



Review Article

ISSN : 2277-3657  
CODEN(USA) : IJPRPM

## ***An Overview on Carpal Tunnel Syndrome Diagnosis & Surgical Management Approach***

**Alanoud Abdullah Alharbi<sup>1\*</sup>, Al Hammam Sultan Yahya M<sup>2</sup>, Zainab S Almeiarfi<sup>3</sup>, Jaffar Mohamed Ali<sup>4</sup>, Anas Mohammed Alomair<sup>5</sup>, Ali Adel Alsakkak<sup>6</sup>, Ali Yousef Alturaifi<sup>6</sup>, Abdulaziz Shalan Alhumaidi<sup>7</sup>, Talal Abdullah Alqarni<sup>8</sup>, Bader Hamdi Binyousef<sup>9</sup>, Abdullah Mohammad Alhalafi<sup>10</sup>**

<sup>1</sup> Faculty of Medicine, Qassim University, Qassim, KSA

<sup>2</sup> Faculty of Medicine, Najran University, Najran, KSA

<sup>3</sup> Department of Orthopedic, King Abdulaziz Medical City, Jeddah, KSA

<sup>4</sup> Faculty of Medicine, Xi'an Jiaotong University, Shaanxi, China

<sup>5</sup> Department of Orthopedic, Domat Al Jandal General Hospital, Al Jouf, KSA

<sup>6</sup> Faculty of Medicine, King Faisal University, Al Ahsa, KSA

<sup>7</sup> Faculty of Medicine, Taif University, Taif, KSA

<sup>8</sup> Faculty of Medicine, King Saud bin Abdulaziz University for Health Science, Riyadh, KSA

<sup>9</sup> Faculty of Medicine, King Abdulaziz University, Jeddah, KSA

<sup>10</sup> MBBS, King Khalid University, Abha, KSA

\*Corresponding Author

---

### **ABSTRACT**

*Background: Carpal tunnel syndrome is identified as an entrapment neuropathy mainly caused by compression of the median nerve when passing through the carpal tunnel of the wrist. This disease is noted a lot in society that it is shown to account for up to 90% of all neuropathies. Patients usually present with pain, numbness, and paresthesia, along with the distribution of the nerve, with variable intensity. Unfortunately, some cases may present with radiation of these symptoms affecting the whole arm. Moreover, this disease has many possible complications such as decreased fine motor coordination, and thenar atrophy, thus early diagnosis and management are crucial. Objectives: We aimed to review the literature reviewing the pathophysiology of carpal tunnel syndrome, clinical features, risk factors, diagnosis, and management of this disease. Methodology: PubMed database was used for articles selection, papers on were obtained and reviewed. Conclusion: Diagnosing carpal tunnel syndrome remains the pivotal step in the management of these patients, and thus it had been studied widely for many years. With mainly clinical findings to guide the clinician, simple tests are crucial to identify these patients and to start the management. The mainstay treatment of this condition is a conservative approach if diagnosed early. However, more options are available when conservative management fails, including glucocorticoid usage and surgery. Nevertheless, recurrence is still a major problem with all these treatment options, and many studies are focusing on how to reduce this issue in this population while causing no side effects.*

**Key words:** Carpal tunnel syndrome, Risk Factors, Clinical Features, Diagnosis, Management

---

### **INTRODUCTION**

Carpal tunnel syndrome (CTS) is identified as an entrapment neuropathy mainly caused by compression of the median nerve when passing through the carpal tunnel of the wrist [1]. This disease is noted a lot in society with studies suggesting it affects up 5 percent of the general population. Moreover, it accounts for almost 90% of all

neuropathies, making it the most common condition out of all nerve entrapment neuropathies [2]. Patients usually present with pain, numbness, and paresthesia, along the distribution of the nerve, with variable intensity [3]. Unfortunately, some cases may present with radiation of these symptoms affecting the whole arm. With many risk factors associated with this disease and the multifactorial theory behind its pathophysiology, CTS remains widely studied nowadays. Moreover, this disease has many possible complications such as decreased fine motor coordination, and thenar atrophy, thus early diagnosis and management are crucial [4, 5]. In this paper, we will review this disease focusing on its pathophysiology, clinical features, diagnosis, and management.

## METHODOLOGY

PubMed database was used for articles selection, and the following keywords were used in the Mesh (“Carpal tunnel syndrome”[Mesh]) AND (“Diagnosis”[Mesh]) AND (“Management”[Mesh])). In regards to the inclusion criteria, the articles were selected based on the inclusion of one of the following topics; carpal tunnel syndrome evaluation, diagnosis, and management. Exclusion criteria were all other papers that did not have one of these topics as their primary endpoint.

## Review

Carpal tunnel syndrome is a median neuropathy at the wrist, mostly idiopathic, specifically at the carpal tunnel. Due to variations of the anatomy between people, the symptoms for CTS are very different among the population. One of the most important examples is a median nerve variation where it is bifid due to high division, which is seen in up to 3.3% of cases. In these cases, the tenacity of the median artery with an extra division of superficial flexor of the third finger. Another notable variation is in the motor branch of the median nerve, where five types of starting points and paths of the Thenar division exists. The most common variation is the extra ligamentous form, which is seen in 46% of the patients; other types are subligamentous (seen in 31%), and the transligamentous (seen in 23%). Thus, thenar branch nerve bundles can be on the radial, anterior, or central part of the median nerve, and in some cases, it even passes through a tunnel before entering the (thenar) muscles. These variations cause wide different and inconstant motor disabilities in severe cases. Another variation is noted in the palmar cutaneous branch of the median nerve. Usually, palmar cutaneous division starts 4-7 cm above the wrist fold, moving close to the median nerve (1.6-2.5 cm<sup>3</sup>) [6]. Afterward, this branch enters a tunnel consists of the fascia at the medial edge of flexor carpi radialis (FCR) and innervates the skin of the thenar eminence where it enters around 1cm above the wrist flexion wrinkle [7]. Moreover, the palmar cutaneous branch can cross the transverse ligament of the carpus or go through the ulnar side of the median nerve. Intratunnel positioning of the ulnar nerve is another anatomical variation and affected cases can present with combined symptoms of both, ulnar and median nerves [8].

## Pathophysiology

The carpal tunnel is a very compact structure where –most notably- the median nerve passes along with many structures such as the finger flexor tendons. The length of this tunnel, defined by the transverse carpal ligament edges, is 12.7 mm with around 2.5 mm variation. Moreover, the cross-section of this area is 134.9 mm<sup>2</sup> (with 23.6 mm<sup>2</sup> variations) with a volume of around 1,737 mm<sup>3</sup> (with 542 mm<sup>3</sup> variations) [9]. Movements of the wrist joint influence the size and form of carpal tunnel overall. This is noted even under the normal range of motion, where the width of the tunnel decreases due to carpal bones moving in relation to each other because the bony walls of the tunnel are flaccid. Moreover, extension and flexion increase the pressure in the carpal tunnel. However, when flexing the wrist joint a cross-section of the proximal opening of the carpal tunnel decreases. This happens due to the movement of the distal end of the capitate bone and the circular changes of the transverse carpal ligament (TCL). On the other hand, the extreme extension will result in scrunching the carpal tunnel because the lunate bone pushes towards the interior part of the tunnel [9, 10]. The pathophysiology of CTS involves multiple –possible- mechanisms involving increased pressure, mechanical trauma, and ischemic damage, which affect the median nerve within the carpal tunnel. The normal pressure in the carpal tunnel varies between 2 and 10 mmHg, and this can even further fluctuate depending on the position (and movement) of the wrist. The main example is with the wrist extension where pressure increases more than 10 times compared to the initial value, and flexion increases it by –around- eight. [10] Thus, repetitive movements of the wrist joint have been an integral part in the development of CTS. Regarding possible nerve injury, damage to the median nerve is usually noted in the form of demyelination. This injury once occurs will expose the nerve to even further automatic forces. The most usual

location for demyelination is in the site of compression and it will spread to the intermodal segment sparing the axons. Continuous compression will lead to interruption of blood flow to the endoneurial capillary system, which will cause disturbance of the blood-nerve barrier and endoneurial edema follows after. Afterward, venous congestion, ischemia, and local metabolic alterations happen causing a vicious cycle to develop. The ischemic injury is significant in these patients because of the rapid relief of symptoms after carpal tunnel release surgery. Moreover, limb ischemia in general increases paresthesia in these patients. Paresthesia occurs in three main phases, starting with increased intrafunicular pressure, then injury to the capillary (with leakage and edema), leading to obstruction of arterial flow. [11]

### **Risk Factors**

This disease is more noted in women than in men with its prevalence ratio reaching almost 3:1. Moreover, older age is associated with CTS along with diabetes, genetic heredity, and rheumatoid inflammation. There are more medical conditions associated with CTS due to the increasing volume of the tunnel; these include obesity, menopause, pregnancy, hypothyroidism, use of oral contraceptives, kidney failure, and congestive heart failure. Moreover, any lumps and tumor-like strains in the surrounding area can result in the disease. Patients with upper limb trauma have a higher risk to develop CTS especially when the distal radius is injured. Ecological risk factors for this condition include excesses of wrist extension or flexion for extended periods of time, exposure to vibration, and monotonous use of the flexor muscles. The median nerve itself can be affected with alcoholism, vitamin deficiency or toxicity, and exposure to toxins leading to possible development of symptoms. [12, 13]

### **Clinical Features and Differential Diagnosis**

Patients with CTS present usually pain in hand, tingling and/or numbness in the distal distribution of the median nerve, which includes thumb, middle finger, index, and the radial side of the ring finger. Moreover, a reduction of the grip strength and function of the affected hand is reported. These symptoms worsen at night and may even wake patients up. "Flick sign" is a common phenomenon in these patients where flicking or shaking the wrist helps in relieving the symptoms [14].

Clinically, CTS is usually divided into 3 clinical diagnostic stages. In the first stage, the patient wakes up with pain, numbness, and/or tingling on the affected hand, without noticeable swelling. This tingling and numbness are known as brachialgia paresthetica nocturna. Moreover, the pain can be extreme and radiates from the wrist until the shoulder. As mentioned before, most cases report a relive of pain after shaking the wrist, and the hand may feel firm later on. The second stage of CTS development is the occurrence of symptoms, which happens typically during the day. This is more noticeable when the patient has a repetitive activity especially wrist flexion, or when he/she maintains a specific position for long periods of time (e.g. computer users). Moreover, clumsiness is reported notably when trying to grip objects. The last stage appears when there is atrophy or hypotrophy of the thenar eminence, with aching in it. Furthermore, severe compression, weakness of the opponens pollicis and abductor pollicis brevis is reported, and the sensory symptoms may diminish [8, 14].

### **Diagnosis**

Clinicians shall approach carpal tunnel syndrome with a precise method in taking history and a well-done physical examination because clinical diagnosis is the mainstay in this disease. The physician shall require about the frequency of symptoms, relieving and exacerbating factors, as well as the time of onset (night or day). Patients must be asked about any positions or repeated movements that provoke their symptoms, and if they use any vibratory objects. Moreover, the assessment of patients for conditions and risk factors associated with CTS that we mentioned before must be done. Physical examination is crucial in diagnosis because certain findings may help the clinician in his/her completely approach to the case and even change it. For example, any abrasions or ecchymosis on the hands (and wrist) may indicate damage to the tissue, which may involve direct damage to the median nerve. There are special examinations to be carried out in suspected carpal tunnel patients; these are eliciting Tinel's sign and Phalen's maneuver. Tinel's sign is positive when the patient reports symptoms when the clinician taps along the carpal tunnel. In Phalen's maneuver, the patient flexes the wrist to 90 degrees, a positive test is when this move produces symptoms along the distribution of the median nerve. Moreover, the physician shall examine in details any and all the neurological symptoms that the patient may have (numbness, and tingling). Thus, two-point discrimination, vibration, as well as, monofilament testing, shall be assessed and may produce sensory effects in these patients. A self-diagnostic questionnaire is available and known as the Katz Hand

Diagram. In this questionnaire, the patient can specify the parts with symptoms, and classify the character like pain, numbness, tingling, and/or hypoesthesia [15, 16].

There is a controversy about the need for confirmatory testing and the role of them in the assessment of CTS. However, there are multiple tests that can be done and the role of each is different, these tests include nerve conduction studies, ultrasonography, electromyography, and MRI. The Nerve conduction study is the most significant out of these since it provides information on the physiological health of the median nerve. This is done by comparing its latency and amplitude with another nerve not passing in the carpal tunnel (e.g. radial nerve), with a specificity of between 80 and 99%, and sensitivity of around 80 and 92% [17]. However, due to high false negatives, false positives, and its high cost; nerve conduction study is not efficient to be the only way of diagnosis [18].

The differential diagnosis of carpal tunnel syndrome is wide because of the various symptoms that the patient may present. Moreover, some complications of diseases may produce similar symptoms to CTS, like in carpometacarpal arthritis of the thumb, where excruciating thumb movement, positive grind evaluation are all noted. Thus, the clinician shall acquire precise and thorough information through his history taking and clinical examination. Other conditions include cervical radiculopathy, where the patient reports pain in the neck, with possible numbness of the thumb and index finger, and the patient will have a positive Spurling test. De Quervain tendinopathy is another way of differentiation and will cause tenderness at the distal radial styloid, which may confuse physicians. Other differential diagnoses include pronator syndrome, presence of pain in the forearm, sensory loss over thenar eminence, and weakness with wrist extension, and thumb flexion. Moreover, peripheral neuropathy, cubital tunnel syndrome, and Raynaud syndrome are all to be excluded as well in some cases (Table 1) [11, 16].

**Table 1:** Carpal Tunnel Syndrome Differential Diagnosis

Differential Diagnosis	Specific Clinical findings
Carpal Tunnel Syndrome	Paraesthesia at the thumb, index, and middle fingers, worse at night, Tinel and Phalen test positivity
Carpometacarpal arthritis	Wrist pain on movement, radiologic evidence at carpometacarpal joint
Cervical radiculopathy C6 nerve root	Neck pain, altered sensation limited to thumb and index
Flexor carpi radialis tenosynovitis	Tenderness at the base of thumb
Median nerve compression at the elbow	Tenderness at proximal forearm
Cubital tunnel syndrome	Dorsal interosseous weakness, paraesthesia limited to the ring and small (fourth and fifth digits) fingers
Wrist arthritis	Motion restriction at the wrist, radiological evidence of arthritis

## Management

The physicians' aim in the management of these patients is focused on relieving the symptoms, halt the progress of the disease, and preserve the neurological and motor functions. The choice of best management approach of carpal tunnel syndrome patients will depend mostly on the severity of the symptoms. In general, minor and moderate symptoms are to be started first with conservative treatment. The main methods of this approach include splinting, corticosteroids, physical therapy, yoga, and therapeutic ultrasound. Usually, up to 80% of patients will show a positive response, and relief of symptoms is reported as early as two to six weeks. However, the maximum benefit of these treatment options may take up to three months. Unfortunately, there is an up to 80% chance that the symptoms will reoccur in these cases within one year. Splints have a major role in the conservative treatment in minor and moderate cases, which is attributed to its easy access, effortless application and usage, and being relatively cheap. In addition, splints are perfect to use when reversible risk factors (e.g. pregnancy) are in play, and splints can be combined with other treatment options. Corticosteroids are mainly used in the form of oral prednisone (20 mg once daily), which have been proved to be effective in relieving symptoms with lasting effects up to 8 weeks. Local corticosteroid injections are also used in some patients, helping in relieving the symptoms; however, it does not halt the progression of the disease. Moreover, repetitive local injections of lidocaine showed some symptom reductions with electrophysiological improvement. Physiotherapy is indicated in these patients, and it includes carpal bone mobilization and nerve glide exercises but they are less effective and need a specialist therapist's supervision. Recently, Low-level laser therapy has been implemented in the management as well and showed promising results in improving the function and relieving the symptoms (especially handgrip strength) up to three months after therapy [19-21].

On the other hand, patients with severe carpal tunnel syndrome and/or suffering from direct nerve injury diagnosed with the electro-diagnostic test are indicated for surgical management. Another indication or surgical options is the persistence of symptoms after conservative treatment, and/or if the motor or sensory deficit is progressive. The main surgical option and the golden standard of carpal tunnel syndrome is the surgical decompression. The clinician shall assess the median nerve with nerve conduction studies before doing the operation to fully assess the neurological function in the patient. Surgical decompression mainly aims to release carpal tunnel content, mainly the median nerve, by transection of the transverse carpal ligament. This operation can be done in a traditional –open- technique where the surgeon performs a long longitudinal wrist incision and visualize the transverse carpal ligament directly before releasing the carpal tunnel contents. Other approaches include the minimally invasive approach known as short wrist incision and the endoscopic approach. In terms of long term prognosis and functional outcome, multiple studies have been done but no significant difference was established. Nevertheless, the endoscopic technique has a shorter postoperative recovery period, less surgical scar surface area, less scar tenderness, and earlier discharge rate than the open approach. However, endoscopic decompression surgery is a lot more expensive and associated with higher rates of nerve damage [22-24].

## CONCLUSION

Diagnosing carpal tunnel syndrome remains the pivotal step in the management of these patients, and thus, it has been studied widely for many years. With mainly clinical findings to guide the clinician, simple tests are crucial to identify these patients and to start the management. The mainstay treatment of this condition is a conservative approach if diagnosed early. However, more options are available when conservative management fails, including glucocorticoid usage and surgery. Nevertheless, recurrence still a major problem with all these treatment options and many studies are focusing on how to reduce this issue in this population while reducing the side effects frequency.

## REFERENCES

1. Asal MS, Elgendy MH, Ali OI, Labib AA. Contralateral versus ipsilateral neural mobilization of median nerve in patients with unilateral carpal tunnel syndrome. *Journal of Advanced Pharmacy Education & Research* | Jan-Mar. 2018; 8(1).
2. Pourmemari, M. H., Heliövaara, M., Viikari-Juntura, E., & Shiri, R. Carpal tunnel release: Lifetime prevalence, annual incidence, and risk factors. *Muscle & nerve*. 2018; 58(4), 497-502.
3. Rezaei B, Mahdavinejad R. Massage therapy and Splint in males with Carpal Tunnel syndrome. *J. Adv. Pharm. Educ. Res.* 2020; 10(1):181-6.
4. Katz JN, Simmons BP. Carpal tunnel syndrome. *New England Journal of Medicine*. 2002 Jun 6; 346(23):1807-12.
5. Nusrat A. Diagnosis of carpal tunnel syndrome in perspective of clinical features, neurophysiological studies and high resolution ultrasound. *World Journal of Advanced Research and Reviews*. 2020;6(3):086-96.
6. Elsafy BA, Abdelrahman KI, Mohamed MA, Abdelwahab AM. To pin or not to pin, extra-articular distal radius fractures?. *Archives of Pharmacy Practice*. 2019 Oct 1;10(4).
7. Amiri F, Attari SG, Karimi YA, Motamedzadeh M, Karami M, Moghadam RH, Samiei V. EXAMINATION OF WORK-RELATED MUSCULOSKELETAL DISORDERS AND THEIR RELATED FACTORS AMONG FARMERS OF ASADABAD CITY IN 2015. *Pharmacophore*. 2020 Jan 1;11(1).
8. Ghasemi-Rad M, Nosair E, Vegh A, Mohammadi A, Akkad A, Lasha E, Mohammadi MH, Sayed D, Davarian A, Maleki-Miyandoab T, Hasan A. A handy review of carpal tunnel syndrome: From anatomy to diagnosis and treatment. *World journal of radiology*. 2014 Jun 28;6(6):284.
9. Pacek CA, Tang J, Goitz RJ, Kaufmann RA, Li ZM. Morphological analysis of the carpal tunnel. *Hand*. 2010 Mar;5(1):77-81.
10. Uchiyama S, Itsubo T, Nakamura K, Kato H, Yasutomi T, Momose T. Current concepts of carpal tunnel syndrome: pathophysiology, treatment, and evaluation. *Journal of Orthopaedic Science*. 2010 Jan 1;15(1):1-3.
11. Genova A, Dix O, Saefan A, Thakur M, Hassan A. Carpal Tunnel Syndrome: A Review of Literature. *Cureus*. 2020 Mar;12(3).

12. Stevens JC, Witt JC, Smith BE, Weaver AL. The frequency of carpal tunnel syndrome in computer users at a medical facility. *Neurology*. 2001 Jun 12;56(11):1568-70.
13. Geoghegan JM, Clark DI, Bainbridge LC, Smith C, Hubbard R. Risk factors in carpal tunnel syndrome. *Journal of Hand Surgery*. 2004 Aug;29(4):315-20.
14. Gyanchandani Khushboo, Chaudhry Neera. Carpal tunnel syndrome: a review. *INT J of Scientific Research*. March 2020; 9(3):1-4. 1582979317 4207610.
15. Aroori S, Spence RA. Carpal tunnel syndrome. *Ulster Med J*. 2008;77(1):6-17.
16. Wipperman J, Goerl K. Carpal tunnel syndrome: diagnosis and management. *American family physician*. 2016 Dec 15;94(12):993-9.
17. Salerno DF, Franzblau A, Werner RA, Bromberg MB, Armstrong TJ, Albers JW. Median and ulnar nerve conduction studies among workers: normative values. *Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine*. 1998 Aug;21(8):999-1005.
18. Werner RA, Andary M. Carpal tunnel syndrome: pathophysiology and clinical neurophysiology. *Clinical Neurophysiology*. 2002 Sep 1;113(9):1373-81.
19. Ono S, Clapham PJ, Chung KC. Optimal management of carpal tunnel syndrome. *International journal of general medicine*. 2010;3:255.
20. Martins RS, Siqueira MG. Conservative therapeutic management of carpal tunnel syndrome. *Arquivos de Neuro-Psiquiatria*. 2017 Nov;75(11):819-24.
21. Pourmokhtari M, Mazrooyi M, Vosoughi AR. Conservative or surgical treatment of carpal tunnel syndrome based on the severity and patient risk factors. *Musculoskeletal surgery*. 2020 May 11.
22. Liawrungrueang W, Wongsiri S. Effectiveness of Surgical Treatment in Carpal Tunnel Syndrome Mini-Incision Using MIS-CTS Kits: A Cadaveric Study. *Advances in Orthopedics*. 2020 Feb 14;2020.
23. Williamson ER, Vasquez Montes D, Melamed E. Multistate comparison of cost, trends, and complications in open versus endoscopic carpal tunnel release. *HAND*. 2019 Mar 29:1558944719837020.
24. Devana SK, Jensen AR, Yamaguchi KT, D'Oro A, Buser Z, Wang JC, Petrigliano FA, Dowd C. Trends and complications in open versus endoscopic carpal tunnel release in private payer and Medicare patient populations. *Hand*. 2019 Jul;14(4):455-61.