ULNAR NERVE

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1. Core Definition

The **ulnar nerve** is a critical peripheral nerve originating from the brachial plexus, primarily responsible for providing both motor and sensory innervation to specific regions of the forearm and hand. Classically described as the nerve of the elbow, it is a mixed nerve, meaning it carries both afferent (sensory) signals back to the central nervous system and efferent (motor) signals to the muscles it controls. Its fibers are derived principally from the eighth cervical spinal root (C8) and the first thoracic spinal root (T1), though minor contributions may sometimes be observed from C7. The nerve is integral to the fine motor skills of the hand, especially those movements involving the intrinsic muscles necessary for grasping, pinching, and separating the fingers.

Historically, the ulnar nerve has been associated with the layman's term "funny bone," a misnomer derived from the distinct, often painful tingling sensation experienced when the nerve is struck or compressed near the medial epicondyle of the humerus. This nerve segment is particularly vulnerable due to its superficial position at the elbow, where it passes through the cubital tunnel. The core function of the ulnar nerve is to control the powerful flexors and adductors of the wrist and fingers, ensuring coordination and strength in grip action, while simultaneously transmitting sensation from the medial (ulnar) side of the hand, including the little finger and the medial half of the ring finger. Understanding its precise anatomical trajectory and functional profile is paramount in diagnosing various entrapment neuropathies and traumatic injuries affecting the upper limb.

In terms of its pathway through the brachial plexus, the ulnar nerve is considered the direct continuation of the medial cord. This positioning distinguishes it from other major nerves of the arm, such as the median and radial nerves, highlighting its unique role in supplying musculature that often works synergistically with, yet independently of, those controlled by neighboring nerves. Damage to the **ulnar nerve** can result in significant functional deficit, often characterized by the classical "claw hand" deformity (ulnar claw), which severely compromises the patient's ability to perform activities of daily living that require precision and strength, underscoring its profound importance in upper limb physiology.

2. Anatomical Course and Branches

The **ulnar nerve** begins high in the axilla, traversing the arm initially deep to the biceps and triceps muscles, running medial to the brachial artery. Unlike the median nerve, which remains anterior, the ulnar nerve takes a distinct posterior course at the mid-humerus, piercing the medial intermuscular septum to enter the posterior compartment of the arm. This crucial transition ensures

its passage directly behind the elbow joint. It passes through the cubital tunnel, a fibro-osseous canal formed by the medial epicondyle, the olecranon, and the cubital tunnel retinaculum (arcuate ligament of Osborne). This narrow passage is the most common site of compression, leading to cubital tunnel syndrome, the second most frequent upper extremity entrapment neuropathy after carpal tunnel syndrome.

Upon entering the forearm, the ulnar nerve travels between the two heads of the flexor carpi ulnaris (FCU) muscle, providing motor branches to the FCU and the medial half of the flexor digitorum profundus (FDP). These are the only muscles in the forearm proper that receive their entire or partial innervation exclusively from the ulnar nerve. Throughout its descent, the nerve runs alongside the ulnar artery, deep to the FCU, maintaining a relatively protected position within the anterior compartment of the forearm. Before it reaches the wrist, it gives off several important sensory branches, ensuring the distal sensation characteristic of its territory.

As the ulnar nerve approaches the wrist, it divides into its terminal branches near the proximal border of the transverse carpal ligament. The main trunk passes superficial to the flexor retinaculum, traversing through Guyon's canal (ulnar canal), another potential site of entrapment. Within or immediately distal to Guyon's canal, the nerve typically divides into a superficial terminal branch, which is predominantly sensory, and a deep terminal motor branch. The deep branch is arguably the most critical for hand function, curving laterally around the hook of the hamate bone to supply the majority of the intrinsic muscles of the hand, thus governing fine manipulative control and digital dexterity. This complex distal branching pattern dictates the specific motor deficits observed depending on the level of injury.

3. Motor Function and Innervation

The motor function of the **ulnar nerve** is vital for the strength and coordinated movement of the wrist and digits. In the forearm, it innervates two key muscle components: the entire **Flexor Carpi Ulnaris (FCU)**, which acts as a powerful flexor and adductor of the wrist, and the medial two tendons of the **Flexor Digitorum Profundus (FDP)**, which are responsible for flexing the distal phalanges of the ring and little fingers. Damage proximal to the elbow will therefore affect both forearm and hand function, resulting in a compounded motor deficit.

The deep motor branch of the ulnar nerve is responsible for innervating the majority of the intrinsic muscles of the hand, which are crucial for subtle, precise movements. These muscles include the hypothenar muscles (abductor digiti minimi, flexor digiti minimi brevis, opponens digiti minimi), which control the little finger; all seven interossei muscles (four dorsal and three palmar), which are essential for finger abduction and adduction; and the medial two lumbricals, which flex the metacarpophalangeal (MCP) joints while extending the proximal and distal interphalangeal (PIP and DIP) joints of the ring and little fingers. Furthermore, the deep branch supplies the adductor

pollicis, a strong muscle critical for gripping and pinching actions involving the thumb. The profound impact of these innervations means that ulnar nerve palsy significantly impairs grip strength and precision movements.

The resulting motor loss in severe ulnar neuropathy manifests in characteristic ways. The paralysis of the interossei and the medial lumbricals leads to an imbalance between the extrinsic extensors (unaffected) and the intrinsic flexors (paralyzed). This imbalance produces the classic **ulnar claw hand** deformity, particularly pronounced in the ring and little fingers, where the MCP joints are hyperextended and the IP joints are flexed. Furthermore, the paralysis of the adductor pollicis leads to the inability to powerfully adduct the thumb, which patients often compensate for by using the flexor pollicis longus (innervated by the median nerve) to hyperflex the IP joint of the thumb during pinching, a phenomenon known as **Froment's sign**. These specific motor deficits serve as powerful diagnostic indicators for clinicians assessing the extent and location of ulnar nerve injury.

4. Sensory Function and Innervation

The sensory role of the **ulnar nerve** is equally distinct, providing cutaneous sensation to the medial aspect of the hand. The main sensory branch, the dorsal cutaneous branch, usually arises in the distal third of the forearm, piercing the deep fascia to become superficial on the dorsum of the hand. This branch supplies the sensation for the dorsal aspect of the little finger, the medial half of the ring finger, and the corresponding dorsal metacarpal area. Importantly, this branch exits the main nerve trunk proximal to Guyon's canal; therefore, sensation in this area is typically preserved in cases of isolated entrapment within the canal.

The superficial terminal branch of the ulnar nerve, after traversing Guyon's canal, becomes the primary provider of palmar sensation. It innervates the palmar surfaces of the little finger, the medial half of the ring finger, and the associated palmar region. This sensory distribution is crucial for fine tactile discrimination and temperature perception on the gripping surface of the hand. Loss of sensation (anesthesia or paresthesia) in this specific area--often described as numbness or tingling--is a hallmark symptom of ulnar nerve compression, particularly at the elbow or wrist.

The sensory innervation provides vital feedback loops necessary for coordinated motor action. For instance, the ability to perceive pressure and texture on the ulnar side of the hand is essential for activities like holding tools or manipulating small objects. Because the sensory branches are often affected earlier than the deep motor branches in cases of mild compression, sensory disturbances frequently serve as the initial warning sign of impending or developing neuropathy. Detailed testing of the specific cutaneous zones supplied by the dorsal and palmar branches allows clinicians to accurately localize the site of nerve injury--whether it is proximal (at the elbow, affecting all branches) or distal (at the wrist, potentially sparing the dorsal cutaneous branch).

5. Clinical Significance: Ulnar Neuropathy

Ulnar neuropathy refers to any condition resulting from damage, compression, or irritation of the **ulnar nerve**, leading to functional impairment. Due to its long course and superficial passage at the elbow, it is highly susceptible to both acute injury and chronic compression. Ulnar nerve lesions are among the most common peripheral neuropathies encountered in clinical practice, second only to median nerve lesions (carpal tunnel syndrome). The presentation of neuropathy varies significantly based on the severity of the damage and, crucially, the anatomical location of the injury.

The severity of neuropathy can range from mild, intermittent sensory symptoms (paresthesia) to severe, chronic motor loss resulting in muscle atrophy and fixed deformities. Mild compression often leads to temporary numbness and tingling, frequently exacerbated by sustained elbow flexion (e.g., while sleeping or talking on the phone). Chronic or severe compression results in persistent pain, objective sensory loss, and progressive weakness in the intrinsic hand muscles, which manifests visibly as the wasting of the interosseous muscles (guttering between the metacarpals) and the hypothenar eminence. Failure to treat severe compression can lead to irreversible damage to the axons, resulting in permanent functional deficits.

Differentiating the level of injury is a critical clinical task. A lesion at the wrist (Guyon's canal) affects the terminal branches, leading to intrinsic hand muscle weakness and palmar sensory loss, typically sparing the FCU, FDP, and the dorsal cutaneous sensory area. Conversely, a lesion at the elbow (cubital tunnel) affects all motor and sensory branches distal to that point, including the forearm muscles innervated by the nerve (FCU and medial FDP). Specialized neurological testing, including nerve conduction studies (NCS) and electromyography (EMG), are essential tools for confirming the diagnosis, localizing the site of entrapment, and assessing the degree of axonal damage versus demyelination, guiding appropriate medical or surgical intervention.

6. Common Sites of Compression

The **ulnar nerve** is vulnerable to compression at several distinct anatomical bottlenecks along its path from the shoulder to the hand. The most prevalent site of entrapment is the **Cubital Tunnel**, leading to Cubital Tunnel Syndrome. This fibrous arch, formed by the fascia connecting the two heads of the flexor carpi ulnaris (Osborne's ligament), constricts the nerve, especially when the elbow is flexed, which tightens the retinaculum and decreases the volume of the tunnel. This position stretches the nerve, causing internal ischemia and mechanical irritation, making prolonged elbow flexion a common mechanism for symptom provocation.

A second crucial site of compression is the wrist, specifically within **Guyon's Canal**. This fibro-osseous tunnel is bordered by the pisiform bone and the hook of the hamate bone, with the transverse carpal ligament forming its roof. Compression here is often associated with localized

trauma, repetitive pressure (e.g., from cycling or using crutches), or space-occupying lesions such as ganglia or tumors. Since the nerve branches into its sensory and motor components within or just distal to the canal, the specific symptoms experienced depend entirely on which part of the nerve is compressed. For example, compression affecting only the deep motor branch results in isolated hand weakness without sensory loss.

Less common, but clinically significant, sites of compression include the retro-epicondylar groove (often due to direct blow or bony spurs), and more proximal locations such as the arcade of Struthers (a fibrous band in the arm, although this is a debated structure in some literature), or within the medial head of the triceps muscle. Furthermore, external factors such as prolonged immobilization during anesthesia or periods of unconsciousness (e.g., "Saturday night palsy" affecting the radial nerve, but sometimes also the ulnar nerve) can cause temporary or permanent damage due to sustained external pressure on the nerve trunk, particularly when the elbow is left in an acutely flexed position.

7. Diagnosis and Management

The diagnosis of **ulnar neuropathy** relies heavily on a meticulous clinical history and physical examination, followed by confirmation using electrodiagnostic studies. Clinicians look for specific signs, including the presence of sensory changes in the ulnar half of the hand, atrophy of the intrinsic muscles (especially the first dorsal interosseous muscle and hypothenar eminence), and the presence of positive provocative tests, such as **Tinel's sign** (tapping over the nerve at the elbow or wrist causes electrical sensations distally) and the aforementioned **Froment's sign**.

Electrodiagnostic studies, primarily **Nerve Conduction Velocity (NCV)** tests and **Electromyography (EMG)**, are standard confirmatory procedures. NCV measures the speed and amplitude of electrical signals transmitted along the nerve segment, revealing slowing across the area of compression (e.g., the cubital tunnel). EMG evaluates the electrical activity of the muscles at rest and during contraction, identifying denervation (nerve damage) and the specific muscles affected, thereby localizing the site of the lesion (e.g., differentiating elbow involvement from wrist involvement, or root compression from peripheral compression).

Management strategies are tailored to the severity and duration of the symptoms. Non-operative management is typically initiated for mild to moderate cases and involves modifying activity, avoiding prolonged elbow flexion (especially during sleep, often achieved using night splints), and utilizing anti-inflammatory medications. If conservative measures fail, or if the neuropathy is severe (indicated by progressive motor weakness and muscle atrophy), surgical intervention is often required. Common surgical procedures include **ulnar nerve decompression** at the specific site of entrapment (e.g., cubital tunnel release) or, in cases of recurrent subluxation or persistent severe compression, ulnar nerve transposition, where the nerve is moved anteriorly to a less vulnerable

position in front of the medial epicondyle to relieve tension and pressure.

Further Reading

Ulnar Nerve (Anatomy and Function)
Cubital Tunnel Syndrome
Brachial Plexus
Clinical Anatomy of the Ulnar Nerve