lymphatic malformations** |
| **MIP** | **Maximum intensity projections** |
| **MPRs** | **Multiplanar reconstructions** |
| **MRI** | **Magnetic resonance imaging** |
| **MUAP** | **Motor unit action potential** |
| **NCS** | **Nerve conduction studies** |
| **NCV** | **Nerve conduction velocity** |
| **NECS** | **Nerve entrapment and compression syndrome** |
| **NF1** | **Neurofibromatosis 1** |
| **PIN** | **Posterior interosseous nerve** |
| **PNs** | **Polyneuropathies** |
| **PNST** | **Benign peripheral nerve sheath tumours** |
| **PVNS** | **Pigmented villonodular synovitis** |
| **SNAP** | **Sensory nerve action potentials** |
| **SNR** | **Signal-to-noise ratio** |
| **STIR** | **Short tau inversion recovery** |
| **TE** | **Time of echo** |
| **TR** | **Time of repetition** |
| **TSE** | **Turbo spin echo** |
| **VMs** | **Venous malformations** |

# Introduction and Aim of Work

The median, radial, and ulnar nerves of the upper limbs may be affected by various peripheral neuropathies, each of which may be categorized according to its cause, as either an entrapment or a nonentrapment neuropathy **(Andreisek et al., 2006)**.

Entrapment or compressive neuropathies are important and widespread debilitating clinical problems, especially in patients with predisposing occupations or with certain medical disorders. They are caused by mechanical dynamic compression of a short segment of a single nerve at a specific site, frequently as it passes through a fibro-osseous tunnel, or an opening in fibrous or muscular tissue **(Bayramoglu, 2004).**

Non entrapment neuropathies include traumatic nerve injuries, infectious and inflammatory conditions, polyneuropathies, and mass lesions at anatomic locations where entrapment syndromes typically do not occur **(Andreisek et al., 2006).**

Medical imaging, including MR imaging, is playing an increasingly important role in the diagnosis of disorders affecting the peripheral nerves and muscles. In past, practical application of MR imaging of nerves has been limited by technical difficulties in obtaining good image contrast to help distinguish nerve from neighboring tissues. Recently advances and enhancements of MR imaging techniques have transformed the evaluation of a variety of conditions that have posed diagnostic challenges in the past **(Filler et al., 2004).**

MR Neurography can have a sensitivity and specificity similar to that of needle electromyography in the evaluation of some nerve-compression syndromes. Studies comparing outcomes in carpal tunnel and ulnar nerve release surgeries show that MR Neurography is as effective as needle elecromyography for identifying patients who are helped by surgical treatment **(Filler et al., 2004).**

MRI provides high-resolution depiction of nerves and allows visualization of primary abnormalities, such as a mass lesion compressing a nerve, as well as secondary abnormalities, such as nerve enlargement and enhancement due to neuritis. However, the primary nerve abnormality may not be visible in some cases. In such cases, the observation of signal intensity changes in the muscle that is innervated by the abnormal nerve may be used to diagnose and localize the nerve lesion **(Andreisek et al., 2006).**

## Aim of work:-

The aim of this work is to study the value of different MRI imaging features of peripheral neuropathies of the upper limb and to correlate these imaging features with electrophysiological studies.

# Anatomy of the Peripheral Nerves of the Upper Limb

## Anatomy of the Median Nerve:-

### Course of the Median Nerve:-

The median nerve is formed by the fibers of the lateral and medial cords of the brachial plexus. At the upper arm the nerve runs lateral to the brachial artery to the mid humerus, then crosses over and reaches a more superficial and medial anatomic position **(Bodner,2008).**

The median nerve and the brachial artery enter the volar compartment in the antecubital fossa. The median nerve travels under the bicipital aponeurosis (figure 1), a strong membranous band that reaches inferiorly across the antecubital fossa to join the deep fascia covering the flexor muscles. The nerve passes between the deep and superficial heads of the pronator teres and descends distally. It passes deep in relation to the fibrous arch formed by the flexor digitorum superficialis and is closely bound to the deep surface of this muscle by its fascial sheath. The median nerve becomes more superficial and enters the carpal tunnel at the wrist **(Boles et al., 2000).**

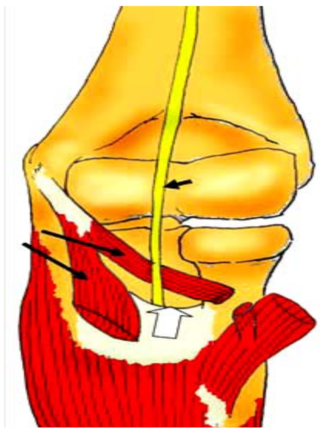

***Figure 1:- Schematic diagram of the median nerve at the cubital fossa. The median nerve (short arrow) enters the elbow beneath the bicipital aponeurosis (not shown) and then passes between the two heads of the pronator teres muscle (long arrows). It subsequently passes beneath the edge of the fibrous arch of the Flexor digitorum sublimes (blank arrow). These three locations are the potential sites of entrapment (Kim et al., 2007).***

The nerve then passes through the carpal tunnel into the hand, lying in the carpal tunnel anterior and lateral to the tendons of flexor digitorum superficialis, in the hand the nerve divides into a muscular branch and palmar digital branches. The muscular branches supply the thenar eminence, the palmar digital branch supplies sensation to the palmar aspect of the lateral 3 1/2 digits (figure 3) and the lateral two lumbricals (**Mcnamara, 2003a**).

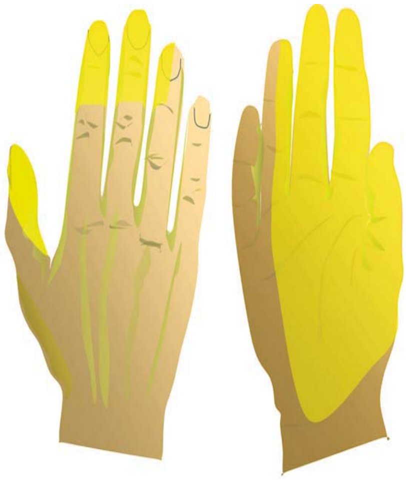

***Figure 2:- The sensory innervation at of the median nerve at the volar and palmar aspect at the right hand (Bodner, 2008).***

## Branches of the Median Nerve:-

The median nerve has no major branches in the arm, but a branch to one of the muscles of the forearm, the pronator teres muscle, may originate from the nerve immediately proximal to the elbow joint. Most branches to the muscles in the superficial and intermediate layers of the forearm originate medially from the nerve just distal to the elbow joint:-

- The largest branch of the median nerve in the forearm is the **anterior interosseous nerve (figure 3, 4)**, which originates between the two heads of pronator teres, passes distally down the forearm with the anterior interosseous artery, innervates the muscles in the deep layer (flexor pollicis longus, the lateral half of flexor digitorum profundus, and pronator quadratus) and terminates as articular branches to joints of the distal forearm and wrist.

- A small **palmar branch** originates from the median nerve in the distal forearm immediately proximal to the flexor retinaculum, passes superficially into the hand and innervates the skin over the base and central palm. This palmar branch is spared in carpal tunnel syndrome because it passes into the hand superficial to the flexor retinaculum of the wrist (**Drake et al., 2007**).

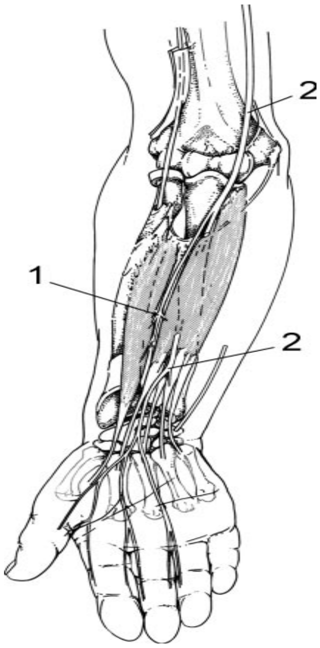


***Figure 3:- Schematic diagram provides an anterior view of the course of the anterior interosseous nerve (1), which arises from the median nerve (2) in the forearm (Andreisek et al., 2006).***

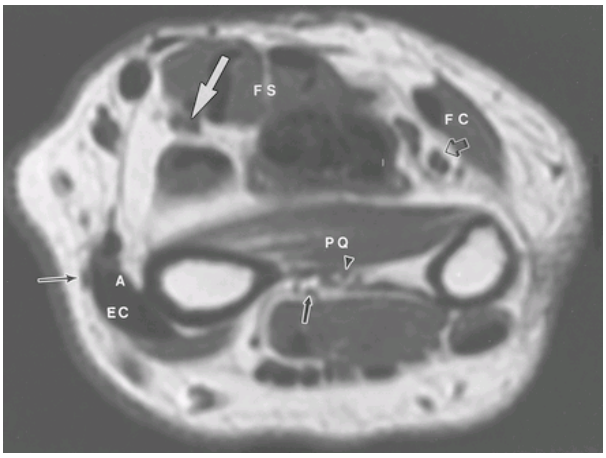


***Figure 4:-Anterior interosseous nerve (arrowhead) is deep in relation to pronator quadratus. Sensory remnant of posterior interosseous nerve (straight thick arrow) is now adjacent to interosseous membrane. White arrow is median nerve. Shaded open arrow is ulnar nerve, and long thin arrow is superficial radial nerve (Boles et al., 2000).***

## Anatomy of the Carpal Tunnel:-

The carpal tunnel (Figure 5, 6, 7) is a space bordered by the carpal bones and flexor retinaculum (transverse carpal ligament). The space is approximately 6 cm in length from the wrist to the mid-palm. In addition to the median nerve, eight tendons of flexor digitorum profundus and flexor digitorum superficialis (sublimes) and one flexor pollicis longus tendon pass through this space. The flexor retinaculum is approximately 3 cm to 4 cm wide and 2.5 mm to 3.5 mm in thickness. It is attached to the tuberosity of the scaphoid and the crest of the trapezium on the radial side and to the pisiform and the hook of hamate on the ulnar side. On its radial side, the flexor retinaculum splits into two layers to envelop the flexor carpi radialis tendon_and the contents of Guyon's canal and flexor carpi ulnaris tendon ulnarly. Thus, the deep investing antebrachial fascia at this level is volar to the contents of the carpal tunnel and dorsal to Guyon's canal (**Kim et al., 2007**).

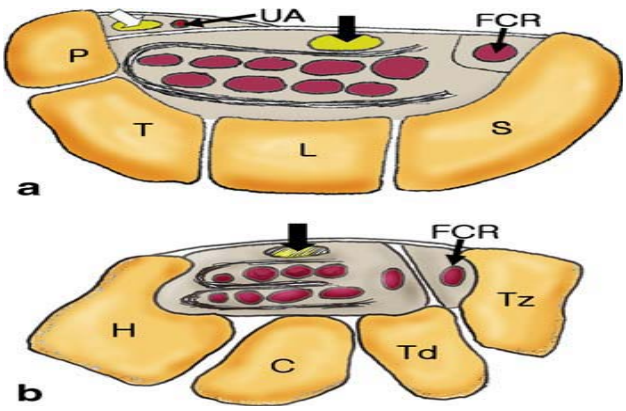


***Figure 5:- Schematic diagrams of the carpal tunnel and Guyon's canal at the pisiform level (a) and hamate level (b). The median nerve (black arrows) is passing through the carpal tunnel and is seen volar to the tendons of the second and third flexor digitorum superficialis The ulnar nerve (white arrow) and ulnar artery (UA) pass superficial to the flexor retinaculum on the radial side of the pisiform within Guyon's canal covered by the volar carpal ligament. The flexor carpi radialis tendon (FCR) passes between the split fibers of the flexor retinaculum. P pisiform, T triquetrum, L lunate, S scaphoid, H hamate, C capitate, Td trapezoid, Tz trapezium (Kim et al., 2007).***

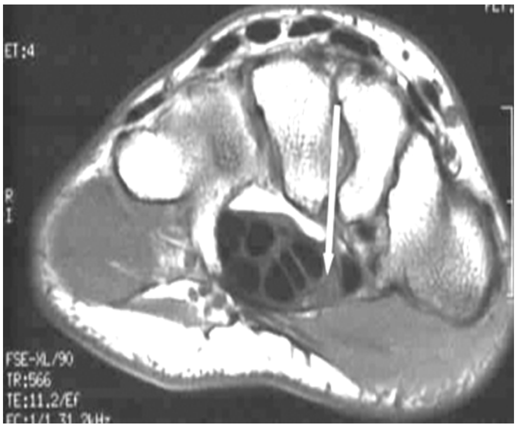


***Figure 6:-Normal findings on an axial spin-echo T1 WIs. MRI of the carpal tunnel is showing the intermediate signal intensity of the median nerve (arrow) (Allmann et al., 1997).***

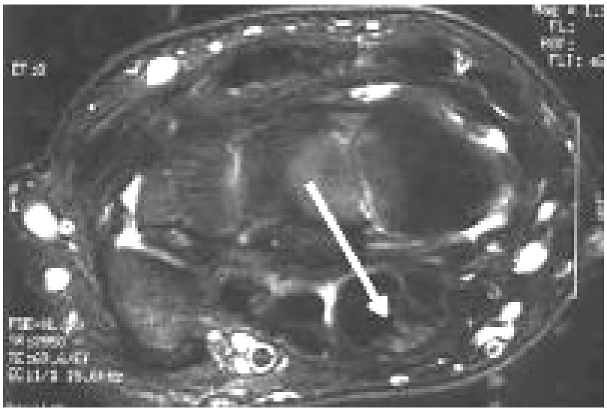

***Figure 7:-Normal findings of isointense-to-hypointense appearance of the median nerve on fast spin-echo T2-weighted MRI (arrow). Note the fairly well-defined nerve fascicles within the median nerve sheath (Balci and utku, 2007).***

# Anatomy of the Ulnar Nerve:-

## Course and branches of the Ulnar Nerve:-

The Ulnar nerve is derived in most instances exclusively from the C8/T1 nerve roots although sometimes there is a minor C7 component. Nearly all ulnar fibres arise in the lower trunk of the brachial plexus and pass through the medial cord, the terminal extension of which is the ulnar nerve. The ulnar nerve runs down the medial aspect of the arm, and there are no significant branches in the arm. At the elbow the nerve passes into the groove between the medial epicondyle and olecranon process, the ulnar groove. Just beyond the groove the nerve runs under a tendonous arch formed by the two heads of the flexor carpi ulnaris muscle. This