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Carpal Tunnel Syndrome: Part 1: The Condition, Symptoms, and Risk Factors

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Goals. The goals of this two-part lesson series are to discuss carpal tunnel syndrome and provide information on its management with medical and nonmedical interventions.

Objectives. At the conclusion of this lesson, successful participants should be able to:

1. describe carpal tunnel syndrome, state suspected causes and/or factors that aggravate symptoms, and list individuals who are at risk for developing it;
2. identify anatomical and physiological considerations on the etiology and pathogenesis of carpal tunnel syndrome;
3. recognize specific symptoms and identify means of assessment for carpal tunnel syndrome; and
4. distinguish between carpal tunnel syndrome and other pathologies that may mimic it.



Gossel



Wuest

Carpal tunnel syndrome (CTS) is the most common peripheral neuropathy in the U.S., and a component of a group of pathologies described as repetitive motion injuries, overuse syndromes, chronic upper limb pain syndromes, and nerve entrapment disorder. CTS is a frequent cause of work disability and the most prevailing cause of nighttime hand discomfort and pain.

Little is known about its prevalence in the general population. One estimate places its incidence in the U.S. close to 3 percent of adults. Studies in workers representing specific high-risk occupations reveal that CTS occurs more often in certain specialized groups (Table 1) than the general population. For example, 62.5 percent of supermarket checkers

surveyed reported symptoms of CTS. Approximately 7 percent of employees of an electronics manufacturing plant developed symptoms over four years. More than 14 percent of meat handlers developed symptoms over a 12-year period. Fifteen percent of workers, on average, in high-risk industries are affected annually.

Today, repetitive motion disorders, as a group, account for more than one-half of all occupational illnesses in the U.S. and the number appears to be increasing. A 1996 study revealed the average total cost for bilateral CTS that required surgery, in workers' compensation cases, to be \$74,000. Economic considerations due to direct and indirect health care costs, as well as patient quality of life issues, are therefore significant. Work disability due to CTS may be prolonged and, in fact, sufferers may need to change occupations even if treated surgically.

There is a bright side, though. The condition is usually controlled adequately with simple conservative measures. Nearly 90 percent of persons reporting mild symptoms are expected to recover completely

Table 1
Examples of Job Tasks and Occupations
Associated with Carpal Tunnel Syndrome

Job Tasks	Occupation
handling child safety caps	pharmacist and technician
handling objects on conveyor belts	assembly line worker
hand weeding	gardener
using a spray gun	painter
playing a stringed instrument with bow	musician
using laser scanner	cashier
key punching, typing	computer operator

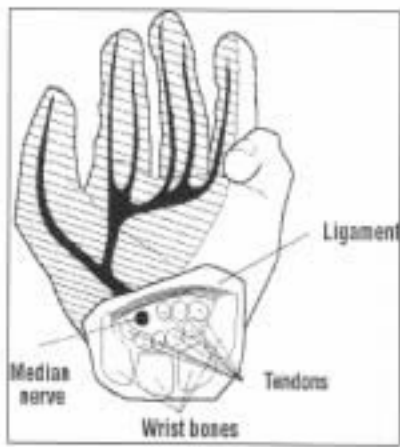


Figure 1. Left hand showing carpal tunnel and distribution of median nerve (shaded area).

with appropriate treatment. Sufferers can learn to reduce their chance for re-injury by changing the frequency and process of repetitive movements, and increasing rest periods between work sessions.

This lesson is the first in a two-part series that describes CTS and its management. In Part 1, discussion centers on describing factors known to aggravate the condition. It describes etiologic and pathogenic considerations, and identifies symptoms and clinical assessment procedures. Part 2 in the lesson series discusses management of CTS with medical and nonmedical interventions. It also provides information to help patients understand the disorder and obtain maximum benefit from treatment.

Anatomical and Physiological Considerations

Figure 1 shows anatomical features of the wrist that are relevant to an understanding of CTS. A canal (tunnel) extends along the longitudinal axis connecting the forearm with the hand. Within this canal are located the nine tendons that control finger movement, and the median nerve that innervates the thumb, index finger, middle (long) finger, and adjacent half of the fourth (ring) finger. The median nerve transmits impulses from the brain to the innervated fingers and

hand, and transports information about temperature, touch, and pain from the hand to the brain. It is the only nerve within the carpal tunnel.

The carpal tunnel, named after the eight carpal bones of the wrist, is bound on the dorsal and lateral aspects by bone and a strong, broad ligament called the transverse carpal ligament on the volar surface. The carpal tunnel is a clearly limited space that cannot enlarge significantly. Any factor that alters its shape or competes for the limited space, such as changes following a fracture or with bending the wrist sharply, can exert sufficient pressure on the median nerve to compress or "pinch" it. This can result in distal motor and sensory dysfunction.

Tenosynovitis (i.e., inflammation of a tendon sheath) within the tunnel is the most common cause of symptoms. Inflammation can be caused by numerous factors including repetitive use of the hand and wrist. Symptoms often begin during pregnancy in response to fluid retention. Oral contraceptives may also incite fluid retention, as can numerous medical conditions, including thyroid disorders and connective tissue disease.

CTS is accurately described as a disorder affecting the median nerve at the wrist brought on by repetitive stress, physical injury, or other conditions that produce swelling of the tissues around the nerve. When inflamed, the tissues within the tunnel thicken and expand in size and, thereby, compress the median nerve. The outcome is pain, numbness, and tingling (paresthesias) in the wrist, hand, first three fingers and adjacent half of the fourth – the zone of distribution of the median nerve. The little finger and half of the ring finger adjacent to it are spared of symptoms since they are not innervated by the median nerve. Compression incites symptoms of discomfort in the radial-palmar aspect of the hand, palm, and wrist, and may also be perceived proximal to the compression site, even into the forearm and shoulder. Discom-

fort is usually more intense at night. Sensory deficit in the palmar aspect of the affected fingers and/or weakness with eventual atrophy of muscles controlling movement of the thumb can occur.

Pathophysiology

The tissue pressure within a compartment of the arm (i.e., the carpal tunnel) is normally 7-8 mm Hg. This pressure may increase in CTS to 30 mm Hg or more, near the point at which damage to the median nerve can occur. Pressure may increase to 90 mm Hg or higher with wrist flexion or extension. At these high levels, ischemia adds to the basic dilemma that leads to the syndrome. As sensory function is impaired over time, the individual may attempt to compensate by adopting a more forceful grip or developing other compensatory maneuvers that can intensify symptoms and add further injury.

The increased pressure within the canal is usually caused by nonspecific flexor tenosynovitis. Persons at high risk are typically between ages 40 and 60 years. Women are three times more likely than men to be affected. Table 2 identifies examples of disease processes associated with increased incidence of CTS.

Chronic focal compression of a nerve can deform its myelin sheath, the fatty substance that insulates nerve fibers. Approximately 1 percent of persons with CTS develop permanent injury. Ischemia accounts for the intermittent tingling that begins during the night or with wrist flexion. Ischemia may also contribute to irreparable damage to affected tissues.

Increasing grip force can increase carpal tunnel pressures and accelerate CTS. Fingertip force applied to tools and other objects being held is increased when there is diminished sensation, such as exposure to cold weather, or when wearing thick gloves or using vibrating tools.

Table 2
Examples of Diseases and Situations Associated with Carpal Tunnel Syndrome

Occupations (see Table 1)
 Trauma
 Osteoarthritis
 Rheumatoid arthritis
 Gout
 Diabetes mellitus
 Congestive heart disease
 Edema
 Obesity
 Infection (e.g. Lyme disease, rubella, *Mycobacterium* sp.)
 Amyloidosis
 Hypo- or hyperthyroidism
 Acromegaly
 Median artery aneurysms
 Congenital defects in carpal tunnel
 Tumors of the tendon sheaths
 Wrist fractures and dislocations
 Ganglionic cysts
 Lipomas
 Thrombosed artery
 Pregnancy
 Use of oral contraceptives
 Menopause
 Gynecological surgery

A correlation between the ratio of wrist thickness to width and median nerve sensory latency has been noted. Some individuals may have a naturally smaller carpal tunnel volume and, therefore, be at increased risk for symptoms. This correlation has been suggested more often for persons with square wrists (thickness and width are about the same) than those with the more common rectangular wrists. Not all investigators agree on the clinical relevance of this association.

Specific Factors

Hormonal Changes. Alterations in fluid retention during pregnancy and hormonal fluctuations associated with menopause, as noted earlier, may predispose some women to develop CTS. Symptoms associated with pregnancy are typically bilateral. Symptoms are often noted during the third trimester, and usually resolve after delivery.

Gender. The reason why females are at higher risk for CTS

than males is not known. Part may be due to the hand-intensive nature of numerous domestic chores, typing, and other work traditionally attributed to women. Hormonal changes may also play a significant role. The influence of gender is wide open to continued debate and investigation.

Genetics. There may be increased risk of CTS in persons who have a family history of the condition. Research continues in an attempt to identify abnormalities in specific genes that regulate myelin. Another potential familial relationship may be that some individuals are born with abnormalities of the carpal bones.

Repetitive Motion as a Cause of Carpal Tunnel Syndrome

It is believed that the tendons within the tunnel can become inflamed when people use their fingers intensively and/or bend their wrists repetitively over time. This results in localized injury with an inflammatory response that may lead to tendon and synovial disorders, muscle tears, ligamentous disorders, degenerative joint disease, bursitis, or nerve entrapment. Because the immovable borders of the tunnel do not provide for extra space to accommodate this swelling, the median nerve is compressed and symptoms appear.

At high risk for CTS are persons whose occupations demand repeated grasping, turning and/or twisting, or applying force to the fingers and hand for long periods. Stressful hand, arm, and neck positions from activities such as working long hours at a desk or driving long distances can aggravate the potential for damage. Persons at risk include those who use hand-held vibrating tools such as chain saws and jackhammers. They also include individuals in food processing industries, assembly line workers, musicians, postal workers, and dentists and dental technicians. Any worker who moves his hands and wrists repetitively is at some

risk. Note that Table 1 includes a partial list of specific job tasks and occupations noted to have a high incidence of CTS among their workers. Repetitive stress injuries may also result from sports activities including rowing, golf, tennis, downhill skiing, archery, competitive shooting, and rock climbing.

Clinical Assessment

CTS may be difficult to diagnose definitively. About 25 percent of patients with work-related repetitive stress disorders will show false-positive evidence of other conditions whose symptoms resemble CTS. Moreover, it is often difficult to determine whether the primary cause is due to vocational or avocational (i.e., recreational pursuits, hobbies) conditions or an underlying pathology.

A positive diagnosis is suggested by the patient's vocational history and enhanced by the presence of one or more disorders known to aggravate symptoms. CTS is then confirmed upon presentation of appropriate symptoms (pain, tingling, etc. depicted in the pattern shown in Figure 1), physical findings (Phalen's maneuver, Tinel's sign, or decreased sensation to pin prick or vibration), and objective evidence via electromyogram or median nerve conduction defect at the wrist. Phalen's maneuver (wrist-flexion test) is performed by holding the forearms upright and bending the wrists 90 degrees. Individuals with CTS feel symptoms in the median nerve distribution within 60 seconds. Tinel's sign is positive when symptoms appear in the distribution of the median nerve while tapping over the nerve at the wrist. As expected, these physical tests have a high incidence of false positive results and, used alone, are often of doubtful clinical significance. In one study of 2,466 persons in a general population, 14 percent reported symptoms in the distribution of the median nerve. Nerve conduction studies confirmed median nerve neuropathy in approximately 45

Table 3
NIOSH Definition of
Work-Related
Carpal Tunnel Syndrome

Criteria A, B, and C must be met:

A. Symptoms suggestive of CTS
Tingling, pain or numbness affecting at least part of the median nerve distribution of the hand

B. Objective findings consistent with CTS

(1) One or more of the following physical findings: Tinel's sign, Phalen's maneuver, or decreased or absent sensation to pin prick in the median nerve distribution of the hand; or

(2) Electrodiagnostic findings of median nerve dysfunction across the carpal tunnel

C. Evidence of work relatedness (one or more of the following): frequent, repetitive or forceful hand work on affected side; sustained awkward hand position; use of vibrating tools; prolonged pressure over wrist or base of palm; temporal relationship of symptoms to work or association with carpal tunnel syndrome noted in co-workers.

percent of these symptomatic patients. It was interesting to note that nerve conduction studies were negative in nearly one-third of "clinically certain" patients and positive in approximately one-third of "clinically uncertain" patients. Of 125 asymptomatic patients in the control group, 18 percent were shown to have median nerve neuropathy on nerve conduction testing. Consensus committees representing the American Academy of Neurology, American Academy of Physical Medicine and Rehabilitation, and American Association of Electrodiagnostic Medicine now recognize nerve conduction studies as the diagnostic standard for CTS.

The National Institute for Occupational Safety and Health (NIOSH) has proposed a surveillance case definition for work-related CTS (Table 3). A positive diagnosis requires the presence of

median nerve symptoms; one or more occupational risk factors; and objective evidence of CTS, including one of three physical examination findings or nerve conduction tests diagnostic of CTS.

Symptoms

Symptoms range from minor inconvenience to severe and disabling. Many mild cases resolve on their own following avoidance of aggravating factors. For example, following pregnancy as noted earlier, peripheral edema with swelling in the wrists disappears and symptoms of CTS abate.

Often, the patient's chief complaint is awakening at night with episodic bouts of tingling or numbness in one or both hands. Symptoms may also appear while driving or working at a keyboard. Symptom onset is often insidious, developing over months or longer. Numbness in the fingertips may be described as a "pins and needles" response, or as tingling. Individuals may say their "hand is asleep." As noted earlier, mild symptoms typically involve the first three digits and at times the radial half of the fourth finger. Mild symptoms are often relieved by hanging the hands down or "flicking" the wrists as if shaking down a thermometer. Over 70 percent of patients complain of nocturnal numbness of the hand; about 40 percent experience proximal forearm pain concurrent with tingling.

There is often a subjective feeling of uselessness or clumsiness of the fingers during activities requiring fine motor skills, such as buttoning a shirt or blouse, writing, sewing, unscrewing a bottle top, turning a key, or picking up small objects. Objects such as dishes or an article of clothing may be dropped. Patients may not be able to distinguish hot from cold. Their hands may feel swollen even though there is no visible inflammation. In severe cases, pain in the hand or wrist is usually described as aching or burning. It may feel like "electric

shocks." The person may complain of shooting or darting pains from the center of the wrist or forearm into the hand, sometimes extending upward to the shoulder, neck, and chest. Sensory loss in the area innervated by the median nerve, weakness of these muscles, and slowing of nerve conduction across the carpal tunnel are characteristic.

Symptoms usually progress gradually over a period of weeks to months, and in some cases, years. Left untreated, severe cases may lead to atrophy of muscles at the base of the thumb with subsequent loss of sensation. Symptoms can be so crippling as to prohibit affected individuals from performing even simple tasks at home.

Summary

CTS is the most common cause of nocturnal hand discomfort and pain, and a frequent cause of work disability. It is also controlled in many patients by simple prophylactic and treatment measures. Affected individuals should learn how to avoid exerting undue stress on the hands and wrists, and perform regular exercises to strengthen the fingers, hands, wrists, forearms, shoulders, and neck. There is little evidence that any of these methods can provide complete protection against CTS, but all need to be explored early in therapy.