1995

Diagnostic Criteria and Management of Carpal Tunnel Syndrome

Holly Rogers
University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad

Part of the Physical Therapy Commons

Recommended Citation

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinab.yousif@library.und.edu.
DIAGNOSTIC CRITERIA AND MANAGEMENT OF CARPAL TUNNEL SYNDROME

by

Holly Rogers
Bachelor Science in Physical Therapy
University of North Dakota, 1994

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of Master of Physical Therapy

Grand Forks, North Dakota
May
1995
This Independent Study, submitted by Holly L. Rogers in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title Diagnostic Criteria and Management of Carpal Tunnel Syndrome

Department Physical Therapy

Degree Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this independent study or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature [Signature]

Date 2/27/95

iii
TABLE OF CONTENTS

LIST OF FIGURES................................................................. v
LIST OF TABLES................................................................. vi
ABSTRACT............................................................................. vii

CHAPTER

I. INTRODUCTION................................................................. 1
II. ANATOMY AND PATHOLOGY................................................ 5
III. ETIOLOGY................................................................. 9
IV. INCIDENCE, COST AND RISK FACTORS......................... 12
V. CLINICAL EVALUATION................................................. 17
VI. TREATMENT................................................................. 27
VII. DISCUSSION................................................................. 44

APPENDIX........................................................................... 51
REFERENCES......................................................................... 56
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Anatomy of the carpal tunnel.</td>
<td>6</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diagnostic tests for carpal tunnel syndrome.</td>
<td>22</td>
</tr>
</tbody>
</table>
ABSTRACT

Carpal tunnel syndrome (CTS) is an entrapment neuropathy involving the median nerve as it passes through the carpal tunnel. CTS is widely recognized as the most common of all nerve entrapment syndromes. CTS develops when irritation causes the tendon sheaths passing through the carpal tunnel to swell, constricting the tunnel and compressing the median nerve. Manifestations of CTS are varied, but usually include pain, numbness and weakness of the hand. Incidence of CTS has risen sharply in the past five years. Prevention of CTS and reduction of it's effects appears to be the best solution for this disorder. Physical therapists are in a key position to provide preventative programs for early, acute cases.

The purpose of this study is to identify those people who are at an increased risk for CTS and provide guidelines for the physical therapist’s management of CTS. Due to the increased incidence of this condition and rising health care costs, therapeutic management will be in the best interest of all those involved with carpal tunnel syndrome.
CHAPTER I
INTRODUCTION

Carpal tunnel syndrome (CTS) is an entrapment neuropathy involving the median nerve as it passes through the carpal tunnel. The carpal tunnel is a passageway formed by the wrist carpal bones and the transverse carpal ligament. The median nerve and tendons that supply the hand's sensory and motor function pass through the carpal tunnel. CTS develops when irritation causes the tendon sheaths to swell, constricting the tunnel and compressing the median nerve. CTS is widely recognized as the most common of all nerve entrapment syndromes.

Although CTS has received considerable attention recently, it was first described by James Paget in 1854 secondary to a distal radius fracture.\(^1\) The term for CTS was coined by Modus in 1938. Wright and Wilkes described the first recorded surgical treatment for CTS in 1947.\(^2\) Through the years a variety of symptoms associated with CTS have been identified, including impaired sensation, weakness and clumsiness of the hand. The aggravation of symptoms is experienced with increased use of the hand, especially grasping. Manifestations of CTS are varied, but usually
include pain, numbness and weakness of the hand. There are
two broad categories of this syndrome, primary CTS and
secondary CTS. Primary or idiopathic CTS occurs from an
unknown cause. Secondary CTS is associated with another
disease process such as rheumatoid arthritis or with a
trauma such as a distal radial fracture.

Newspapers and magazines have given considerable
attention to the impact of CTS on certain segments of the
work force. One such article indicates reports of CTS
related injuries have risen from 20,000 in 1983 to almost
74,000 in 1987 (Business Week, January 1989). More
complaints of CTS have been heard in the past five years
than in the previous two decades. This is not because CTS
is a new problem. The increase can be largely attributed to
the widespread industry shift to faster forms of automation.
To make the human portion of a job match the speedy
production of new technology, actual tasks have been
specialized to the extreme. CTS frequently occurs in jobs
that offer little relief from repetitive wrist motion, or
require a force exceeding ten pounds. It is repetition
without adequate recovery time that causes inflammation and
swelling in the wrist's carpal tunnel. A study at the
University of Michigan, sponsored by the National Institute
for Occupational Safety and Health (NIOSH), reported that
excessive repetitions did not allow the wrist sufficient
time to produce enough lubricating fluid. The resulting
friction, in the absence of lubrication, leads to swelling and scarring. The stress is far more than the wrist was anatomically designed to handle. Prevention of CTS and reduction of it's effects appears to be the best solution for this disorder. Physical therapists are in a key position to educate and provide preventative programs for early, acute cases. This paper will highlight those people who are at an increased risk for CTS and provide techniques and suggestions to prevent it's progression.

Many doctors and third party payers worry that CTS is being over diagnosed and over treated. Increased awareness of CTS in the health care community may result in classifying many upper extremity symptoms as CTS, thus actually over reporting the incidence. Conversely, studies show a reluctance in some areas to report CTS as occupationally related leading to under reporting of the incidence.¹ A study by the Centers for Disease Control (CDC) indicated that health practitioners substantially under reported the number of work related CTS cases.⁵

The establishment of a compression neuropathy of the median nerve at the wrist is the first step in the diagnosis of CTS. There are a collection of symptoms associated with CTS which can range from mild tingling in the fingers to crippling muscle-wasting in the thumbs. Presentations of CTS are diverse with various tests employed to establish the diagnosis. Seldom would it be appropriate or necessary to
use all tests and sometimes the predictive value of these tests is questionable. To have determined that there is a deficit in the median nerve is to have made half of a diagnosis of CTS. The second half of the diagnosis involves discovery of the underlying cause and successful management.

The purpose of this paper is to provide guidelines for the physical therapist's management of CTS. Symptoms, etiology and diagnostic tests which provide the information needed to effectively manage CTS will be discussed. There are several non-medical as well as medical procedures for alleviating the pain and discomfort associated with CTS. Some of these non-medical strategies are often listed as preventive techniques. Treatment of diagnosed CTS usually involves a conservative approach initially and if no relief is obtained, surgical decompression is recommended. Therapeutic management of people with CTS varies in the type and length of treatment required. Current treatment techniques and their efficacy will be discussed. This paper will add to the body of knowledge regarding CTS by providing information which will allow physical therapists to effectively understand the anatomy, etiology, diagnosis and management of this entrapment neuropathy.
The carpal tunnel is a passageway formed by the carpal bones and transverse carpal ligament, through which passes the median nerve and the tendons that supply the hand's sensory and motor function. Figure 1 shows the median nerve as it passes through the carpal tunnel. The floor of the tunnel is formed by a concave arch of carpal bones covered by the intrinsic and extrinsic palmar wrist ligaments. The roof of the canal is formed by the transverse carpal ligament. This transverse carpal ligament attaches to the scaphoid and trapezium on the radial side of the pisiform and hook of the hamate on the ulnar side. The transverse carpal ligament is 2 to 5 cm long, 2 to 3 cm wide and 2.5 to 5 mm thick. The proximal border of the carpal tunnel ligament is located at the level of the distal palmar crease. The median nerve becomes superficial to the flexor digitorum superficialis muscle bellies about 5 cm proximal to the transverse carpal ligament and usually lies superficial in the carpal tunnel. Due to it's position, the median nerve is the most sensitive to pressure of all the structures within the carpal tunnel. As the median
Figure 1.—Anatomy of the Carpal Tunnel. (Adapted from: Chow JC, Endoscopic Release of the Carpal Ligament, Andover, MA: Smith and Nephew Dyonics. 1991)
nerve passes through the carpal tunnel it divides into sensory and motor branches to the thumb, index, middle and radial half of the ring finger. The anatomy of the median nerve and its branches vary so significantly that a cautious surgical approach is warranted to avoid a disabling sensory or motor deficit. Surgeons have performed extensive anatomical studies of the median nerve to improve surgical approaches and to decrease the risk of nerve injury.¹

The median nerve becomes compressed in the carpal tunnel either because there is too little space or too much tissue within the tunnel. The effects of compression are due to ischemia, not mechanical deformation. Gelkerman using a wick catheter technique, determined that the normal pressure within the intracarpal tunnel is 2.5 mm Hg; the pressure increases to about 30 mm Hg with 90 degrees of wrist extension. Rydevik et al found that pressures of 20 to 30 mm Hg applied to peripheral nerves will result in slowing of blood flow in venules.¹

Sunderland differentiated acute compression of the median nerve from chronic progressive compression.⁹ In acute compression a severe force causes mechanical deformation of the carpal tunnel and ischemic changes of the median nerve. Immediate surgery is the usual course to relieve an acute compression. Chronic compression is more common than acute, and typically involves a progressive degeneration.
Sunderland outlined three states of degeneration in chronic progressive compression. In stage I, obstruction of venous return occurs, causing the circulation to slow in the associated tissues, which in turn impairs the nutrition of the median nerve fibers.\textsuperscript{9} At this stage the structural changes may be corrected by reducing pressure in the carpal tunnel. Nocturnal pain and diminished sensation in the median nerve distribution may occur gradually and indicate a stage I compression. In stage II, capillary circulation slows so severely that anoxia damages the endoneurium.\textsuperscript{10} Edema occurs as protein leaks into the surrounding tissues. Individual nerve fibers experience segmental demyelination, axon thinning, and destruction of axons. The severity of the lesion increases, resulting in greater damage to the sensory and motor fibers unless decompression occurs.\textsuperscript{10} Burning pain and referred shoulder pain may indicate a stage II neuropathy. In stage III, nerve fibers undergo wallerian degeneration with a loss of axons, resulting in a reduction in the number of axons available for regeneration. During this level of degeneration pain response is variable, the pain may have subsided or become quite severe.
CHAPTER III
ETIOLOGY

Identifying the cause of the median nerve neuropathy allows for the development of a more precise, individualized treatment program. The carpal tunnel is a limited space containing bone, tendon, connective tissue, synovium and nervous tissue. Therefore, disease or trauma to any of these components can decrease this space and increase the pressure in the tunnel. There are a multitude of pathological causes for CTS.¹ These may range from the most common cause, which is nonspecific flexor tenosynovitis, to conditions such as rheumatoid arthritis, amyloidosis, diabetes, tuberculosis or pregnancy.

There is reason to believe that patients with CTS may share some anatomical peculiarities. Dr. E Johnson, a physical medicine specialist, believes individuals with square-shaped as opposed to rectangular or oblong-shaped wrists are prone to develop CTS.¹⁰ The area of the carpal tunnel has been shown to be smaller in symptomatic workers as compared to those without symptoms.¹¹

Nonspecific Flexor Tenosynovitis
The majority of patients with CTS have nonspecific
tenosynovitis as the cause. The tenosynovium shows various degrees of proliferation and thickening. Clinically these patients frequently have degenerative arthritis. Historical findings are suggestive of repeated mechanical stresses, often due to occupational activities leading to the development of CTS.\textsuperscript{4,7,12}

Rheumatoid Arthritis

CTS is the most common rheumatoid compression neuropathy, seen in approximately 23\% of rheumatoid patients.\textsuperscript{13} It may be the initial manifestation of the disease, as it is not uncommon to have the diagnosis of rheumatoid arthritis (RA) made after a carpal tunnel release for what was thought to be an idiopathic CTS.

Trauma

Many traumatic conditions around the wrist may result in chronic or acute CTS. Acute CTS may be associated with Colles' fracture, fracture of the distal radius, or dislocations/fractures of the carpals.\textsuperscript{14} CTS is associated with crushing injuries to the hand, burns, lacerations or a blow to the wrist. Chronic CTS may result from any of the above conditions causing progressive compression of the median nerve.

Pregnancy

The marked increase in symptoms of CTS during pregnancy, has led many studies to implicate the extra fluid and fat associated with pregnancy.\textsuperscript{15} Relaxin, an ovarian
hormone, has been implicated as the cause of the initial fluid retention.\textsuperscript{16,17} According to Soferman et al, the typical time of onset is in the sixth month.\textsuperscript{18} In two large studies of 1000 or more pregnant women, one-third reported hand symptoms during pregnancy with 10\% having symptoms typical of CTS.\textsuperscript{19,20}

Other Conditions

Many space-occupying conditions, including tumors, and flexor tendon anomalies have been reported to cause CTS.\textsuperscript{14} Congenital defects such as bony protrusions, or a median nerve anomaly are also responsible for the syndrome. Vitamin deficiency (pyridoxine), amyloidosis, vascular lesions, gout, diabetes, myxedema, oral contraceptives, menopause and endocrine disorders have all been associated with CTS.\textsuperscript{7,14}
CHAPTER IV
INCIDENCE, COST AND RISK FACTORS

Controversy surrounds the incidence of carpal tunnel syndrome (CTS). Newspapers and magazines have given considerable attention to the impact of CTS on the work force. One such article indicates reports of CTS related injuries have risen from 20,000 in 1983 to almost 74,000 in 1987 (Business Week, January 1989). Predictions are that repetitive motion injuries will comprise 50% of workers' compensation claims by the year 2000. CTS is the most prevalent condition classified as a cumulative trauma disorder (CTD). Data from the Bureau of Labor Statistics (BLS), reported the number of disorders associated with repeated trauma rose from 23,000 in 1981 to 223,600 in 1991, an almost ninefold increase. Half of these cases involved hand and wrist disorders and of these 112,000 workers, about 10,000 were diagnosed with CTS.\textsuperscript{21}

Data suggests that workers' compensation counselors, physicians and rehabilitation specialists can expect to be serving a large number of clients with CTS. In 1991 cumulative trauma disorders (CTD) represented 61% of all occupational illness. However, this may be misleading. The
BLS distinguishes between occupational illnesses and occupational injuries; CTS is classified as an occupational illness, whereas low back pain is an occupational injury. In 1991 occupational illness represented 5.8% of the total; occupational injuries 94.2%. Therefore CTS represents 3.5% of the total of occupational injuries and illnesses reported by the BLS.\textsuperscript{22} When reporting the incidence of CTS, the media often over-represents the prevalence by making it a percentage of all occupational injuries.

Although there have been many reports of the increased incidence of CTS, it has been difficult to determine it’s associated costs. The National Council on Compensation Insurance (NCCI) reported the average cumulative trauma injury claim cost for 1989 was $24,158.\textsuperscript{22} Costs for a CTS case have been reported to range from $10,000 to $30,000 when surgical intervention is required.\textsuperscript{22,23} Direct costs include: workers compensation payments for lost workdays; insurance premiums; and actual medical and rehabilitation costs. The indirect costs include expenditures associated with worker absence, replacement wages, productivity losses, morale, and increased turnover. Indirect costs are more difficult to ascertain than the direct costs. The direct and indirect costs of CTS cases can range from $20,000 to $200,000.\textsuperscript{24} To date the heaviest fines imposed on industry by the Occupational Safety and Health Administration (OSHA) have been for cumulative trauma related injuries.\textsuperscript{23}
A study conducted by Webster and Snook gathered information on upper extremity cumulative trauma disorders from 45 states. They suggest the incidence and costs of upper extremity CTDs are far lower than low back pain injuries, and therefore, reporting of CTS may be inflated. However, CTS does represent a significant problem in certain industries. Control measures can be cost-effective by decreasing disability and increasing productivity. The average cost per case for CTS can be used to calculate the payback period for recommended engineering or administrative controls.

Carpal tunnel syndrome is not a new problem, but the incidence has risen dramatically in the past few years. The contributing risk factors can be categorized into medical factors and occupational factors. Medical conditions such as rheumatoid arthritis, Paget’s disease, neoplasms, gout, myxedema, pregnancy, amyloidosis, acromegaly, diabetes mellitus, Raynaud’s disease, hypothyroidism, and malaligned fractures can predispose a person to CTS. Occupational risk factors include repetitiveness, posture, force, vibration, and temperature. It is primarily the occupational risk factors, which have become inherent in many current jobs, that is causing the number of cases of CTS to skyrocket. According to the American Academy of Neurology, there is a 10% lifetime risk of developing CTS. CTS strikes men and women of all ages although it occurs most often between the
ages of 40 and 60 and predominates in women, at a ratio of 3:1. Posture is the most frequently cited risk factor for occupational CTS. Posture which results in raised shoulders, prolonged wrist flexion and/or extension, and ulnar deviation can contribute to median nerve compression. Occupations requiring repeated finger flexion with the wrist flexed or positions where the elbows are elevated more than 30 degrees and abducted from the body, can predispose the worker to CTS. The most mechanically efficient position is one in which the wrist is extended approximately 30 degrees, the fingers are slightly flexed and elbows are down and close to the body.

Individuals in a variety of occupations have experienced CTS. Carpal tunnel syndrome has surfaced among meat packers, assembly line workers, carpenters, dental hygienists, mail handlers, musicians, jackhammer operators, typists, computer operators, athletes, supermarket checkers, and homemakers. High risk activities include heavy use of hand tools, repetitive keyboarding, sewing, playing an instrument, assembling, and cutting activities. Depending upon the study, the largest group affected by CTS are people in administrative occupations (technicians, secretaries, computer workers) accounting for 20% of all CTS cases; homemakers accounted for 16% of the cases; laborers were the third largest group with 15.8% of the cases. CTS is often related to more than a single activity. For example, while
clinicians judge non-occupational factors to be responsible for 27% of CTS cases, they consider CTS in 49% of these same cases to be job related; there may be some overlap which has not been taken into account. Insufficient education and training programs, especially for new employees, can lead to inadequate understanding of correct and safe techniques and postures for proper job performance.
CHAPTER V
CLINICAL EVALUATION

Subjective

History.--An accurate history is an effective diagnostic tool. The onset, duration, timing and anatomic location of the symptoms are important in establishing a valid diagnosis and in correlating treatment and prevention techniques. Acute CTS is rare and occurs primarily in trauma situations with a rapid and intense development of symptoms. The pathophysiology is similar to acute compartment syndrome, with surgical decompression the treatment of choice. More commonly CTS has a gradual onset presenting first in a single finger, and spreading to the rest of the median nerve distribution. Symptoms are often intermittent.

In the typical, middle-aged, female patient, symptoms often occur at night. Night numbness may indicate sleeping with the wrist in a flexed position. The symptoms are usually relieved by shaking or rubbing the fingers and hand. Because the numbness is temporary and not debilitating, it may be ignored for an extended period of time. The relationship of the onset of symptoms to work and hobby activities should be documented along with specific
information about tools used, repetitive movements, vibrations, hand and wrist positions and gripping mechanisms.

Obtain a medical history as well, there are a number of conditions common to CTS. In reviewing current and previous medical history, this will elicit information on diabetes, renal failure, pregnancy, trauma, fractures, rheumatoid arthritis, and any previous surgery to the arm. Chronic conditions such as osteoarthritis and diabetes mellitus may accentuate the syndrome. According to some researchers, the presence of diabetes mellitus is more prevalent with CTS than any other systemic condition.

**Sensation.**—Phalen noted that 80% of those diagnosed with CTS present with sensory complaints. CTS typically begins with sensation related symptoms such as burning, tingling, or a feeling of "pins and needles," usually in the thumb, middle finger, index finger, or the medial side of the ring finger. Isolated numbness in the middle finger or in both the middle and index finger is the most frequent presentation. Many patients are unaware of the true distribution of their paresthesia and will report it in all digits. The problem affects both hands in 50% of the cases, however, symptoms usually appear first and more severely in the dominant hand. The problem may progress to pain and numbness or a sensation of coldness in the hand. The hand may also feel swollen, although no swelling is
detected. Some people experience pain in the forearm and an inability to distinguish between hot and cold.

**Motor Function.**—Compression within the carpal tunnel often results in loss of motor function to some of the muscles innervated by the median nerve. These muscles include the flexor pollicis longus, flexor digitorum profundus, flexor digitorum superficialis, opponens pollicis, abductor pollicis brevis, flexor pollicis brevis and the first and second lumbricals. The degree of muscle impairment varies with the severity of the nerve compression. When CTS interferes with movement of the hand, the thumb often becomes clumsy and weak. Weakness may be reported by the patient as there is a tendency to "drop things," which may actually be due to decreased stereotaxis from decreased fingertip sensation. In severe cases, the muscles of the thumb may atrophy and there will be loss of grip strength.\(^{12}\)

Since sensory fibers are more pressure sensitive than motor fibers, only 40% of those with CTS will present initially with thenar atrophy.\(^{33}\) As CTS reaches the advanced stages, thenar muscle weakness will be evident and response to conservative measures will provide only temporary relief.

**Functional Disability.**—In addition to evaluating specific sensory and motor loss, functional disability should be evaluated. This information is important regarding the present condition, and in determining the treatment which would be most effective.\(^{14,34}\) Symptoms of paresthesia and
hypoesthesia often cause sleep disturbances. Scientists believe this is due to dilation of the blood vessels when the arm is at rest, leading to crowding in the carpal tunnel. Others postulate this "nocturnal numbness" is the result of the lack of muscle movement in the hand, which decreases the blood supply to the fingers. Circulation also slows during sleep, causing fluid accumulation in the tunnel. CTS is often associated with a habit of sleeping with one hand tucked under the head.

As thenar muscle function deteriorates, fine motor skills and pinch strength are affected. Loss of grip strength and clumsiness make simple tasks such as opening jars, tying shoes, or winding a watch difficult and painful.

An autonomic nerve impairment characteristic of CTS often results in loss of sweat function. Areas of the hand innervated by the median nerve are dry and shiny in many of the people suffering from CTS. The dexterity necessary for grasping and manipulating objects is enhanced by moistness of the hand.

Objective

Diagnostic Tests.--Presentations of CTS are diverse, at times requiring a variety of tests to establish the diagnosis. History and symptoms help guide the selection of the most appropriate test or tests to administer. For ease of discussion, these diagnostic tests have been separated into provocative, sensory and electrodiagnostic categories.
Table 1 summarizes some of the more common diagnostic procedures.\textsuperscript{28}

The most frequently used provocative tests are Tinel's tapping test, and Phalen's flexion test. Tinel's sign uses percussion over the transverse carpal ligament and is positive in approximately 60% to 67% of patients with CTS.\textsuperscript{28,30} Phalen's test uses maximal flexion of the wrist, with a sensitivity of 75% to 88%.\textsuperscript{28,30} Another method is the tourniquet test, a blood pressure cuff is placed proximal to the elbow and inflated to a pressure above the patient's systolic blood pressure. The test is positive when numbness develops in less than two minutes.\textsuperscript{35} Phalen's test is the most sensitive and useful of these three tests.\textsuperscript{7,30} The tourniquet test is the least reliable, with a 40% false positive rate and therefore is not considered useful.\textsuperscript{36}

Sensory testing is most effectively accomplished initially using static and moving two-point discrimination. If these tests show abnormalities, other sensory tests are not essential.\textsuperscript{28} If two-point discrimination is normal, then the more sensitive Semmes-Weinstein monofilament test or vibratory testing should be pursued. The vibrometer is used to measure the perception of frequencies in the hand. Few studies have been published with statistics to validate this measure.\textsuperscript{29} There have been attempts to quantitate these sensory tests to improve their diagnostic yield.\textsuperscript{37}
<table>
<thead>
<tr>
<th>Name of Test</th>
<th>How Performed</th>
<th>Positive Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phalen’s Test</td>
<td>Patient places elbows on table, forearms vertical, wrists flexed</td>
<td>Numbness or tingling on radial-side within 60 seconds</td>
</tr>
<tr>
<td>Tinel’s Test</td>
<td>Examiner lightly taps along median nerve, at the wrist</td>
<td>Tingling response in fingers at site of compression</td>
</tr>
<tr>
<td>Static Two-point Discrimination</td>
<td>Determine minimum separation of two points perceived as distinct when lightly touched to palmar surface of digit</td>
<td>Failure to discriminate points more than 6 mm apart</td>
</tr>
<tr>
<td>Moving Two-point Discrimination</td>
<td>As above, but with points moving</td>
<td>Failure to discriminate points more than 5 mm apart</td>
</tr>
<tr>
<td>Vibrometry</td>
<td>Vibrometer head is placed on palmar side of digit; amplitude at 120 Hz increased to threshold of perception; compare median, ulnar nerves, both hands</td>
<td>Asymmetry with contralateral hand or radial versus ulnar</td>
</tr>
<tr>
<td>Semmes-Weinstein Monofilaments</td>
<td>Monofilaments of increasing diameter touched to palmar side of digit until patient can tell which digit is touched</td>
<td>Value greater than 2.83 in radial digits</td>
</tr>
<tr>
<td>Distal Sensory Latency and Conduction Velocity</td>
<td>Orthodromic stimulus and recording across wrist</td>
<td>Latency greater than 3.5 mm/sec; asymmetry of conduction velocity greater than .5 mm/sec vs. contralateral hand</td>
</tr>
<tr>
<td>Distal Motor Latency and Conduction Velocity</td>
<td>Orthodromic stimulus and recording across wrist</td>
<td>Latency greater than 4.5 mm/sec; asymmetry of conduction velocity greater than 1 mm/sec</td>
</tr>
<tr>
<td>EMGs</td>
<td>Needle electrodes placed in muscle</td>
<td>Fibrillation potential sharp waves, increased insertional activity</td>
</tr>
</tbody>
</table>
Electrodiagnostic studies have been used more extensively in recent years for the diagnosis of CTS; slowed conduction of the median nerve across the wrist is a frequent finding in those with CTS. These tests have potential pitfalls and therefore should not be undertaken casually. The tests are operator dependent, and some concept of normal must be available for comparison. Published population norms may be used or the suspected median nerve may be compared with other nerves in the same patient. Beware that bilateral CTS and general neuropathies are common in these patients. The important role of electrophysiologic tests is to confirm the diagnosis of CTS.

Nerve conduction velocity (NCV) involves placing electrodes at various points on the arm and fingers and then measuring the time it takes for an electrical impulse to travel between them. Since nerve compression slows conduction time, nerve conduction velocities can pinpoint the location of median nerve compression. The median nerve is composed of 94% sensory fibers and 6% motor fibers. The sensory conduction time is more likely to show early abnormality than would be found in a motor conduction test. The results of electrophysiologic tests can be classified for the clinician as "mild" (sensory only), "moderate" (sensory and motor), or "severe" (denervation of the median
nerve intrinsic muscles). These measurements can be used to estimate the severity of the disease and the prognosis for surgery.

Electromyography (EMG) involves inserting needles into various points in the muscles of the thumb to measure electrical activity. Some individuals object to the invasive use of needles and although EMG is considered to be accurate it is expensive and must be conducted by a specialist. Most patients with CTS can be diagnosed on history alone. There are times, however, when EMG is useful in differentiating CTS from its simulators, this may prevent an unnecessary operation. In CTS an EMG is abnormal in about 50-80% of cases.

Differential Diagnosis

In most cases the diagnosis of CTS can reliably be made based on history. The examination and diagnostic tests are needed primarily to confirm the initial impression. However, there are some conditions that can cause numbness and tingling in one or both hands, which may lead to diagnostic confusion.

Radiculopathy.—Compression of one or more cervical nerve roots, primarily C6, is a common source of diagnostic confusion with CTS. Patients with CTS may have some diffuse pain in the arm, but neck and shoulder pain are unusual. Relief of pain by massaging or shaking are common practices with CTS, while patients with radiculopathy find use of the
arm or hand makes the pain worse. CTS patients typically have symptoms at night, nerve root problems typically occur during the day with quiet nights. If C6 is involved there may be weakness of elbow flexion and wrist extension with a decreased biceps reflex. Electrophysiological studies involving NCV or EMG will help make the proper diagnosis.

Thoracic Outlet Syndrome.—Thoracic outlet syndrome (TOS) may initially be confused with CTS, but a good history will usually differentiate between the two. This syndrome is caused by compression or irritation of the brachial plexus and subclavian vessels as they pass through the costoclavicular space. Pain is the usual presenting symptom, occurring diffusely in the arm, over the shoulder and up the back of the neck. Compression of the ulnar nerve often causes the whole hand or arm to become numb. Elevating the arm aggravates this syndrome. By determining the sensory and motor deficits, and looking at pain patterns, TOS can be distinguished from CTS.

Central Nervous System Lesions.—In most circumstances it is easy to distinguish central from peripheral nervous system lesions. Painful parasthesias point to nerves or roots, while clumsy, slow movement and active tendon reflexes direct attention to the central nervous system. There are however, potentially confusing situations. It is not unusual for a patient with transient ischemic attacks to report numbness, tingling or weakness of one or two
fingers. Some attacks of migraine affect the cortical sensory area of the hand, and resemble CTS.

Vascular Disorders.--There may be diagnostic confusion with Raynaud's phenomenon when both conditions are present. Distinction between reflex sympathetic dystrophy (RSD) may at times also be difficult. In patients with true RSD there is more trophic change, redness and cyanosis of the finger tips, and atrophy of the fingertips. It is important to realize CTS can be the source of RSD, and that RSD can follow carpal tunnel release.

Generalized Peripheral Neuropathy.--Nerves involved in general neuropathies are often vulnerable to pressure, for example the median nerve in the carpal tunnel and the ulnar nerve at the elbow. There is a tendency for those with diabetes to suffer from pressure palsy and entrapment neuropathy. Care must be taken to determine that the median nerve is indeed entrapped at the carpal tunnel and not in the arm (ligament of struthers) or at the forearm (pronator teres). Electrophysiological tests will usually identify the median nerve involvement at the carpal tunnel if CTS exists.
CHAPTER VI
TREATMENT

Treatment of CTS depends on the etiology, duration of symptoms, and intensity of nerve compression. If the syndrome is secondary to a systemic disease, the primary process should be treated first. When CTS is diagnosed soon after symptoms appear, conservative measures are often effective. Nonsurgical treatment is most appropriate when the etiology is expected to be transient. If significant damage to the nerve has occurred, surgery to decompress the nerve is required.

Many businesses and health care plans, in the interest of controlling health care cost, have an incentive to identify and treat CTS at an early stage when nonsurgical treatment is most effective. Patients need assurance that CTS is a condition that usually is treated successfully with or without surgery. In a retrospective study of 265 patients, 71% of the participants were treated nonsurgical with the remaining 29% receiving surgery. An abnormal NCV was necessary to be included in the evaluation. Both nonsurgical and surgical patients considered the results to be satisfactory.
In a recent study, designed to examine the frequency of CTS symptoms in primary care settings and to identify the strategies of diagnosis and management, the following data was found. Treatments most frequently prescribed at the first CTS visit were splints (56.3%) and nonsteroidal anti-inflammatory drugs (50.8%). Only 1.6% of patients were given a local injection, 2.9% were recommended for surgery and 7.6% were referred to a specialist for treatment. A job change was recommended for 4.7% of these patients. A four month follow-up of 68% of patients revealed 10% reported complete relief of symptoms, 45% reported improvement, 27% reported no change and 17% reported worsening symptoms.\(^{27}\)

**Conservative Therapy**

About two thirds of all patients diagnosed with CTS have relief of symptoms without surgical treatment.\(^{30}\) Kaplan identified five factors considered important in predicting response to nonsurgical treatment: age over 50 years, duration over 10 months, constant paraesthesia, stenosing flexor tenosynovitis and Phalen test positive in fewer than 30 seconds.\(^{34}\) When none of these factors were present two thirds of patients were cured with conservative therapy. Failure of nonsurgical treatment occurred in 60% of patients with one factor; 83% with two factors; and 93% with three factors. No patient with four or five factors present was cured with a conservative approach.

Treatment of CTS has become somewhat standardized over
the years and in reviewing the literature there is substantial agreement among authors. However, there are several areas of controversy. Conservative therapy includes avoidance of trauma or repetitive actions, immobilization, anti-inflammatory medication, corticosteroid injections, myofascial release, biofeedback, exercise, and activity/job modification.

Avoidance.--Initially the focus of conservative management is to prescribe an initial trial of 'rest' to relieve symptoms. Some repetitive processes can be changed to allow recovery from injury. Avoidance of activities that produce symptoms, such as gripping, pinching, or repetitive wrist flexion/extension movement should be initiated.\(^{42}\)

Biofeedback has been used to alter behavior by using audible EMG signals to discourage stressful hand positions. Although some participants felt biofeedback increased their awareness, this study showed the program to be insignificant in treating CTS.\(^{43}\)

Anti-inflammatory Agents and Corticosteroid Injections.--

Nonsteroidal anti-inflammatory agents have little proven effect in relieving the symptoms of numbness and night pain, but are often recommended as a first treatment.\(^{30}\) Some physicians use intrathecal injections of steroids to reduce the symptoms of CTS. Injection is made at the level of the proximal wrist crease midway between the palmaris longus and flexor carpi ulnaris tendons. It has been found
that injection will give relief of all symptoms in 50-60% of patient. The duration of relief varied from a few weeks to 4 to 6 months with recurrence requiring surgery in two thirds of these patients.\textsuperscript{14,30} Multiple injections are to be avoided, all authors point to the danger of tendon rupture and median nerve injury from repeated steroid injections. A maximum of three to four injections are allowed prior to insisting on surgical release. Neural injuries have been associated with this treatment causing some physicians to reject this as an option.\textsuperscript{29,31} Injections can also cause scarring and damage to the synovial membrane of the tendon sheaths, therefore, oral corticosteroids are often recommended.\textsuperscript{31}

\textbf{Immobilization/Splinting.--}Splinting the wrist avoids the increase in pressure within the carpal tunnel associated with flexion and hyperextension.\textsuperscript{42} This treatment is particularly effective in reducing night pain and numbness. There is controversy over the splint design and wearing duration.\textsuperscript{44} The design should include a forearm based splint with the fingers and thumb kept free. The position of the wrist is controversial. Studies have shown that the wrist position may depend on whether the entrapment is in the proximal or distal part of the carpal tunnel. The recommendation is that if the proximal part of the tunnel is involved, the wrist should be positioned in slight dorsiflexion. Neutral positioning should be used for a more
distal entrapment.

No objective criteria for splint referral have been established. Most studies advocate the following criteria for the use of splints: in cases of mild symptoms of recent onset, those with normal thenar strength and mass, and those with a 1 to 2 second prolongation of either motor or sensory latencies. Studies report approximately 67% of those wearing splints obtain relief. There is a tendency to increase the wearing time in those who seem to have the most discomfort. Often the splint is only worn at night, but if symptoms occur during the day, the splint may be worn all day.

Vitamin B₆.—Pyridoxine HCl or vitamin B₆ may be helpful in those showing a deficiency in this chemical. A causal relationship has not been proven so this treatment remains controversial. It is postulated that this vitamin helps the kidneys excrete edemic fluid. Doses of 200 mg a day are given until symptoms have improved, then decreased to 50 mg daily. High dosages (above 300 mg daily) should be avoided because of reported toxic effects.

Job modification.—Changing the design of tools or work stations to eliminate or reduce stimuli for cumulative trauma can be both preventative and curative. Body position and tolerances to the effects of vibration and motion need to be considered. Tools can be modified to avoid sharp wrist flexion; work stations need to be adjustable to place
the hands/wrist in neutral positions. Rest periods including rotation of duties need to be incorporated into those jobs with repetitive motions. Ergonomic redesign is widely practiced but rarely described in medical terms or with efficacy studies.

**Exercise and Edema Reduction.**--Exercises to promote differential tendon gliding in the flexor digitorum superficialis and flexor digitorum profundus may help alleviate problems with edema. Elevation, pressure wraps, ice, and contrast baths may also assist in edema reduction within the carpal tunnel.

Weight reduction can help some patients with CTS. In those who retain fluid, a diuretic or low salt diet may be effective.\(^6,31\)

**Myofascial Release.**--Sucher has performed studies showing myofascial release of the carpal canal combined with the patient's self-stretch, effective in reducing pain, numbness and improving EMG results.\(^48,49\) A three-phase myofascial release and stretching maneuver is performed by the health care provider. The first step involves "opening" of the carpal canal with stretching to "extend" the canal. In the next step the attachment of the abductor pollicis brevis muscle is released by pulling the thumb into hyperextension and abduction while simultaneously performing the stretch in step one. The last step involves an indirect stretch of the carpal canal by hyperextending the digits and wrist
simultaneously.\textsuperscript{48} Patients are instructed in performing a self-stretch maneuver 5 to 10 times daily. Nerve conduction studies (NCS) were taken before and after treatment as well as magnetic resonance imaging (MRI) measurement. The NCS documented electrical improvement consistent with clinical recovery. MRI measurements demonstrated increases in both the anteroposterior and transverse dimensions of the canal.  

**Cold Laser.**--General Motors has been studying the use of a portable cold laser to treat CTS. The laser uses a wavelength that penetrates the skin up to one inch without damaging tissue. The laser introduces a stream of photons which are believed to act on the mitochondria to help cells heal themselves\textit{(PT Bulletin, Feb. 2, 1994)}. This is still in the experimental treatment stage and results have not been published.  

**Surgical Treatment**  

If conservative measures are unsuccessful after 8 to 12 weeks, then surgery is often considered. There is controversy about the indications for surgery with some recommending surgery for most cases with a definite diagnosis and others suggesting surgery when conservative treatment fails.\textsuperscript{30,50} Indications for surgery include thenar atrophy, tactile sensory loss, failure of nonoperative treatment, electrophysiological classification of severe, excessive pain, and acute post-traumatic CTS.\textsuperscript{30,51} Some feel prolonged conservative therapy of greater than 6 to 8 months
can lead to less optimal results from surgery.\textsuperscript{1} The goals of both conservative and surgical treatments is to restore the sensory capacity of the nerve, eliminate pain, and restore the hand to normal function.

Surgical treatment consists of sectioning the transverse carpal ligament. Conventionally this is done with an open curvilinear incision on the volar aspect of the wrist.\textsuperscript{52} Endoscopic release is becoming the method of choice due to it's ability to reduce postoperative morbidity.\textsuperscript{52,53} The reported advantage of the endoscopic approach is a 1 to 2 week faster relief of pain with a shorter disability time when compared with an open carpal tunnel release.\textsuperscript{30} To date, sufficient data is not available to claim superiority by any one surgical technique, but an increasing number of physicians are moving towards the endoscopic approach. The major problem has been in collecting objective data for comparison. Feinstein has reported patients who had endoscopic carpal tunnel release on one side and open release on the other side preferred the endoscopic to the open procedure.\textsuperscript{52} Gellman et al noted patients with endoscopic carpal tunnel release regained their preoperative grip strengths faster and more completely than did patients who had open releases.\textsuperscript{54} Endoscopic carpal tunnel release is contraindicated in patients with severe rheumatoid arthritis and flexor synovitis, which both prevent hyperextension of the wrist.
The surgical treatment for CTS is one of the most successful operations that can be performed on the hand. However, the operation demands skill and care; complications or poor functional outcomes almost uniformly are related to poor surgical technique.¹⁴ The results of carpal tunnel release, as with treatment for many entrapment neuropathies, depends on the degree of preoperative defect. Statistics vary but the majority of patients regain normal sensory and motion function with 80%-95% reporting good results.⁶,¹⁴,⁴¹,⁵²,⁵⁵

The surgical procedure is done on an out-patient basis unless there are unusual medical problems. Failure to improve following the operation usually suggests an incomplete section of the ligament or an erroneous diagnosis. Complications following surgery are rare. Potential problems include damage to surrounding structures, palmar hematoma, reflexive sympathetic dystrophy, infection, adhesions and scarring.⁵¹ The most common complications are incision tenderness, digital stiffness, persistent swelling, and a generally slow rehabilitation.¹⁴ These complications can be reduced by a precise technique, as well as postoperative care and rehabilitation. When a post-surgical patient presents with numerous complaints, a reluctance to exercise, and an excessive need for narcotics, immediate hand therapy and careful monitoring is imperative.

Postoperative management.—After surgery, the goals are to control edema, enhance range of motion, prevent adhesion
formation and encourage use of the hand. Immediately following surgery the wrist is usually held in $10^\circ$ to $20^\circ$ of extension with a volar plaster splint and a loose elastic wrap. Finger motion is often encouraged immediately although some physicians may wait 24 hours before promoting digital motion. Patients are encouraged to keep the hand elevated above heart level to prevent swelling; sling use is not usually promoted. At the first dressing change a small, elastic velcro-type splint is used to support the hand and wrist. Sutures are removed in 7 to 10 days, but the volar splint is often maintained for 3 to 4 weeks.

To prevent adhesion formation differential tendon gliding exercises are performed three to five times daily, ten repetitions each. Patients are instructed to increase exercises gradually to prevent tenosynovitis. Passive and active exercise of the affected hand and fingers is essential for effective outcomes and healing. Healing usually occurs in 4-10 weeks, depending on the type of surgical technique used. Frequent scar massage (3-5 times daily) may be performed directly over the healed incision site. The patient to watch is the anxious person with a low pain tolerance, who will not actively flex the fingers. Normally complications with these patients can be prevented by beginning immediate supervised exercises.

Most patients will be able to return to employment within a few days. The exception may be carpenters,
construction workers, and laborers who due to the nature of their work, may be out of work for an average of 4 to 6 months. By 6 to 9 months following surgery, most patients have regained grip strength and endurance and can return to previous employment.\textsuperscript{7,14} Workers who work on assembly lines requiring repetitive motion will often need a job change or some job modifications to reduce or eliminate those factors which initially brought on the CTS.

Depending on preoperative severity of symptoms and response to surgery, some patients may require few or no therapy sessions, some require moderate intervention (3 to 8 weeks), and some may require a comprehensive program (8 to 16 weeks). If the patient lacks full range of motion at 3 weeks post surgery an exercise and stretch program needs to be implemented. Edema, sensory disturbances and pain can all complicate and prolong the rehabilitation process. A protocol for rehabilitation after carpal tunnel release is given in Appendix A.\textsuperscript{56}

Management of patients with CTS varies in the type and length of treatment. Most patients who have endoscopic carpal tunnel release require minimal therapy because of the low morbidity. The majority do not require therapy beyond 3 weeks of the operation. However, depending on the severity of symptoms, a more intensive therapy program may be indicated.\textsuperscript{52} Splinting and instructions on techniques to minimize pressure on the median nerve may be sufficient for
patients with mild carpal tunnel syndrome. Patients with moderate symptoms may require prolonged therapy with instruction on edema control, tendon gliding exercises, scar management, stretching and strengthening of the involved hand. As the severity of CTS increases the patients ability to perform activities and work duties may need modification along with techniques to manage chronic pain.

PREVENTION

Several patterns of CTS have been presented with treatment based on specific diagnostic features. Although improvement in treatment has occurred, the magnitude of the problem is so great that the best solution is still prevention. Modification of the environment as well as of the individual’s activities are priorities for the prevention of the development of CTS. Early detection can enhance the process of conservative management and help avoid surgical intervention.

Work related cases comprise nearly half of the reported cases of CTS. Not all people working at a given job develop symptoms, therefore it is reasonable that screening tools are being sought to identify susceptible individuals. Electrophysiologic studies are the most objective examination tool at this time, however, total clinical correlation still has not been achieved. Vibrometry may have promise as a screening tool, however the necessary objective measurement studies are currently lacking.
Fortunately, most of the occupational risk factors contributing to CTS can be minimized, and often entirely eliminated before symptoms appear.

A multifaceted education and prevention program should be implemented in worksites with risk factors. The first step may be to educate management on the characteristics and cost of CTS. It is imperative that top management have an understanding of the ramifications of CTS in order to have an effective prevention program. If the attitude of management is one of suspicion towards employees with CTS, viewing it as a workers' compensation ploy, the program will lack beneficial outcomes. Dortch and Trombley conducted a study to determine whether education modified habitual hand-use behaviors of workers at risk for CTD.\(^57\) Results indicated educational programs were significantly effective in reducing the number of at-risk movements one week after receiving education. Further study is needed to determine if workers permanently change their hand-use habits to less harmful patterns as a result of education programs.

An investigation or assessment of risk areas in the worksite needs to be conducted after the education phase of the program. The task of job analysis can be complex and the skills of an expert may be required. The evaluation of the worksite should include:\(^58\)

- **Workstation design and maintenance.** Often worksites will have appropriate equipment but fail to adjust,
maintain, or replace the equipment. Posture needs to be assessed while in the work station, for awkward movements and extreme reaching.

- **Design and maintenance of tools.** Ergonomically correct tools will reduce CTS problems.

- **Product flow.** The rate of speed at which production lines move or the time frames set by management may be a problem. In one job site slowing down product lines actually increased productivity by increasing efficiency.

- **Personal protective equipment.** Equipment provided to decrease risk of injury needs to be assessed for function and usefulness on an individual basis.

- **Administrative controls.** Factors such as job rotation, rest breaks, and identifying light duty jobs need to be evaluated for their effectiveness.

There are often numerous modifications, which may be made immediately, with minimal costs involved to remove some of the worst areas of risk. Changing heights and positioning in chairs and workbenches; implementing preventive splints and gloves; rotating between jobs and encouraging exercise breaks are all ways to modify the work environment. Some major risk factors along with prevention strategies are listed in Appendix B. The National Institute for Occupational Safety and Health (NIOSH) has compiled and published recommendations and guidelines for management of
CTS for distribution to the public. Some of the references in the packet are outdated, however, the illustrations and explanations for workers to reduce risk factors are still useful.

Workers should be encouraged to insure their own working future by reducing high risk postures and activities. Taking brief rests, learning to grip and grasp objects with minimal force, and using the whole hand not just the fingers, are strategies to reduce wrist tension.

Exercise can be a key to prevention. Job specific exercises done while in the workplace can help prevent the injury from occurring in the first place. Physical therapists are conducting on-site analysis of the workplace and designing short exercise programs to prevent fatigue and thereby reduce injury. The result has been a decrease in problems and injuries in a number of participating companies.

Dental hygienists are well recognized as being at risk for CTS. Gerwatowski, et al identify some specific occupational risk factors and offer some prevention techniques. Contributing risk factors include repetitiveness, posture, force, mechanical stress, vibration and temperature. These risks are inherent within the profession of clinical dental hygiene. Specific preventative strategies for each risk factor are outlined in Gerwatowski’s paper. A four point program, similar to one recommended by OSHA for meatpackers, was used in a baking
company cited for CTD problems. Awareness and implementation of preventive techniques can minimize the incidence of CTS in those occupations with increased risk.

Employers are increasingly applying principles of ergonomics in seeking to reduce the incidence of CTS. Some of these principles include:  

1. Adjustable chairs with cushioned arm rests to support forearms.  
2. Orienting fixtures to allow activities to be performed within normal range of hand and arm movement.  
3. Consideration of tool size in minimizing force, vibration, stress and pressure on the hand.  
4. Reduction in the weight or size of items to be moved.  
5. Proper selection of hand wear to modify temperature and force factors.  

Employers who institute an ergonomics program may not see an immediate reduction in costs, however, the long term benefits will make the process worthwhile.  

The Labor Department holds the employer responsible, even when CTS may have been caused by the employee's negligence or poor body mechanics. This means the employee is often eligible for Worker's Compensation. Surgery may relieve the inflammatory problem, but a worker who returns to the same conditions that triggered the disorder will often have a reoccurrence. Workplace modifications may cost as little as a few dollars or as much as several thousand
dollars, but those figures must be compared to the cost of carpal tunnel surgery, which can exceed $30,000 when lost wages, surgery and rehabilitation are totaled. Many unions and companies, including the American Postal Workers Union, the United Automobile Workers, and 9 to 5 have established educational programs to teach prevention and recognition of CTS. If companies continue to implement preventative programs, perhaps CTS may not become, as some have predicted, the "occupational disease of the future."

Physical therapists have been working in industrial and corporate settings to educate employers and employees about CTS, what causes it and how to prevent it through proper use of the musculoskeletal system. Physical therapists can target and correct poor work habits and improper work designs. A typical education program includes exercises employees can do at work and home, adjustments to the work site, and early detection of symptoms to avoid surgery. Activities outside of work may also contribute to CTS: knitting, sewing, cooking, housework, TV computer games, playing sports or cards, and hobbies or carpentry which use power tools for extended periods of time all play into CTS. Treatment used in the work setting needs to be incorporated into the home environment as well.
CHAPTER VII

DISCUSSION

Carpal tunnel syndrome is a constellation of symptoms that arise when the median nerve is compressed as it travels under the transverse carpal tunnel ligament. Opinions on etiology, incidence and treatment methods are diverse. Although it is not clear just how prevalent this disorder is, there is no doubt it's incidence is on the rise. In North Dakota alone, 328 CTD claims last year cost $1.1 million in Workers' Compensation and $436,000 in medical costs. (Grand Forks Herald, May 26, 1994). Although these numbers represent all CTDs, it is important to remember CTS is the most prevalent CTD. Those who feel CTS is being over diagnosed and over treated, may be correct in pointing out that surgery should be considered as a last resort treatment. But if all those workers with aching hands and wrists don't have CTS, what do they have? Most experts would probably agree these people have inflamed tendons, which might develop into CTS if left untreated.7

Those patients with milder forms of CTS should be provided with treatment every bit as aggressive as those with severe symptoms in order to help control the
advancement of this disorder. As there is no such thing as being a "little bit" pregnant, there is no such thing as "mild" CTS--you either have it or you don't. By taking this approach reporting may more accurately reflect the need for aggressive prevention programs, not necessarily the need for more surgical treatment.

Many businesses and managed health care plans, in the interest of controlling health care cost, have an incentive to identify CTS at an early stage when nonsurgical treatment is more likely to be effective. Screening devices, such as the Vibrotactile Tester, will no doubt become more prevalent as the incidence of CTS rises. Care must be taken to assure these devices are valid and reliable before they are introduced into the market as a screening tool. The subjective diagnostic tests described earlier have studies detailing their reliability and validity, however, the sensitivity of these tests is less than .75. 

The most sensitive and objective test used to diagnose CTS is electrodiagnosis. The data reported in the literature is variable with electrical abnormalities correlating with clinical findings in 50%-90% of patients. Some argue that nerve conduction studies only add unnecessary cost to patient treatment. This is no doubt true in some cases, but with current litigation trends and the diversity of neurological disorders, an electrophysiological test is almost mandatory if surgery is
being considered. A recent study designed to understand the frequency, diagnosis, and management of CTS found most cases presenting in a primary care setting could be treated with relatively inexpensive interventions.\textsuperscript{27} More than 90\% of these patients were managed without a change in employment status with 55\% obtaining full relief of symptoms. The clinicians in this study rarely used EMG or NCS to diagnose, preferring more conservative diagnostic techniques initially.

Due to the variability of CTS, the achievement of an optimal diagnostic test is questionable. The absence of a traditional gold standard for diagnosis of CTS is an unavoidable weakness. Therefore, the efforts of physical therapists need to focus on prevention when the diagnosis seems questionable. In no instance would preventative treatment be contraindicated or harmful.

The last area to discuss is the treatment of CTS. Conservative versus surgical treatment continues to be a dilemma. The answer is based on each individual case. The cumulative trauma patterns of tenosynovitis and position can be controlled in about two thirds of cases by nonsurgical management.\textsuperscript{30} Surgery for CTS, although often effective, is not a cure-all; studies report surgical failure rates of 7\% to 20\%. To assure optimal surgical outcomes, patient’s need to confirm their doctors qualifications for performing surgery by being conscientious consumers. With a variety of
approaches to carpal tunnel surgery, patients need to become informed about the types of surgery performed by their physician and the outcomes achieved.

Because the majority of CTS patients find relief with nonsurgical or conservative therapy, the question to ask is who is providing this treatment and is it effective in preventing progression of this disorder? There are no studies delineating the percentage of CTS patients receiving conservative treatment, how extensive this therapy/treatment is, and whom is providing the therapy. This would be of interest and benefit to correlate with outcome studies of CTS treatment. The primary care physician is most often the ultimate "authority" on how a patient’s presentation of CTS will be managed. The physician has many referral options: to refer the patient on to a hand specialist, monitor the patient herself, or perhaps refer to physical therapy, occupational therapy, or an industrial nurse practitioner. All these professionals should have the knowledge base to provide care for CTS patients. What must not happen is: evaluating a patient for what appears to be CTS, educating him/her concerning the nature of the disorder, and then providing no follow-up treatment or inquiry. To recognize CTS at it’s early stages and fail to provide proper counsel, treatment, and follow-up is negligent of any health care provider.

The patient’s involvement in a therapy program
following surgery depends on a combination of several factors: the severity of involvement, the physician's recommendations, and the surgical outcome. Although every surgical patient is not a candidate for physical therapy, especially with the emergence of endoscopic CTS surgery, the rehabilitation phase is just as important as the surgery. To undergo the time, cost and trauma of surgery and put minimal or no emphasis on rehabilitation is irresponsible. Active involvement by the physician and therapist is important to motivate the patient to become more involved in their rehabilitation. A program of physical therapy to restore strength, flexibility, and function to the wrist and resolve any pain problems is important. This is especially necessary when the patient will be returning to the job/activities responsible for the CTS. An adequate program of PT can also restore the worker's confidence in the ability to perform the job without fear of re-injury. A goal of surgery for CTS is to return the patient to work or activities in the shortest possible time. Nathan et al conducted a study to determine the influence that incision length and a program of physical therapy had on a patient's return to work. Their findings suggest early post-surgery hand therapy, is more important than incision length for regaining function and decreasing time-loss. This study reaffirms the importance physical therapy has in treatment of CTS. Hand therapy paid for itself several times over by
reducing time-loss costs, for an average of $3,080 for each workers' compensation client.

The best way to treat CTS is to prevent it from occurring and progressing. Not to prevent CTS's occurrence through job modification and education is gambling with the consequences of astronomical medical bills, morale problems among employees, and high insurance premiums. Physical therapists are in a unique position to assist companies in developing a prevention program. As more employees are filing workers' compensation claims for CTS, OSHA is responding by fining employees for failing to provide a safe workplace. Since both CTS and OSHA are not going to go away any time soon, employers cannot afford to ignore either. By contracting therapists to assess ergonomic changes and provide preventative practices required by OSHA, employers should be able to make the programs pay for themselves in reduced lost time and workers' compensation liability.

Societal, business, and occupational trends provide explanations for the increased incidence of CTS and help to forecast future safety and health program needs. Increased work loads, at faster speeds, with little variation, all contribute to the problem of repetitive trauma associated with CTS. Education is a key component in the treatment and prevention of CTS. Physical therapists with their knowledge of the musculoskeletal system can provide treatment programs to both the surgical and nonsurgical patient. In addition,
Physical therapists can target and correct poor work habits, identify improper work designs, and provide educational programs to reduce the incidence of CTS in the workplace. Physical therapists have an important role in the management of carpal tunnel syndrome and need a thorough understanding of the nature of this disorder to be effective in today's environment.
APPENDIX A
CARPAL TUNNEL RELEASE
POST SURGICAL PROTOCOL

Precautions:
1. Keep dressing clean and dry until removed.
2. Avoid pushing with palm until there is no soreness.
3. Avoid excessive wrist motion.
4. Avoid high force/repetition movements.
5. Avoid lifting heavy objects for at least 2-3 weeks.
6. Avoid forceful pinching or gripping movements.
7. Avoid high frequency vibration--lawn mowing, electric razor, hand tools

Patient Education:
1. Anatomy
2. Mechanism of injury
3. Surgical process
4. Healing process
5. Precautions
6. Rehabilitation process
7. Return to work/activity time frame

Rehabilitation Focus:
1. Controlling edema
2. Avoiding adhesion formation of flexor tendons
3. Strengthening of thumb, wrist and fingers
4. Full range of motion
5. Remodeling scar
6. Return to work and previous activity level

Day 0 - Week 2
1. Hand immobilized in a volar splint
2. Elevation of the hand above the heart for edema
3. Active ROM for fingers, thumb, elbow and shoulder
4. Tendon gliding exercises to prevent adhesion formation
5. Whirlpool treatment to assist with wound healing, if necessary

Week 3 - Week 6
1. After suture removal, scar massage initiated
2. Increase tendon gliding exercises to 5X/day, 20 reps.
3. Active ROM for wrist
4. Desensitization exercises/fluidotherapy for hypersensitive incisions
5. Strengthening with theraputty or a hand exerciser

Week 4 - Week 8
1. Stretching exercises
2. Isometric strengthening exercises--beware of tenosynovitis
3. Modalities as needed:
   - Contrast baths--to increase circulation; 15-30 minute treatment
   - High volt galvanic stimulation--to increase circulation and decrease muscle tightness in the neck and shoulder region
   - TENS--for pain control; beware of electrode placement
4. Monitor for persistent pain and swelling--onset of RSD

Week 8 - Week 16
1. Fine motor skill exercises--macrame, card-playing
2. Work hardening initiated for endurance--light work chores, housecleaning
3. Evaluate work/activity tolerance--repetitive resistive exercises,
lifting; monitor for swelling or symptoms

4. Educate in proper body mechanics:
   a. neutral alignment for wrist
   b. avoid sustained grip/pinch
   c. use proper tool size (1.5" - 2" diameter)
   d. break repetitive movements every 30 minutes

Maintenance
1. Use of wrist splint as needed
2. Lifestyle/occupational modifications
3. Stretching, strengthening exercises as needed
APPENDIX B
PREVENTION OF CARPAL TUNNEL SYNDROME

**Factor:** Working with bent or flexed wrists.  
**Prevention:** Take measures to prevent bending—wrist pads for keyboards, modified tools to reduce bending and force, splinting.

**Factor:** Repetitive hand, arm and shoulder motions.  
**Prevention:** Reduce number of motions, smooth the motions, alternate with other tasks.

**Factor:** Long reaches.  
**Prevention:** Use turntables, sliding shelves and other equipment to bring materials closer; reduce dimensions of the work surface, adjust heights.

**Factor:** Long periods of sitting or standing.  
**Prevention:** For standing, provide leaning stands or stools; alternate between sitting and standing; foot rests and anti-fatigue mats. For sitting, adjustable chairs, foot rests, frequent "stretch" breaks.

**Factor:** Working with neck bent forward.  
**Prevention:** Headrests/headphone for telephone, document holder to hold document at eye level, adjustable desk and chairs to allow proper heights.

**Factor:** Working with vibrating tools or equipment.  
**Prevention:** Reduce vibration by modifying tools, dampening tool grips, gloves.


42. Totten PA, Hunter JM. Therapeutic techniques to enhance nerve gliding in thoracic outlet syndrome and carpal tunnel syndrome. Hand Clinic. 1991;7(3):505-20.


49. Sucher BM. Myofascial manipulative release of carpal tunnel syndrome: Documentation with magnetic resonance imaging. JAOA. 1993;93(12):1273-8.


56. Hand Rehabilitation Center of Indiana. Carpal Tunnel Syndrome (conservative management).


