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The accuracy of ultrasound study in the diagnosis of carpal tunnel syndrome in comparison with nerve conduction study

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Abstract
Back ground: Carpal tunnel syndrome (CTS) is one of the most common upper limb compression neuropathies. CTS accounts for approximately 90% of all entrapment neuropathies. The diagnosis of carpal tunnel syndrome (CTS) is mainly based on clinical findings and nerve conduction study. It has been recently suggested that ultrasonography (U/S) can be used to diagnose CTS.
Aim of study: The aim of this study is to determine the accuracy of Ultrasound (U/S) in diagnosis of (CTS) in comparison with nerve conduction study (NCS) of median nerve.
Patient and Methods: The study was a comparative cross sectional study, which done in ALshaheed Gazi AL-Hariri Hospital for specialized surgery/Baghdad–Iraq, From June 2011 to May 2012. sample included 40 patients who met the inclusion criteria they were 37 (92.5%) females, with a mean age was 38.74 ± 6.7 years range (22- 52 years), in addition, 3 (7.5%) males with a mean age was 38.83 ± 6.35years range (39-47), the mean age for all patients (40) was 38.76 ± 6.6., and 80 Asymptomatic healthy comparison group. 72 of them (90%) were females with a mean age 37.8 ± 7.43 years range (25–53 years), and the remaining 8 comparision group 10% were males with a mean age 38.4 ± 6.3 ranges (23-52), and the mean age of all comparision group was 38.1 ± 6.5. All subjects in both groups were underwent and U/S and NCS, then the Statistical analysis for the results were done.
Results: The Ultrasound signs show the following results: AP diameter of median nerve: show accuracy rate, sensitivity, specificity, as 80%, 78%, 81% respectively. Cross sectional area of median nerve: show accuracy rate, sensitivity, and specificity, as 85%, 85%, 85 respectively.
Conclusions: 1. CTS is mainly affect middle age females. 2. We can concluded that sonography can be adds a benefit in diagnosis of CTS. 3. U/S has potential advantages to other diagnostic tools as availability, shorter Examination time and non-invasive.

Keywords: CTS, examination, ultrasound.

Introduction
Carpal tunnel syndrome (CTS) is one of the most common upper limb compression neuropathies. CTS accounts for approximately 90% of all entrapment neuropathies. Sir James Paget described it in 1854 (tardy median palsy).The lesion has been well established as a clinical entity during the past by the article of Phalen in the 1950s it is due to an entrapment of the median nerve in the carpal tunnel at the wrist [1]. It is a condition of middle-aged individuals and affects females more often than males. Several studies have reported marked female preponderance and a peak incidence around 55 to 60 years. The mean age at diagnosis was 50 years for men and 51 years for women. It is one of the most widely recognized occupational health conditions; particularly in industries where work involves high force/pressure and the repetitive use of vibrating tools. Although the basic etiology is a compression lesion of the median nerve at Wrist level, this lesion has an impact on the whole length of the neurons from finger tips to the dorsal root ganglia and spinal cord level. The signs and symptoms are often puzzling, with pain and sensory disturbances not only in the hand but sometimes also involving the whole extremity. Today it represents a very substantial problem with high impact on life quality for a large number of patients and with important socio-economic consequences so we choose this study [2].

Aim of study

The aim of this study is to determine the accuracy of Ultrasound (U/S) in diagnosis of (CTS) in comparison with nerve conduction study (NCS) of median nerve.

Anatomy

The flexor retinaculum, consisting of the deep forearm fascia proximally, the transverse carpal ligament over the wrist, and the aponeurosis between the thenar and hypothenar muscles distally. Transverse carpal ligament, is a thick band of fibers which runs between hamate & pisiform medially to scaphoid and trapezium laterally, and forms fibrous sheath which contains carpal tunnel interiorly within fibro-osseous tunnel; posteriorly, tunnel is bordered by carpal bones, and transports median nerve & finger flexor tendons from forearm to hand; lies deep to Palmaris longus & is defined by 4 bony prominences; proximally, by pisiform & tubercle of scaphoid; distally by hook of hamate & tubercle of trapezium; from hamate & pisiform medially to scaphoid & trapezium laterally; transverse carpal ligament, portion of volar carpal ligament, runs between these 4 prominences & forms fibrous sheath which contains carpal tunnel anteriorly within fibro-osseous tunnel [3].

Superficial anatomy

The palmaris longus passes in front of flexor retinaculum to become continuous with the palmar fascia. Palmar cutaneous branch of median nerve, which innervates skin over base of thenar eminence, arises short distance proximal to the flexor retinaculum, pierces deep fascia, & course superficial to the flexor retinaculum to reach the skin. It then divides into one radial and one or multiple ulnar branches which innervate the palmar skin of the proximal hand. Palmar cutaneous nerve branch of ulnar nerve course superficial to transverse carpal ligament & is not involved in CTS [4].

Contents of tunnel

The tunnel transports median nerve & finger flexor tendons (FDS, FDP, & FPL). All eight flexor tendons are covered by a common synovial sheath. The flexor pollicis longus tendon, contained in its own synovial sheath, is located on the radial aspect of the flexor tendons within the carpal tunnel. The median nerve resides just under the flexor retinaculum and abuts its inner surface. It is located on the lateral side of the flexor digitorum superficialis between the flexor tendon of the middle finger and the flexor Carpi radials the nerve is round or oval at the level of the distal radius; it becomes elliptical at the pisiform and hamate. Its position and morphology both are altered during flexion and extension [5]. With the wrist in neutral position, the median nerve is seen anterior to the flexor digitorum superficialis tendon of the index or poster laterally between the flexor digitorum tendon of the index finger and flexor pollicis longus tendon. The nerve is forced against the transverse carpal ligament in dorsiflexion or palmar flexion of the wrist. In wrist extension, the median nerve assumes a more anterior position, deep to the flexor retinaculum and superficial to the flexor digitorum superficialis tendon of the index finger. In wrist flexion, the median nerve can be found anterior in the flexor retinaculum or between the flexor digitorum superficialis tendons of the index finger and thumb or middle and ring fingers. In the flexed position, the elliptical shape of the median nerve flattens. Alteration of the median nerve morphology is less pronounced in wrist extension. As much as 20 mm of the excursion of the median nerve can occur and frictional forces between the median nerve, adjacent tendons, and the transverse carpal ligament compound the potential irritation caused by morphologic plasticity during flexion and extension [6]. Branches of median nerve in hand: The motor branch innervates the two radial lumbricals, opponents' pollicis, abductor pollicis brevis, and the superficial head of the flexor pollicis brevis. The motor branch takes a more variable route to its destination. It most often branches off distal to the transverse carpal ligament. However, it may branch off within the tunnel or pass directly through the transverse carpal ligament. Numerous variations in the motor branch have been described (table-1). Sensory branches innervate lateral three and 1/2 digits & palm of the hand [7].

Table 1: Median nerve variation

Studies Number of hands	Khalil Alizadeh 60	Lanz 246	Steinberg 46	Olave 60	Kozin 101	Stancic 65
Median N. bifurcation	8.3%	2.8%	—	—	—	—
Recurrent branch of the median N.						
Extraligamentous	46.7%	46%	—	48.3%	19%	47.7%
Trassligamentous	11.7%	23%	28.3%	15%	7%	18.5%
Transfascial	13.3%	—	—	—	74%	—
Subligamentous	28.3%	31%	—	18.3%	—	20%
From ulnar side	11.7%	—	16.7%	16.7%	0%	4.6%
Accessory branch	31.7%	—	—	38.3%	4%	—
Proximal	13.3%	1.6%	—	—	—	—
Distal	13.3%	7.2%	—	—	—	20%
Both	5%	—	—	—	—	—

Etiology

There are two distinct varieties of CTS - acute and chronic. The acute form is relatively uncommon and is due to a rapid and sustained rise of pressure in the carpal tunnel. This is most commonly associated with a fracture of the radius as Sir James Paget described in 1854 [8]. It is also associated with burns, coagulopathy, local infection and injections and lunate dislocation. The chronic form is much more common and symptoms can persist for months to years. However, in only 50% of cases is the cause identified (50% idiopathic), and can be divided as summarized in below [9].

Causes of CTS

- Anatomy
- Decrease in Size of Carpal Tunnel
- Bony abnormalities of the carpal bones
- Acromegaly
- Flexion or extension of wrist
- Increase in Contents of Canal
- Forearm and wrist fractures (Colles fracture, scaphoid

fracture)
- Dislocations and subluxations (scaphoid rotary subluxation, lunate volar dislocation)
- Posttraumatic arthritis (osteophytes)
- Musculotendinous variants
- Aberrant muscles (lumbrical, palmaris longus, palmaris profundus)
- Local tumors (neuroma, lipoma, multiple myeloma, ganglion cysts)
- Persistent median artery (thrombosed or patent)
- Hypertrophic synovium
- Hematoma (hemophilia, anticoagulation therapy, trauma)
- Physiology
- Neuropathic Conditions
- Diabetes mellitus
- Alcoholism
- Double-crush syndrome
- Exposure to industrial solvents
- Inflammatory Conditions
- Rheumatoid arthritis
- Gout
- Nonspecific tenosynovitis
- Infection
- Alterations of Fluid Balance
- Pregnancy
- Menopause
- Eclampsia
- Thyroid disorders (especially hypothyroidism)
- Renal failure
- Long-term hemodialysis
- Raynaud disease
- Obesity
- Lupus erythematosus
- Scleroderma
- Amyloidosis
- Paget disease
- External Forces
- Vibration
- Direct pressure

Pathophysiology

The exact pathogenesis of CTS is not clear. Several theories have been put forward to explain the symptoms and impaired nerve conduction studies. The most popular ones are

1. Mechanical compression,
2. Micro-vascular insufficiency,
3. Vibration theories.

1. **Mechanical compression theory:** symptoms of CTS are due to compression of the median nerve in the carpal tunnel. The major drawback of this theory is that it explains the consequences of compression of the nerve but does not explain the underlying etiology of mechanical compression. Brain and colleagues attributed the symptoms of CTS to spontaneous median nerve compression in the carpal tunnel. The term 'spontaneous' was used due to lack of clear association between wrist joint deformities and symptoms. The compression was believed to be mediated by several factors such as exertion strain, overuse, hyperfunction, repeated or prolonged wrist extension, prolonged grasping of tools, and unaccustomed manual work [9].

2. **Micro-vascular insufficiency theory:** proposes that the lack of blood supply leads to depletion of nutrients and oxygen to the nerve causing it to slowly lose its ability to transmit nerve impulses. Scar and fibrous tissue eventually develop within the nerve. Depending on the severity of injury, changes in the nerve and muscles may be permanent. The characteristic symptoms of CTS, particularly tingling, numbness and acute pain, along with acute and reversible loss nerve conduction are thought to be secondary to ischemia of the affected nerve segment [10].

3. **Vibration theory:** The symptoms of CTS could be due to the effects of long-term use of vibrating tools on the median nerve in the carpal tunnel. Lundborg *et al* noted epineural oedema in the median nerve within days following exposure to vibrating hand-held tools. Furthermore, the authors also noted similar change following mechanical, ischemic, and chemical trauma. Interestingly, the authors also report animal studies that show a temporary accumulation of smooth axoplasmic structures and deranged axoplasmic structures following a short exposure to a vibrating force [11].

Incidence and prevalence

Varies, 0.125% - 1% and 5% - 16%, depending upon the criteria used for the diagnosis. It is a condition of middle-aged individuals and affects females more often than males. Several studies have reported marked female preponderance and a peak incidence around 55 to 60 years. The mean age at diagnosis was 50 years for men and 51 years for women. It is one of the most widely recognized occupational health conditions; particularly in industries where work involves high force/pressure and the repetitive use of vibrating tools. Einhorn and Leddy estimated an incidence of 1% in the general population and 5% of workers in certain industries which require repetitive use of the hands and wrists [12].

Diagnosis

Clinical features

The symptoms vary depending upon the severity of the disease. In early stages, patients usually complain of symptoms due to the involvement of the sensory component of the median nerve and only later report symptoms from involvement of motor fibers. The most common symptom is burning pain associated with tingling and numbness in the distribution of median nerve distal to wrist. The portion of the hand involved is classically the thumb, index and middle fingers, and radial half of the ring finger. Patients are often awoken by pain in the middle of the night and report hanging their hand out of bed or shaking it vigorously in order to relieve their pain. Patients may report pain, tingling and numbness of the whole hand, but careful questioning will identify that the little finger is rarely involved as it is innervated by the ulnar nerve. Symptoms of nocturnal paraesthesia are reported to be 51-96% sensitive and 27-68% specific. Less common symptoms include a feeling of clumsiness and weakness in the affected hand that is often made worse by activity or work [13-14].

Signs and tests several tests have been described which help in the diagnosis of CTS. Most of the tests are complementary to each other rather than diagnostic of CTS. A combination of symptoms, signs and diagnostic tests should be taken into account when the diagnosis of CTS is made. The presence or absence of characteristic physical findings has limited diagnostic value [14].

Tinel's sign
In this test, the examiner taps lightly over the site of the median nerve at the distal wrist crease. Development of tingling or discomfort in the fingers supplied by the median nerve constitutes a positive sign. Tinel described this sign in 1915. He noted that a tingling sensation occurred when an injured nerve was percussed over its proximal stump and speculated that this was a sign of axonal degeneration and intended his sign to be used in patients after blunt traumatic injury to follow the course of the regenerating nerve [14]. Tinel's sign is not a precise test and several factors can influence the outcome of the test. Firstly, its efficacy is reduced, as patients with CTS will have continually regenerating nerves at the distal wrist crease. The other limiting factor is the amount of pressure used to elicit the sign. It is difficult to quantify precisely how much pressure should be used to elicit the sign. The use of too much force or a sharp blow over a normal median nerve will produce finger tingling. This must not be interpreted as the presence of Tinel's sign. The Tinel's sign is associated with sensitivities of 23% to 67%, and specificities of 55% to 100% [15].

Phalen's test
Phalen and Kendrick described this test in 1957 [2]. Flexion of the wrist causes compression of the nerve between the transverse carpal ligament and flexor tendons in the carpal tunnel, causing paresthesia in the median nerve distribution reproducing the patient's symptoms. Phalen performed the test by having the patient hold the forearm vertically with the elbows resting on the table and then allowing both hands to drop with complete wrist flexion for approximately one minute. The test is considered positive when paresthesia develops in less than one minute. Patients with advanced CTS often note paresthesia in less than 20 seconds. The reported sensitivity 91% and specificity and 100% [16].

Katz hand diagram
This is a self–administered diagram, which depicts both thedorsal and palmar aspect of the patient's hands and arms. Patients use this diagram to mark the specific location of their symptoms, characterizing them as pain, numbness or tingling or other. The diagnosis is graded as classic, probable, possible or unlikely to be CTS based on criteria that appear in the hand diagram. In diagrams classified as classic or probable the sensitivity of the test is 80% and the specificity is 90% for the diagnosis of CTS [17].

Square wrist sign and weakness of the abductor pollicis brevis
The square-shaped wrist, where the anterior-posterior dimension of the wrist (at the distal wrist crease) divided by the medio-lateral dimension is greater than 0.70, and weakness of the abductor pollicis brevis were the two most sensitive signs (69 and 66%respectively). This test is associated with a sensitivity of 47% to 69% and specificity of 73% to 83% [18].

Pressure provocation test
A positive result in this test is the presence of pain, tingling and numbness in the distribution of the median nerve when the examiner presses with his/her thumb on the palmar aspect of the patient's wrist at the level of the carpal tunnel for 60 seconds. The test is seldom positive. The reported sensitivity is between 28% and 63% and specificity is between 33% and 74% [18].

The tethered median nerve stress test
LaBan described this test in 1986. It is performed by hyperextending the supinated wrist and the distal interphalangeal joint of the index finger for a minute. Patients with chronic carpal tunnel syndrome experience pain on the volar aspect of proximal forearm [19]. LaBan noted that hyper extension of index finger causes distal excursion of the median nerve more than hyperextension of the adjacent fingers [20]. Raudino evaluated this test in 140 patients with electro- physiologically confirmed CTS and noted that the test was positive in 60 hands (42.8%) compared to the 56.4% positive rate with Phalen's sign and 42% positive rate with the Tinel's sign [20].

Tourniquet test
A positive result is the development of paresthesia in the distribution of the median nerve when a blood pressure cuff around the patient's arm is inflated to above systolic pressure for a minute or two. The irritated and compressed median nerve is thought to be more susceptible to ischemia than the normal median nerve. However, even normal individuals can also develop the same symptoms and it is difficult to evaluate, especially in mild cases of CTS. The tourniquet's test sensitivity lies between 21% and 52% with a specificity between 36% and 87% [21].

Sensory testing
Abnormalities in sensory testing are typically late physical examination findings in patients with CTS and may explain their lack of usefulness diagnostically. Automated sensory testing devices (e.g., the Semmes-Weinstein monofilament test, the Weber two point discrimination tests, and the automated tactile tester) have a higher sensitivity and specificity. However, these tests are rarely used in practice [21-22].

Motor examination
Thenar atrophy is a late sign and signifies significant functional loss. Finger weakness associated with an inability to pinch or frequent dropping of grasped objects follows involvement of the motor component. Long-term involvement leads to thenar muscle atrophy with associated loss of thumb abduction and opposition strength. Diminished sensation to pinprick in the median nerve distribution always precedes thenar atrophy. Thenar atrophy is seldom noticed by patients and may not be obvious even to the examiner when examined by looking down onto the palm. However, it will be readily appreciated by comparing both palms together. In Phalen's series the atrophy of abductor pollicis brevis, opponens pollicis and flexor pollicis brevis was noted in 41% of hands. Abductor pollicis brevis is the most commonly affected muscle and testing its function is useful in making the diagnosis of CTS [22].

Electrophysiological nerve conductive studies
Simpson's demonstration in 1956 of slowed conduction of the median nerve across the wrist in CTS was the first important observation in the neurophysiological diagnosis of CTS. It is 85 – 90% accurate in patients with CTS, with a false – negative rate of 10 – 15%. It is reported to be as high as 90% sensitive and 80% specific for the diagnosis of CTS [23].

Sensory conduction
Is the most sensitive criterion for establishing diagnosis? The sensory fibers can be studied either orthodromically or antidromically slowing of the sensory conduction is the most sensitive sign of abnormalities. Comparison of sensory conduction velocity with that of ulnar nerve is a more secure Technique. Bipolar ring electrodes were used to the distal end of fingers innervated by median nerve.

Distal Sensory Latency (DSL) of more than 3.5 m sec is considered abnormal [23, 24].

Motor conduction

Is not sensitive as sensory conduction, determined by applying stimulus using a bipolar surface electrode on the skin. Distal Motor Latency (DML) of more than 4.5 m sec is considered abnormal [25].

Electromyography (EMG)

Is less useful than the conduction velocities in evaluation of CTS. Abnormalities will appear only in more advanced cases, otherwise EMG is unnecessary except for differential diagnosis [26].

Relation of electrophysiological studies to therapy

It was known that the degree of abnormality of the electrophysiological studies does predict, to a certain extent, the success of conservative therapy, but not the results of surgery. Most patients do well after surgery, and there is improvement in the slowed nerve conduction velocity. An immediate improvement has been documented within 15 – 30 minutes of relieving the pressure on median nerve, after this initial increment in conduction velocity there is a second slower phase of improvement that continues over weeks to months following surgery, despite this marked improvement, there will be some degree of slowing that often persists for many years after surgery. Older patient had been seen to show less improvement in conduction velocity than do young ones [27, 28].

Electro-diagnostic findings in CTS

Prolongation of median nerve motor latency upon stimulation at wrist ("terminal" or distal latency) > 4.2 m sec.

1. Normal median nerve conduction velocity in the forearm.
2. Slow median sensory conduction velocity across the wrist (> 3.7 m sec).
3. Normal motor and sensory NCS of the ulnar nerve (not involved in CTS) in comparison with median nerve.
4. Sensory amplitude < 15 M volt.
5. Duration of sensory nerve action potential (SNAP) response > 8.1 m sec.
6. Symptomatic contralateral CTS can be seen in 32% of patients [29, 30].

Table 2: Normal values of median nerve sensory conduction at the wrist

Technique	Amplitude MV	Conduction velocity M/S	Latency to peak m sec
Orthodromic (stimulation from distal to proximal)	30.9 + 2.1 (> 10 MV)	60.9 + 5.07 (> 50)	3.0 + 0.25 (< 3.5)
Antidromic (stimulation from proximal to distal)	> 16	57.4 + 3.8 (> 49.8)	3.2 + 0.25 (< 3.7)

Table 3: Normal values of median nerve motor conduction at the wrist

Segmental	Distal motor latency m sec	Amplitude peak to peak mv
Wrist – to – Abductor pollicis Brevis	3.2 ± 0.3 (2.5 – 3.8) (< 0.7)	15.8 + 5.9 (> 5 mv)

Table 4: Electrophysiological classifications of CTS

Grade	Distal sensor latency (DSL) m. sec ± standard deviation	Distal motor latency (DML) m. sec ± standard deviation
Mild	3.9 ± 0.36 (Std. dev.)	3.9 ± 0.21
Moderate	4.95 ± 0.93	5.1 ± 0.92 (4 – 6)
Severe	5.78 ± 1.37	6.31 ± 0.73

Measurement of pressure in the carpal tunnel

In CTS, the increase in pressure in the carpal canal may disturb the flow of axons and the circulation in the median nerve [32]. Pressure in the carpal canal can be measured by introducing a mercury bag into the carpal canal connected to a manometer by a rubber catheter with entire system filled with mercury. Measurement of pressure inside the canal is recorded in neutral, acute wrist flexion and extension. In neutral position the mean pressure is about 32 mm Hg. This pressure increases to 99 mm Hg with 90º of wrist flexion and to 110 mm Hg with the wrist in 90 degrees of wrist extension, compared to normal (25 mm Hg in neutral, 31 mm Hg with wrist flexion and 30 mm Hg with wrist extension) [33]. Other authors states that: Generally increment of pressure more than 5.5 mm Hg above normal value in resting position had a positive predictive value in patients with CTS [34].

Radiology

A. X-ray: Plain radiographs are useful for evaluating the wrist and carpal bones for trauma and fractures (especially the hook of hamate and the tubercle of the trapezium), severe osteoarthritis and other arthropathies the X-ray are of limited use in diagnosing CTS [35].

B. CT-scan: It is useful for its ability to display and evaluate the cross sectional volume surface area of the carpal tunnel and for detecting subtle calafications in the tendons within the canal.

C. CT also provides excellent tool for evaluating the carpal bones through multiplanar and 3 – dimensional reconstructions. Mean area is about 195 mm2. CT is of limited value to visualize the median nerve and tendons, other methods of visualizing soft tissue are recommended [36].

D. Ultrasound: Ultrasound is a cyclic sound pressure wave with a frequency greater than the upper limit of the human hearing range. Ultrasound is thus not separated from "normal" (audible) sound based on differences in physical properties, only the fact that humans cannot hear it. Although this limit varies from person to person, it is approximately 20 kilohertz (20,000 hertz) in healthy, young adults. Ultrasound devices operate with frequencies from 20 kHz up to several gigahertzes [37]. Ultrasonic imaging (Sonography) is used in human and veterinary medicine. High resolution U/S allows non-invasive imaging of the carpal tunnel and its contents, relatively fast, less expensive than MRI and allowing additional dynamic and blood flow

imaging. On U/S median nerve compression reveals the classic triad of nerve flattening in the distal tunnel, nerve swelling at he distal radius level (less frequently in the proximal tunnel) and palmar bowing of the flexor retinaculum [38].

E. MRI: In patients with flexor tenosynovitis, axial MRI demonstrates bowing of the flexor retinaculum. Regardless of the etiology of CTS, changes in the median nerve are similar and include:

- Diffuse swelling or segmental enlargement of the median nerve, usually seen at the level of pisiform [39].
- The median nerve may flatten (usually best demonstrated at level of hamate)
- Palmar bowing of flexor retinaculum (usually best at level of hamate).

MRI is also useful in detecting and characterizing space – occupying lesions, such as neuromas, ganglion cysts, lipomas and hemangiomas. Enlargement or swelling of the median nerve proximal to the carpal tunnel, termed a pseudoneuroma, has been documented by MRI [39].

Flow – sensitive sequence or dynamic contrast – enhanced MRI can detect circulatory disturbance causing CTS, either marked nerve enhancement (due to hyper vascular edema) or noticeable lack of enhancement (due to nerve ischemia) occurs. Incomplete release of flexor retinaculum can be detected also by MRI, this usually demonstrated by, direct visualization of still connected fibers of the retinaculum, excessive fat in the carpal tunnel, neuromas, scarring and persistent neuritis [40].

Differential diagnosis

Diagnosis can be made depending on history, clinical picture, examination that confirms the initial impression, and the suitable investigations. However, symptoms mimic CTS can be caused by various conditions which might lead to diagnostic confusion. [41] A point to be mentioned in the differential diagnosis of CTS is that though median nerve is mixed nerve it is predominantly sensory in the hand and sensory symptoms much earlier than motor symptoms.

1. **Radiculopathy:** Being caused by compression of one or more cervical roots at the level of exit foramina is a common diagnostic confusing problem, the sixth cervical nerve root is commonly affected and differentiated with careful history, neurological examination, electrophysiological study, myelopathy, CT scan and MRI may be required [42].
2. **Central nervous system lesion:** As transient vascular ischemic attack, migraine, and space occupying lesion of the cord.
3. **Vascular disorders:** Reflex sympathetic dystrophy, Reynaud's phenomenon.
4. Generalized peripheral neuropathy. Toxic agents, uremia, diabetes and most commonly by malnutrition [43].
5. **Miscellaneous:** A-Thoracic outlet syndrome by (cervical rib, costoclavicular compression); B-Ligament of Struthers syndrome; C-Pronator syndrome; D-Anterior interosseous syndrome; E-Guyon canal syndrome [44].

Treatment

The goal of treatment for carpal tunnel syndrome is to allow you to return to your normal function and activities and to address other health conditions if they are making your symptoms of carpal tunnel syndrome worse. Reduce any inflammation of tissues in the wrist that puts pressure on the median nerve. Determine the causes of your carpal tunnel symptoms. You can then identify whether there are activities for you to avoid or do differently and ways you can help prevent the condition. Prevent nerve damage and loss of muscle strength in your fingers and hand. Treatment for carpal tunnel syndrome is based on the seriousness of the condition, whether there is any nerve damage, and whether other treatment has helped. Treatment options include treatment without surgery (nonsurgical treatment) or with surgery.

If treated early, carpal tunnel symptoms usually go away with nonsurgical treatment. If your symptoms are mild, with occasional tingling, numbness, weakness, or pain, 1 to 2 weeks of home treatment are likely to relieve your symptoms. If home treatment does not help, or if your symptoms are more severe (including the loss of feeling in your fingers or hand, or the inability to perform simple hand movements such as holding objects or pinching), have your doctor examine you and recommend treatment. If your symptoms are not severe, expect your doctor to recommend nonsurgical treatment to see whether symptoms improve. Nonsurgical treatment includes: Evaluating any other medical problems that might contribute to carpal tunnel syndrome, and changing your treatment for those problems if needed. Changing or avoiding activities that may be causing symptoms, and taking frequent breaks from repetitive tasks. Wearing a wrista splint to keep your wrist straight, usually just at night. Using non-steroidal anti-inflammatory drugs (NSAIDs) to relieve pain and reduce inflammation. In some cases, oral corticosteroids or corticosteroid injections into the carpal tunnel may be considered if other methods to reduce inflammation do not work. Surgery is sometimes recommended when other treatment has not helped [44, 45].

Discussion

Age and sex

Carpal tunnel syndrome is often the result of a combination of factors that increase pressure on the median nerve and tendons in the carpal tunnel, rather than a problem with the nerve itself. Most likely the disorder is due to a congenital predisposition - the carpal tunnel is simply smaller in some people than in others. Other contributing factors include trauma or injury to the wrist that cause swelling, such as sprain or fracture; mechanical problems in the wrist joint; work stress; repeated use of vibrating hand tools; fluid retention during pregnancy or menopause; or the development of a cyst or tumor in the canal, the effect of these factors appears late, that why the selection of patient`s age was from 27-53 and the largest number of patient occur in age group 46-55 years mean age = 38.83 years + 6.4 years mostly female (92.5%). While in study of Y.M. ELMiedany *et al.*, [49] (2004) mean age = 44.9 ± 6.16 years While in study of al mallouhi *et al.*, [50] (2006) mean age = 58 ± 1.6 years. While in study of Boontaree Wanit Wattanarumlug *et al.*, [51] (2011) mean age = 46.92 ± 7,97 years.This does not match to our study because of short duration & small sample.

Ultrasound signs

Advancements in the resolution of ultrasonography have enabled detailed scanning and precise measurements of peripheral nerves. Several ultrasonographic measurements have been reported to be diagnostic of CTS, including the AP diameter of median nerve, CSA [52].

CSA of the median nerve

Among ultrasonographic measurements, the CSA at the pisiform level was found to be the most predictive of CTS; In the present

study, the diagnostic criterion i.e., the CSA at the pisiform level, had an optimal cut-off value of 0.01mm2 yielding sensitivity of 85% and specificity of 85%. This was not agreed with the results obtained by Swen *et al.,* (2001) [53]. (CSA 0.01 mm2; sensitivity 70% and specificity 63%) & not agreed with specificity but agreed with sensitivity of al mallouhi *et al.,* (2006) [50] (CSA 0.01 mm2; sensitivity 91% and specificity 47%) but very close to the results obtained by Wong *et al.,* (2004) [54] (CSA 0.009 mm2 sensitivity 89% and specificity 83%) & Lin-Yi Wang *et al.,* (2007) [48] (CSA 0.009 mm2 sensitivity 82% and specificity 87.5%). The pathophysiology of median nerve swelling is thought to be the result of a cascade of events after compression, including damming of the axoplasmic flow, endoneural edema, inflammation, demyelination, remyelination, and finally perineural thickening [55]. AP diameter of median nerve: The AP diameter of median nerve, had an optimal cut-off value of 0.01mm yielding sensitivity of 78% and specificity of 81% & accuracy of 80% this was very close to the results obtained by al mallouhi *et al.,* (2006) [50] sensitivity of 75% and specificity of 80% & accuracy of 79% & was close to the results obtained by Swen *et al.,* (2001) [53]. (Sensitivity 80% and specificity 88% & accuracy of 85%). Comparison between sanography and NCS: Sensitivity and specify of ultrasonography (AP and CSA) and NCS, were compared the difference in these validity measurements was statistically not significant There was no significant difference in CSA, AP diameter and NCS between male and female, No significant difference in any measurements were found [56]. Our study had limitations. First: our electro diagnostic unit is a tertiary referral center for the surrounding population of patients from various specialties including general medicine, orthopedics, and neurology, with the study group limited to patients with CTS as a primary diagnosis. Spectrum and selection bias are inherent in this type of hospital-based study because our patients represented those with severe enough symptoms to warrant a referral in the first place [57]. Generalization of our results regarding accuracy of both an electrodiagnostic study and sonography might not be applicable in primary care, as was demonstrated in previously published community-based research in regard to the use of the electrodiagnostic study [58]. Second: electrodiagnostic study results combined with clinical symptoms as determined by a neurologist were regarded as the reference standard in this study; other centers may perform electrodiagnostic study techniques in addition to those we performed in our study to confirm the diagnosis of CTS. The American Academy of Neurology issued new practice parameters that were published toward the end of this study [59]. The performance of sonography compared with such alternative electrodiagnostic strategies is uncertain. It is likely that additional electrodiagnostic studies may produce better sensitivity but reduced specificity [60]. Third: sonography is an operator-dependent test, and appropriate experience is required to ensure reliability and reproducibility. With appropriate training of operators, however, this issue can be resolved readily [61]. Although the data in this study suggest that sonography is effective in the diagnosis of CTS, the extended role of sonography in that diagnosis awaits further definition. In the past, the electrodiagnostic study has had other roles in the treatment of CTS [62].

Conclusions

1. CTS is a problem affect mainly middle age females.
2. We can concluded that sonography can be adds a benefit in diagnosis of CTS.
3. U/S has potential advantages to other diagnostic tools as availability, shorter examination time and non-invasive.

Recommendations

1. We suggest for further study using ultrasonography for other types of entrapment neuropathy.
2. We highly recommend shifting the patient with suspicious of CTS to ultrasonographic examination because of its high diagnostic validity of ultrasonography in diagnosing it in addition to its availability, low cost, repeatable, fast and has no radiation hazard.
3. We recommended that all patients who are suspected of having CTS should undergo sonography as the initial diagnostic test. If sonography yields positive results, CTS is confirmed; if the results are negative, one could then refer the patient for an electro diagnostic study.

References

1. Duncan I, Sullivan P, Lomas F. Sonography in the diagnosis of carpal tunnel syndrome. Am J Roentgenol 1999;173:681-684.
2. Phalen GS. The carpal-tunnel syndrome. Seventeen years' experience in diagnosis and treatment of six hundred fifty-four hands. J Bone Joint Surg Am 1966;48(2):211.
3. Tanaka S, Wild DK, Seligman PJ, Behrens V, Cameron L, Putz-Anderson V. The US prevalence of self-reported carpal tunnel syndrome: 1988 National Health Interview Survey data. Am J Public Health 1994;84(11):1846.
4. Stevens JC, Sun S, Beard CM, O'Fallon WM, Kurland LT. Carpal tunnel syndrome in Rochester, Minnesota, 1961 to 1980. Neurology 1988;38(1):134.
5. Einhorn N, Leddy JP. Pitfalls of endoscopic carpal tunnel release. Orthop Clin North Am 1996;27(2):73-80.
6. Atroshi I, Gummesson C, Johnsson F, Ornstein E, Ranstam. Prevalence of carpal tunnel syndrome in a general population. JAMA 1999;81(2):153-158.
7. Aroori S, Spence R. Carpal tunnel syndrome. Ulster Med J 2008;77(1):6-17.
8. Melhorn JM. CTD: carpal tunnel syndrome, the facts and myths. Kans Med 1994;95(9):89-92.
9. Brian WR, Wright AD. Spontaneous compression of both median nerves in the carpal tunnel. Lancet 1947;1:77-82.
10. George S, Dhalen MD. The carpal tunnel syndrome, carpal tunnel syndrome, clinical evaluation of 598 hands, Cin Orthop 1972:83:29-40.
11. Lundborg G, Dahlin LB, Danielsen N, Hansson HA, Necking LE, Pyykko I. Intraneural edema following exposure to vibration. Scand J Work Environ Health 1987;13(4):6-9.
12. Buch-Jaeger N, Foucher G. Correlation of clinical signs with nerve conduction tests in the diagnosis of carpal tunnel syndrome. J Hand Surg [Br] 1994;19(6):720-4.
13. Hoffmann P, Buck-Gramcko D, Lubahn JD. The Hoffmann-Tinel sign. 1915. J Hand Surg [Br] 1993;18(6):800-805.
14. Kuschner SH, Ebramzadeh E, Johnson D, Brien WW, Sherman R. Tinel's sign and Phalen's test in carpal tunnel syndrome. Orthopedics 1992;15(11):97-99.
15. Golding DN, Rose DM, Selvarajah K. Clinical tests for carpal tunnel syndrome: an evaluation. Br J Rheumatol 1986;25(4):88-90.
16. Wiesler ER, Chloros GD, Cartwright MS, Smith BP, Rushing J, Walker FO. The use of diagnostic ultrasound in carpal tunnel syndrome. J Hand Surg (Am) 2006;31:726-730.
17. Mohammadi A, Afshar AR, Masudi S, Etemadi A. Comparison of high resolution ultrasonography and nerve conduction study in the diagnosis of carpal tunnel

syndrome: diagnostic value of median nerve cross-sectional area. Iran J Radiol 2009;6(3):147-152.
18. Ferry S, Silman AJ, Pritchard T, Keenan J, Croft P. The association between different patterns of hand symptoms and objective evidence of median nerve compression: a community-based survey. Arthritis Rheum 1998;41:720-724.
19. LaBan MM, MacKenzie JR, Zemenick GA. Anatomic observations in carpal tunnel syndrome as they relate to the tethered median nerve stress test. Arch Phys Med Rehabil 1989;70(1):4-6.
20. Raudino F. Tethered median nerve stress test in the diagnosis of carpal tunnel syndrome. Electromyogr Clin Neurophysiol 2000;40(1):57-60.
21. Spindler HA, Dellon AL. Nerve conduction studies and sensibility testing in carpal tunnel syndrome. J Hand Surg 1982;44(1):20.
22. Patterson JD, Simmons BP. Outcomes assessment in carpal tunnel syndrome. Hand Clin 2002;18(2):359-361.
23. Renato AS, Claudia AA, Benedito F. Ultrasound feathers of carpal tunnel syndrome. Skeletal Radiol 2008;37:49-50.
24. Ram Bhala P. Ephrem Thoppily early detection of carpal tunnel syndrome with electromyography and clinical neurophysiological studies. J Hand Surg 2000;21(2):155.
25. Nakamichi K, Tachibana S. Ultrasonographic measurement of median nerve cross-sectional area in idiopathic carpal tunnel syndrome: diagnostic accuracy. Muscle Nerve 2002; 26:798-803.
26. Dennerlien *et al*. Longer Distal Motor Latency Predicts better outcomes of carpal tunnel release. J Occupal & Environ Med 2002;44(2):176-183.
27. Allmann KH, Horch F, Uhl M. MR imaging of the carpal tunnel. Eur J Radiol 2008;25:141-145.
28. Kotevoglu N, Gulbahce S. Ultrasound imaging in the diagnosis of carpal tunnel syndrome and its relevance to clinical evaluation. Joint Bone Spine 2007;72:142-145.
29. Kaymak B, Ozcakar L, Cetin A, Candan Ce-tin M, Akinci A, Hascelik Z. A comparison of the benefits of sonography and electrophysi¬ologic measurements as predictors of symptom severity and function-al status in patients with carpal tunnel syndrome. Arch Phys Med Rehabil 2008;89(4):743-748.
30. Andrea S, Ethan J, Halpern T. Carpal Tunnel Syndrome Assessment with US: Value of additional cross-sectional area measurements of the median nerve in patients versus healthy volunteers. Radiol 2009;250:171-177.
31. Shivde AJ, Dreizin F, Fisher MA. The carpal tunnel syndrome, clinical electrodiagnostic analysis, Electromyography Clin Neurophysiol 2009;21:143.
32. Tanzer RC. The carpal tunnel syndrome clinical and anatomical study. J Bone and Joint Surg 2005;41(A):626.
33. Richard H, Gelberman, Patric T, Hergenroeder, Alan Hargens R. The carpal tunnel syndrome, study of carpal canal pressure. J Bone and Joint Surg 2006;63:380.
34. Buchberger W, Judmaier W, Birbamer G *et al*. Carpal tunnel syndrome: diagnosis with high – resolution sonography, AJR. Am J Roentagenol 2000;159(4):
35. Mesgarzadeh M, Schneck CD, Bonakdrapour A. Carpal tunnel: MR Imaging. Part II, Carpal tunnel syndrome. Radiology 2002;171(3):749–754.
36. Healy C, Watson JD, Longstaff A, Camphell MJ. Magnetic resonance imaging of the carpal tunnel. J Hand Surg [Br] 1990;15(2):243–248.
37. Diana P, Cristina BH, Eugenio MM, Susana SP, Arturo UC, Emilio MM. Validity and usefulness of echography in the carpal tunnel syndrome. Reumatol Clin 2007;4(3):100-106.
38. An assessment of the usefulness of patient evaluation measure questionnaire as an outcome measure after carpal tunnel surgery Bernard Piotuch, Andrzej Żyluk Department of General and Hand Surgery, Pomeranian Medical University in Szczecin Kierownik: prof dr hab 2009;82(6) 347-353.
39. Banniste R. Brain's clinical neurology, carpal tunnel syndrome, eighth edition 2008;33(8):410-412.
40. Keir PJ, Rempel DM. Pathomechanics of peripheral nerve loading. Evidence in carpal tunnel syndrome. J Hand Ther 2005;18:259.
41. Neal NC, McManners J, Stirling GA. Pathology of the flexor tendon sheath in the spontaneous carpal tunnel syndrome. J Hand Surg [Br] 1987;12:229.
42. Nathan PA, Meadows KD, Keniston RC. Rehabilitation of carpal tunnel surgery patients using a short surgical incision and an early program of physical therapy. J Hand Surg [Am] 2009;18(6):1044–1045.
43. Herskovitz S, Berger AR, Lipton RB. Low-dose, short-term oral prednisone in the treatment of carpal tunnel syndrome. Neurology 2002;45:55-59.
44. Nakamichi K, Tachibana S. Restricted motion of the median nerve in carpal tunnel syndrome. J Hand Surg [Br] 2006; 20:460.
45. Chen P, Maklad N, Redwine M, Zelitt D. Dynamic high resolution sonography of the carpal tunnel. Am J Roentgenol 2009;168:533-537.
46. Oztas O, Turan B, Bora I, Karakaya MK. Ultrasound therapy effect in carpal tunnel syndrome. Arch Phys Med Rehabil 2009;79:1540.
47. Lin-Yi Wang MD, Chau-Peng Leong MD, Yu-Chi Huang MD, Jen-Wen Hung MD, Shun-Man Cheung MD, Ya-Ping Pong MD. Best Diagnostic Criterion in High-resolution Ultrasonography for Carpal Tunnel Syndrome Arthritis Rheum 2007;66:1754-60.
48. Ultrasonography versus nerve conduction study in patients with carpal tunnel syndrome: substantive or complementary tests. Y. M. EI Miedany, S. A. Atyl and S. Ashour.Rheumatology 2004;43:887-895.
49. MallouhiA, Pultzl P, Trieb T, Pizza H, Bonder G, predictors of CT scan. AJR 2006;186:1240-1245.
50. Boontaree Wanitwattanarumlug 1', Vithya Varavithya 1 Evaluating the cross-sectional area (CSA) of the median nerve by ultrasound in carpal tunnel syndrome (CTS) Journal of Medicine and Medical Science 2005;2(7):961-965.
51. Lowry WE, Follender AB. Interfascicular neurolysis in the severe carpal tunnel syndrome. A prospective randomized double-blind controlled study. Clin Orthop 2005;227:251.
52. Swen WA, Jacobs JW, Bussemaker FE, de Waard JW, Bijlsma JW. Carpal tunnel sonography by the rheumatologist versus nerve conduction study by the neurologist. J Rheumatol 2001;28:2-9.
53. Shiu Man Wong MD, Andrew CF, Hui MD, James Griffith F, MD. Carpal Tunnel Syndrome: Diagnostic Usefulness of Sonography 2004;44:45-46.
54. Brown RA, Gelberman RH, Seiler JG 3rd *et al*. Carpal tunnel release. A prospective, randomized assessment of open and endoscopic methods. J Bone Joint Surg Am 2008; 75:1265.
55. Luchetti Amadio RP. (Eds.) Carpal Tunnel Syndrome page 2005;10:270.

56. Rhoades CE, Mowery CA, Gelberman RH. Results of internal neurolysis of the median nerve for severe carpal-tunnel syndrome. J Bone Joint Surg Am 2009;67:253.
57. Kessler FB. Complications of the management of carpal tunnel syndrome. Hand Clin 2009;2:401-406.
58. Visser1 LH, Smidt1 MH, Lee2 ML. High-resolution sonography versus EMG in the diagnosis of carpal tunnel syndrome Published Online 2007;(9):33-34.
59. Lee DH, Masear VR, Meyer RD *et al*. Endoscopic carpal tunnel release: a cadaveric study. J Hand Surg [Am] 2006; 17:1003.
60. Urbano FL. Tinel's sign and phalen's maneuver: physical signs of carpal tunnel syndrome. Hosp Phys 2008;7:39-44.
61. Katz JN, Fosse KK, Simmons BP, Swartz RA, Fossel AH, Koris MJ. Symptoms, functional status, and neuromuscular impairment following carpal tunnel release. J Hand Surg [Am] 2009;20:549-555.
62. Ferrari GP, Gilbert A. The superficial anastomosis on the palm of the hand between the ulnar and median nerves. J Hand Surg [Br] 2008;16:511-514.