

Carpal Tunnel Syndrome (CTS)

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Carpal Tunnel Syndrome (CTS)

Primary Disciplinary Field(s): Neurology, Orthopedics, Occupational Medicine, Rheumatology

1. Core Definition and Pathophysiology

Carpal Tunnel Syndrome, commonly abbreviated as **CTS**, is recognized as a highly prevalent neurological condition characterized by chronic compression of the median nerve within the wrist. This compression leads to a distinct set of debilitating symptoms, including **pain**, **tingling** (paresthesia), **numbness**, and **weakness**, primarily distributed across the hand and sometimes radiating up the forearm and arm. As one of the major nerves supplying the hand, the median nerve is pivotal for both sensory perception (thumb, index, middle, and radial half of the ring finger) and motor function (controlling certain muscles at the base of the thumb).

The fundamental mechanism of CTS involves increased pressure within the rigid confines of the **carpal tunnel**. This narrow passage, situated on the palm side of the wrist, is structurally defined by the carpal bones forming the floor and sides, and the tough, fibrous transverse carpal ligament spanning the roof. Contained within this limited space are the median nerve and nine flexor tendons responsible for controlling finger movement. Any pathological process that reduces the effective volume of the tunnel or increases the volume of its contents--such as inflammation, fluid accumulation, or anatomical variation--will impinge upon the median nerve, disrupting its axonal transport and signal transmission, thereby generating the characteristic clinical syndrome.

2. Clinical Manifestations and Symptomatology

The clinical presentation of CTS is characterized by distinct sensory and motor disturbances corresponding directly to the median nerve's innervation pattern. Sensory symptoms are often the earliest and most frequently reported. Patients commonly experience **tingling** and **numbness**, typically affecting the thumb, index finger, middle finger, and the radial aspect of the ring finger, while usually sparing the little finger. A crucial diagnostic clue is the nocturnal exacerbation of these symptoms, often awakening the patient, who may feel compelled to shake or rub their hand to obtain relief.

Beyond paresthesia, significant **pain** is a defining feature of the syndrome. This pain frequently originates at the wrist but can radiate distally into the digits or proximally up the arm, sometimes reaching the shoulder. The intensity of the pain is highly variable, ranging from a dull ache to sharp, burning sensations. Activities involving sustained gripping, repetitive wrist flexion/extension, or holding the hand in a fixed position (such as driving or reading) often provoke or intensify these painful episodes.

As the condition progresses, particularly in moderate to severe cases, **motor symptoms** become

evident. Patients report increasing hand weakness, manifesting as difficulties with fine motor tasks, such as buttoning clothes or handling small objects. Grip and pinch strength are notably diminished, leading to a tendency to drop objects. In chronic, severe, and untreated cases, persistent nerve compression leads to irreversible axonal damage and eventual visible wasting, or **atrophy**, of the thenar muscles (the fleshy mound at the base of the thumb), which severely limits hand function and dexterity.

3. Etiology and Contributing Risk Factors

The etiology of Carpal Tunnel Syndrome is rarely attributable to a singular cause; instead, it is typically multifactorial, arising from the convergence of anatomical, systemic, and environmental influences that collectively elevate pressure on the median nerve. Identifying these contributing factors is essential for holistic management and effective prevention.

Systemic and Anatomical Factors: Numerous medical conditions predispose individuals to CTS. Inflammatory disorders, such as **rheumatoid arthritis**, can cause synovitis--inflammation and thickening of the flexor tendon sheaths--which directly encroaches upon the nerve space. Furthermore, metabolic disorders like **diabetes mellitus** and **hypothyroidism** are strongly associated with increased risk, often due to their deleterious effects on peripheral nerve health and systemic fluid balance. Acute physical trauma, such as wrist fractures, dislocations, or sprains, can directly alter the anatomical dimensions of the carpal tunnel, resulting in acute or chronic compression. Additionally, conditions causing generalized fluid retention, such as **pregnancy**, can lead to transient CTS symptoms that typically resolve postpartum.

Occupational and Ergonomic Factors: Occupational influences play a significant role, particularly in jobs requiring prolonged or intense use of the hands and wrists. Although often debated, the consensus is that activities involving **repetitive motions**, sustained awkward postures (such as excessive wrist flexion or extension), and exposure to high levels of mechanical stress or vibration are critical ergonomic risk factors. Repeated forceful gripping, coupled with improper wrist posture, increases the strain on the tendons and surrounding tissues, leading to inflammation and subsequent compression. Management of these risks necessitates proactive ergonomic adjustments in the workplace.

4. Prevention Strategies and Ergonomics

Given the complex, multifactorial origin of CTS, effective prevention hinges on managing and mitigating identified risk factors, especially those related to repetitive strain and posture. Implementing foundational ergonomic principles is paramount, particularly for individuals engaged in manual labor or intensive computer use.

A key preventative measure involves maintaining **correct posture and alignment** of the wrist and

hand during daily activities. It is crucial to ensure that the wrist remains in a neutral position, avoiding prolonged periods of excessive flexion or extension, which significantly narrow the carpal tunnel. For desk workers, optimizing workstation ergonomics—including chair height, keyboard and mouse placement, and wrist support—is essential to minimize strain.

Incorporating regular physical activity and rest breaks into work routines is another critical strategy. Individuals performing repetitive tasks should take frequent, scheduled **breaks** to allow muscles and tendons to rest and recover, thereby reducing cumulative stress and inflammation. Furthermore, consistent performance of targeted **hand and arm exercises** helps maintain flexibility, improve circulation, and strengthen supportive musculature, contributing to overall wrist joint health and resilience against strain.

5. Management and Treatment Modalities

The treatment pathway for Carpal Tunnel Syndrome is typically phased, progressing from conservative, non-invasive therapies for mild or early-stage symptoms to surgical intervention for severe or refractory cases. The overarching treatment objective is the sustained relief of pressure on the median nerve.

Conservative Management: Initial treatment often focuses on non-operative methods aimed at reducing inflammation and maintaining neutral wrist positioning. The use of **wrist splints**, particularly at night, is a highly effective conservative strategy. The splint prevents unconscious wrist flexion during sleep, reducing nighttime pressure and alleviating characteristic nocturnal symptoms. Pharmacological interventions may include non-steroidal anti-inflammatory drugs (NSAIDs) to manage swelling and pain. For patients requiring more direct symptomatic relief, **corticosteroid injections**--delivered directly into the carpal tunnel--can provide potent anti-inflammatory effects, temporarily reducing tissue swelling around the nerve and alleviating compression.

Surgical Intervention: When conservative treatments fail to provide adequate relief, or when there is objective evidence of significant nerve damage (such as persistent sensory loss or muscle atrophy), **surgery** becomes the definitive treatment. The standard surgical procedure is the carpal tunnel release. This operation involves surgically cutting the transverse carpal ligament, which forms the roof of the tunnel. By severing this ligament, the physical constraint on the carpal tunnel is removed, effectively enlarging the space and immediately decompressing the median nerve. This procedure can be performed either through a traditional open incision (open carpal tunnel release) or minimally invasively using endoscopic techniques (endoscopic carpal tunnel release), both yielding high success rates for long-term symptom relief.

6. Further Reading

[Carpal Tunnel Syndrome: Symptoms and Causes. Mayo Clinic.](#)

[Median Nerve. Wikipedia.](#)

[Carpal Tunnel Release. Johns Hopkins Medicine.](#)

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