



**Neuromuscular ultrasound in ulnar neuropathy at the
elbow: correlation with electrodiagnostic studies**

Thesis

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Introduction

Ulnar nerve entrapment (UNE) at the elbow is the second most prevalent entrapment neuropathy of the upper limb, after median nerve entrapment at the carpal tunnel (*Beekman, et al., 2009*).

Repeated friction of the nerve and its contact with bony surface can cause neuritis and subsequent functional loss (*Volpe, et al., 2009*).

The diagnosis of cubital tunnel syndrome is typically based on clinical symptoms and signs, and confirmed by electrodiagnostic studies (EDX) (*Okamoto, et al., 2000*).

EDX studies determine the underlying pathology whether axonal, demyelinating, or mixed, localize the level of entrapment, and assess chronicity and severity which in turn determine the prognosis. However, EDX sometimes fail to localize the lesion, cannot evaluate the architecture or the anatomical aspect of the nerves and its surrounding structures. Moreover, they are sometimes accompanied with substantial rate of false negative and false positive results (*Miller, et al., 2010*).

Neuromuscular ultrasound (NMUS) has emerged as additional diagnostic tool for neuromuscular disorders. It has

proven itself as a valuable complementary tool to EDX studies. While EDX studies assess the functional aspect of the nerve, NMUS evaluates the anatomical aspect. Nowadays, ultrasound is able to identify successfully almost all main nerve trunks running in the limbs (*Walker, et al., 2004*).

Several studies have been performed to evaluate the ultrasound findings in ulnar neuropathy. These studies have shown that focal enlargement of ulnar nerve at the elbow is a relevant component of ulnar neuropathy and thus can be helpful as an adjunct to EDX in detecting patients with cubital tunnel syndrome (*Thoires, et al., 2008*).

Ultrasonography of the elbow offers a number of advantages over other imaging tools such as magnetic resonance imaging (MRI), being less time consuming, no radiation, easy comparison with other side, better cost-effectiveness ratio, superior spatial resolution and its dynamic capability (*Shahabpour, et al., 2008*).

Most of the published studies focused on the ultrasonographic appearance of ulnar nerve in ulnar neuropathy at the elbow but few addresses its correlation with EDX studies.

Aim of the work

The aim of this study was to perform clinical, electrodiagnostic and NMUS assessment for patients with ulnar neuropathy at the elbow, to determine the possible roles of NMUS in localization of the neuropathy, in detection of its possible etiologies and in determination of its severity.

Ulnar nerve anatomy and lesions

Course of ulnar nerve:

Ulnar nerve (UN) is one of the major nerves of the brachial plexus. It is the terminal branch of the medial cord of the brachial plexus. The UN originates from the 5th cervical and 1st thoracic nerve roots, and occasionally with contribution from C₆ nerve root (**figure 1**). In the axilla, the UN commonly travels medial to the axillary artery and vein, and lies deep to the pectoralis minor muscle. As the UN enters the axilla and passes into the brachium, it lies superficial to the subscapularis, teres major, and the latissimus dorsi's tendinous attachment to the proximal humerus. The UN is deep to the pectoralis major and courses medial to the brachial artery emerging from beneath the pectoralis major, medial to the coracobrachialis and anterior to the long head of the triceps. At the level of the distal attachment of the coracobrachialis to the humerus 'average' 1 cm proximal to the medial epicondyle (ME)', the UN penetrates the medial intermuscular septum to enter the posterior compartment of the brachium (*Contreras et al., 1998*).

Then the UN lies on the anterior border of the medial head of the triceps. A thick fascial band that connects the medial head of the triceps to the intermuscular septum crosses the UN

at approximately 1 cm proximal to the ME (the arcade of Struthers) although, its presence is debatable (***Von Schroeder and Schecker, 2003***)

The UN then runs posterior to the medial humeral condyle, wrapping around the ME at the level of the elbow. As the nerve passes posterior to the epicondyle, it is encased within a fibrous sheath (Osborne's ligament) laterally, and the head of the flexor carpi ulnaris (FCU) posteromedially. Together, these two structures form the cubital tunnel. The first branch of the UN provides sensory innervations to the elbow capsule (***Moore, 1985; Basmajian and Slonecker CE., 1989; Rayan ,1992; Hoppenfeld and deBoer,1994; Khoo et al.,1996***). (*Figure 2*)

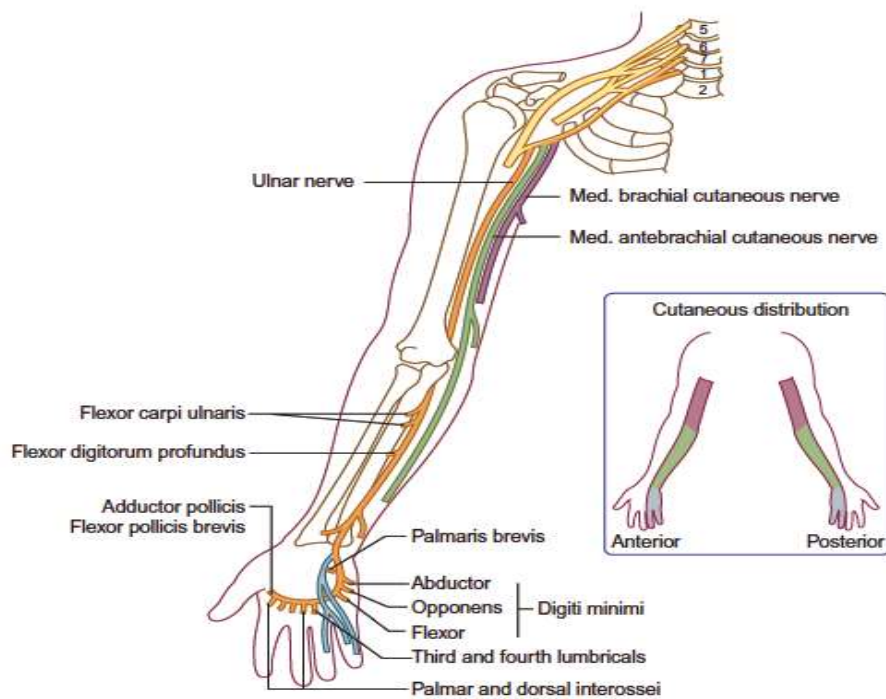


Figure (١) UN course and branches (**Preston, D. C., and Shapiro, B. E., 2012**)

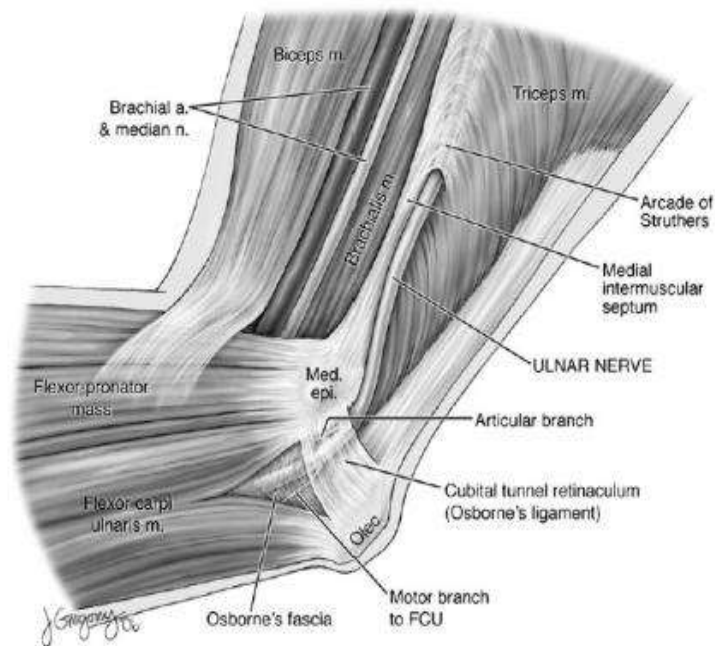


Figure (۲): Anatomy of the UN at the elbow (Polatsch *etal.*, 2007).

As the UN leaves the cubital tunnel, it courses between the two heads of the FCU giving it motor branches and enters the anterior compartment of the forearm.

In the forearm, the nerve travels on the anterior surface of the flexor digitorum profundus (FDP). At approximately ۰ cm distal to the ME, the UN gives off branches to the ulnar aspect of the FDP providing innervations to the long flexors of the ring and small fingers. In the middle of the forearm, at approximately ۱۲ cm distal to the ME (Contreras *etal.*, 1998)

the UN becomes superficial and meets with the ulnar artery as it travels toward the wrist. Before the FCU becomes tendinous, the UN divides. The more superficial of the two branches courses dorsally toward the distal ulna and dorsum of the hand and becomes the dorsal sensory branch of the UN which originates 8,9 cm proximal to the pisiform and 6,8 cm proximal to the ulnar head (**Botte *etal.*,1990**).

The dorsal sensory branch of the UN emerges from beneath the FCU approximately 6 cm proximal to the pisiform and becomes subcutaneous with an average of five branches (range, 3–9 branches) that supply the dorsal ulnar side of the hand.

Nerve of Henle (The palmar cutaneous branch of the UN) arises proximally, approximately 6 to 11 cm distal to the ME and carries innervation to the hypothenar skin and sympathetic fibers to the ulnar artery (figure 3).

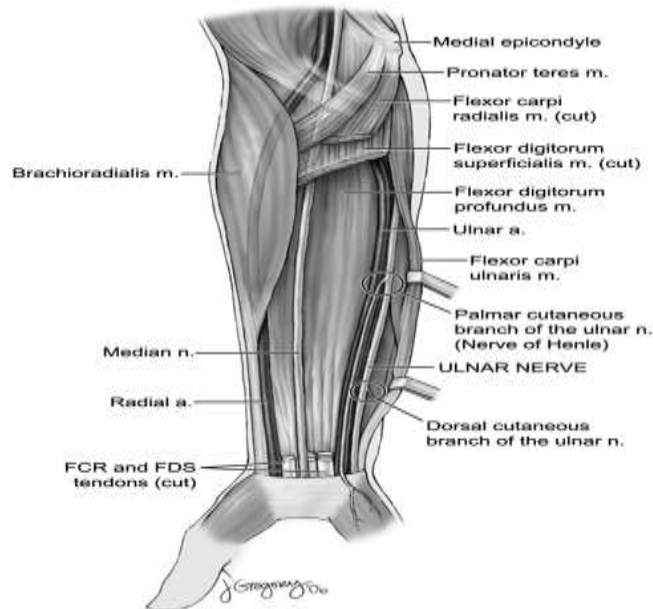


Figure (۳). Anatomy of the UN and palmar cutaneous branch of the UN (nerve of Henle) in the forearm. (*Polatsch et al., ۲۰۰۷*)

Near the wrist the UN travels superficial to the flexor retinaculum and lies beneath the tendon of the FCU before its attachment to the pisiform.

In the wrist and hand, the main trunk of the UN continues subjacent to the FCU and becomes relatively superficial, covered by fascia and skin. The UN and artery enter Guyon's canal, which is a fibro-osseous tunnel formed between the pisiform and the hamate hook (figure ۴).

The pisohamate ligament forms the floor of the canal, and the superficial volar carpal ligament forms the roof. Within

Guyon's canal, the UN bifurcates into superficial and deep branches. At this region, the ulnar artery lies radial to the UN.

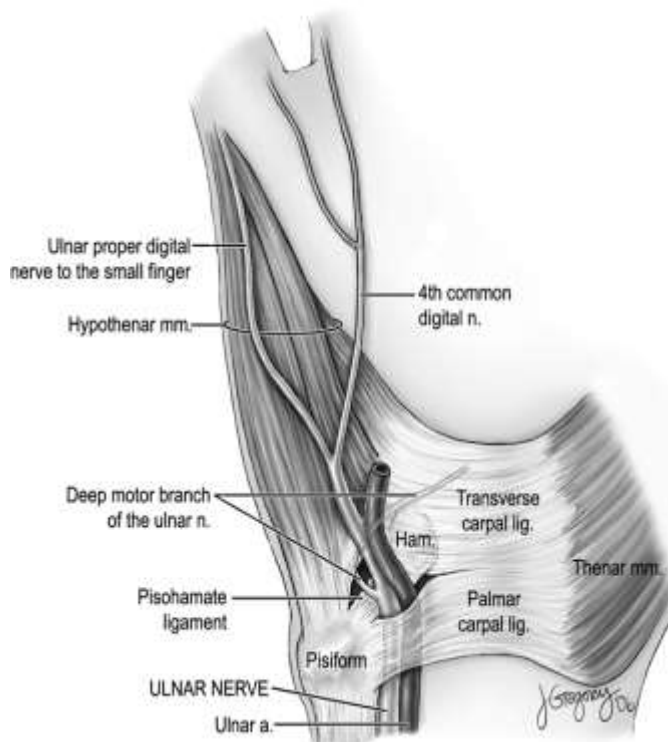


Figure (4) Anatomy of the UN at Guyon canal. (*Polatsch et al., 2007*)

Branches of UN:

In the axilla and arm: the nerve gives no branches.

In the forearm:

1. **Capsular branch:** is the first branch arising from the UN and provides sensory innervations to the elbow capsule (*Moore*

, 1980; *Basmajian and Slonecker, 1989; Rayan, 1992; Hoppenfeld and deBoer, 1994; Khoo et al., 1996*).

2. **Muscular motor branches:** As the UN leaves the cubital tunnel, it courses between the two heads of the FCU giving it motor branches and enters the anterior compartment of the forearm. One of the two motor branches supplies the FCU and the other branch supplies the ulnar half of the FDP (*Standring, et al., 2005*).
3. **The palmar cutaneous sensory branch (Nerve of Henle):** it arises 16 cm proximal to the ulnar styloid and innervates the distal ulnar flexor surface of the forearm carries innervation to the hypothenar skin and carries sympathetic branches to ulnar artery (*McCabe and Kleinert, 1990*).
4. **Dorsal ulnar cutaneous sensory branch:** it separates from the main trunk in the distal third of the forearm, and passes ulnar to the FCU then pierces the fascia of the FCU muscle about 3-5 cm proximal to the ulnar head to enter the dorsal ulnar aspect of the forearm.. Kaplan described an aberrant branch of the dorsal cutaneous nerve arising proximal to the ulnar styloid process and coursing ulnar to the pisiform to rejoin the proximal volar sensory branch of the UN (*Hankins and Flemming, 2005*)

In hand and wrist:

1. **Deep motor terminal branch** which supplies the hypothenar muscles, the palmar and dorsal interossei, the third and fourth lumbricals, and two muscles in the thenar eminence; the adductor pollicis and the deep head of the flexor pollicis brevis. (*Preston and Shapiro, 2012*)
2. **Superficial sensory terminal branches:** it is formed over the hypothenar muscles and divides into the fourth common digital nerve and the ulnar proper digital nerve to supply sensation to the volar fifth and medial fourth digits.

Cubital tunnel anatomy

Cubital space is a tunnel whose roof is formed by a fibrous band that is called the cubital tunnel retinaculum (CTR). The band is about 4 mm wide, extending from the ME to the olecranon, and perpendicular to the FCU aponeurosis.

The CTR appears to be a remnant of the anconeus epitrochlearis muscle and its function is to hold the UN in position. (figure[◦]).

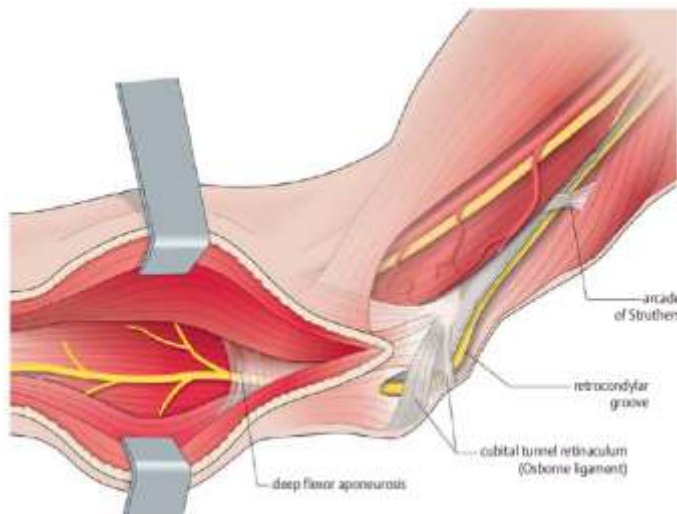


Figure (◦) the anatomy of the cubital tunnel (*Assmus and Martini, 2010*)

Biomechanics of ulnar nerve at the elbow joint

In elbow extension, the ME and olecranon process (OP) are juxtaposed, the humeroulnar aponeurotic arcade (HUA) becomes slack and the UN lying loosely in the groove. With elbow flexion, the OP moves forward and away from the ME. The humeral head of the FCU, attached to the ME, and the ulnar head, attached to the OP, are pulled apart, progressively tightening the HUA across the nerve, resulting in pressure increases up to 9 mm Hg in the ulnar groove. In addition, with elbow flexion, the ulnar collateral ligament bulges into the floor of the groove and the medial head of the triceps may be pulled into the groove from behind. In extension, the ulnar groove is smooth, round, and capacious, but in flexion the nerve finds itself in inhospitable surroundings, in a flattened, tortuous, and narrow canal with the HUA pulled tightly across it. In full flexion, the nerve partially or completely subluxes out of its groove in many normal individuals (***Landau and Campbell, 2013***).