

## Anatomical, Diagnostic, and Management Considerations in Carpal Tunnel Syndrome

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**Received:** 30 May 2026; **Accepted:** 02 August 2026; **Published:** 14 August 2026

**Citation:** Leonardo Martínez Aparicio, Lázaro M. Martínez Estupiñán, Yunier Fernández Rodríguez, Lenier García Lira, Sandra Espino Santos. Anatomical, Diagnostic, and Management Considerations in Carpal Tunnel Syndrome. *J. Integr. Neuropsychiatry Behav.* 2026;1(1):1-5. DOI:

### Abstract

**Introduction:** Carpal tunnel syndrome (STC) is a symptomatic compression neuropathy of the median nerve at the wrist. Controversy still exists regarding its diagnosis and management.

**Objective:** To analyze the anatomical, diagnostic, and management considerations for this condition.

**Method:** A prospective, descriptive, and cross-sectional study was conducted on patients seen in the orthopedic clinic of the University General Hospital "Martyrs of April 9th, with a diagnosis of carpal tunnel syndrome. Scientific research methods were used, and the results were presented in tables for analysis.

**Results:** Carpal tunnel syndrome is highly prevalent in individuals aged 40 to 59 years, with nocturnal pain (98.1%) and hypo esthesia manifestations (93.2%) being the most common clinical findings. On physical examination, the Phalen test is positive in 84.3% of cases, affecting women more than men. Complementary studies can sometimes be used to establish a definitive etiological diagnosis or corroborate etiological factors; however, in most patients, no evident anatomical causes are found. Surgical intervention was performed in the majority of cases.

**Conclusions:** Carpal tunnel syndrome is common in the fourth and fifth decades of life, presenting with classic clinical symptoms and signs. Therapeutic management varies, but surgical intervention is generally necessary in most cases.

### Keywords

Carpal Tunnel Syndrome, Median nerve, Compressive neuropathy.

### Introduction

Carpal tunnel syndrome (STC) is defined as a compression neuropathy due to entrapment of the median nerve, caused by increased pressure within specific non-extensible anatomical structures inside the carpal

tunnel, produced by a compressive force (1). In Cuba, it is considered a highly prevalent disease, although there are no published official data and it is not recorded as a health indicator. It is estimated that more than 30% of the population engaged in manual labor report

discomfort in the upper limbs, considered musculoskeletal disorders, where epicondylitis and carpal tunnel syndrome are the most common (2, 3,4).

The increasing prevalence of STC globally, coupled with its manifestation at increasingly younger ages, constitutes a worrying phenomenon that demands urgent scientific attention. This upward trend suggests the influence of variables that are not sufficiently characterized in the Cuban population, making it necessary to expand knowledge in this regard to improve the diagnosis and management of this condition.

The authors aim to analyze the anatomical, diagnostic, and management considerations of carpal tunnel syndrome.

## Materials and Methods

A descriptive, prospective, and cross-sectional study was conducted at the University General Hospital "Martyrs of April 9th, in Villa Clara, from January 1, 2025, to December 31, 2025, to analyze the anatomical, diagnostic, and management considerations of carpal tunnel syndrome.

The study population consisted of 53 patients from the north-central municipalities of the province who had a diagnosis of carpal tunnel syndrome and met the inclusion criteria. Nerve conduction studies were performed.

### Inclusion criteria

Adults who attended the hospital with clinical manifestations of carpal tunnel syndrome, who gave their informed consent to participate in this study, and who underwent the protocols approved in the project.

### Exclusion criteria

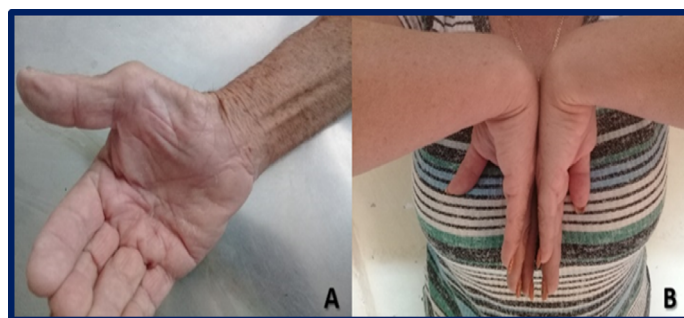
Patients who did not meet the above criteria. A database was created for patients, documenting their clinical manifestations after the interview and physical examination. To describe sociodemographic variables, the following were considered: biological age, a quantitative variable referring to years of life since birth, distributed into age groups: 20-29, 30-39, 40-49, 50-59, 60-69, and over 70 years, based on the date of birth recorded on the identity card. Sex: a dichotomous qualitative variable: male or female, as recorded on the identity card. Duration of symptoms in months, a quantitative variable: less than three months, between three and eight months, and finally, those experiencing symptoms for more than eight months. Clinical manifestations: presentation of symptoms and signs in the studied sample: dichotomous qualitative variable: yes, no: pain, nocturnal hypoesthesia or paresthesia, localization in the median nerve distribution, objective and subjective motor weakness, or thenar atrophy, positive Phalen's and/or Tinel's tests.

Flick sign (Rapid shake sign): the patient was asked if they woke up at night with numbness or pain. If they answered yes, they were asked what they did. If the patient shook their hand or moved it rapidly (without being asked to do so), it was considered a positive rapid shake sign.

The Hoffmann-Tinel sign was performed by tapping the carpal crease with a reflex hammer, and the presence of pain or paresthesia in the hand, in the median nerve distribution, was considered positive.

For the Phalen maneuver, the patient was asked to hyperflex their wrist, and the appearance of sensory symptoms was checked after 60 seconds. A reaction within the first minute in the median nerve

distribution was considered positive (Figure 1).



**Figure 1.** Carpal tunnel syndrome. Note atrophy of the thenar region (A), Phalen's maneuver (B).

For the neurophysiological evaluation, the results of comparative sensory nerve conduction studies of the median and ulnar nerves in patients with a clinical diagnosis of carpal tunnel syndrome (STC) were analyzed. These studies were performed at the neurophysiology service of Milian Hospital. This dichotomous qualitative variable was considered positive when the study was compatible with the abnormality criteria present in STC and negative when the study was normal.

The therapeutic management received by the patients was divided into conservative medical treatment, physiotherapy, infiltration, and surgical management. For data processing and analysis, descriptive statistics with absolute and relative frequency distributions and measures of central tendency such as mean, standard deviation, mode, ratio, and percentage analysis were used, supported by the Excel software program from the Office 2010 suite for Windows.

Ethical considerations were taken into account in the research (Declaration of Helsinki), and the commitment to use the data obtained strictly for the proposed objectives was respected, maintaining the anonymity of the participants' personal data.

## Results

Table 1 shows the anatomical considerations in patients with carpal tunnel syndrome (STC). Most patients showed no abnormalities; however, 11.2 percent of cases presented with anatomical abnormalities of the transverse carpal ligament. Only four patients showed anatomical abnormalities of the carpal tunnel. The majority of patients were between 40 and 59 years of age.

Table 2 supplements the information provided above. Twelve radiological studies were performed, and only four showed bone abnormalities in the carpal tunnel. Ultrasonographic studies in 11 patients revealed anatomical abnormalities in ten, including thickening and edema of the transverse carpal ligament. Several cases also showed inflammation of the flexor tendon sheaths. In most cases, further studies were not necessary. The majority of patients were female (73.4%), with a ratio of 3:1.

Carpal tunnel syndrome is a condition with a wide range of symptoms and signs; however, several are highly characteristic and considered classic for diagnosis. These include nocturnal pain, paresthesia in the fingers and the thenar eminence of the hand, as well as valuable diagnostic tests such as Phalen's test, Durham's test, and Tinel's sign. Table 3 shows that clinical signs are present in over 80% of cases, with nocturnal pain and paresthesia occurring in 98.1% and 93.2% of cases, respectively.

**Table 1.** Anatomical Considerations in Carpal Tunnel Syndrome.

| Distribution by age group in years | Anatomical considerations                       |                                        |                                    |                             | Total n/% |
|------------------------------------|-------------------------------------------------|----------------------------------------|------------------------------------|-----------------------------|-----------|
|                                    | Bone anatomical alterations of the carpal canal | Alterations of the transverse ligament | Intra-canal anatomical alterations | No demonstrable alterations |           |
| 20- 29                             | -                                               | 1                                      | 1                                  | 5                           | 7/13,3    |
| 30- 39                             | 1                                               | 2                                      | 1                                  | 5                           | 9/16,9    |
| 40- 49                             | -                                               | 1                                      | 1                                  | 11                          | 13/24,5   |
| 50- 59                             | -                                               | 2                                      | -                                  | 13                          | 15/28,3   |
| 60- 69                             | 1                                               | -                                      | 1                                  | 5                           | 7/13,3    |
| Mas de 70                          | 2                                               | -                                      | -                                  | -                           | 2/3,7     |
| Total                              | 4/7,6                                           | 6/11,2                                 | 4/7,6                              | 39/73,6                     | 53/100    |

**Table 2.** Diagnostic considerations based on complementary studies in carpal tunnel syndrome with respect to sex.

| Distribution by age group | Complementary study |                  |                         |            | Total   |
|---------------------------|---------------------|------------------|-------------------------|------------|---------|
|                           | Radiological study  | Ultrasound study | Electromyographic study | No studies |         |
| Female                    | 9                   | 7                | 3                       | 22         | 41/73,4 |
| Male                      | 3                   | 4                | 1                       | 4          | 12/22,6 |
| Total                     | 12                  | 11               | 4                       | 26         | 100     |

Female/male STC ratio = 3:1

**Table 3.** Diagnostic considerations in carpal tunnel syndrome with respect to sex.

| Distribution by age group | Diagnostic considerations |                                      |                            |               |               | Total n/% |
|---------------------------|---------------------------|--------------------------------------|----------------------------|---------------|---------------|-----------|
|                           | Nocturnal pain            | Hypoesthesia in the fingers and hand | Muscle weakness or atrophy | Phalen's test | Durham's test |           |
| Female                    | 40                        | 38                                   | 34                         | 35            | 36            | 41/73,4   |
| Male                      | 12                        | 11                                   | 9                          | 9             | 7             | 12/22,6   |
| Total                     | 98,1%                     | 93,2%                                | 81,13%                     | 84,3%         | 81,4%         | 53/100    |

Age: Maximum = 76, Minimum = 24, Mean = 47, Median = 49

**Table 4.** Management considerations in carpal tunnel syndrome.

| Distribution according to evolution time | Management considerations      |                          |                         |                     | Total n/% |
|------------------------------------------|--------------------------------|--------------------------|-------------------------|---------------------|-----------|
|                                          | Conservative medical treatment | Physiotherapy management | Infiltration management | Surgical management |           |
| Less than 3 months                       | 6                              | 3                        | 2                       | 14                  | 17/32,1   |
| Between 4 and 8 months                   | 3                              | 2                        | 3                       | 13                  | 15/28,3   |
| More than 8 months                       | 2                              | 1                        | 1                       | 19                  | 21/39,6   |
| Total                                    | 10                             | 6                        | 6                       | 46                  | 53/100    |

Management considerations for carpal tunnel syndrome, according to the duration of symptoms, are described in Table 4. A small group of patients was treated with conservative approaches such as medication and splints (10 cases), with this type of treatment decreasing as the duration of symptoms increased. A similar pattern was observed with physiotherapy management.

A small group of cases were treated with injections: three with triamcinolone acetate (40 mg) and another three with platelet-rich plasma. However, the most striking aspect of the table is that, despite these approaches, almost all cases were ultimately treated surgically by the end of the study. Only six cases did not undergo surgery: two pregnant patients, one case with clinical conditions that contraindicated surgical management, and three other cases who did not wish to have surgery because their condition resolved.

Compression syndrome resulting from abnormalities in the walls or floor of the canal is observed exclusively as a consequence of wrist trauma; this post-traumatic condition is seen in three types of injuries: isolated lunate dislocation or peri lunate carpal dislocation, malunited radial fractures leading to wrist osteoarthritis, and

fractures of the hook of the hamate. Its occurrence in the presence of bone tumors is rare.

A wrist fracture can alter the space within the carpal tunnel, just as arthritis—causing changes in the small bones of the wrist—can affect the carpal tunnel space. These changes can exert pressure on the median nerve; it has been demonstrated that individuals with smaller carpal tunnels are more likely to suffer from this condition (5). Abnormalities found in the transverse carpal ligament can range from mild edema to massive thickening.

Other anatomical abnormalities within the canal vary depending on the affected component; primarily, tendon sheaths may exhibit mild signs of inflammation with diffuse infiltration and adhesion formation—usually caused by rheumatoid arthritis, gout, or other conditions resulting in swelling, inflammation, or fluid retention. This can exert pressure on the median nerve. Other rare etiological factors include gouty tophi, ganglia, pisiform bursitis, amyloidosis of the tendon sheaths, ulnar artery thrombosis, and hemangiomas; there are also intrinsic factors within the median nerve that increase volume and occupy space in the tunnel, including tumors and

pseudotumoral lesions (6).

The most frequently reported clinical findings in STC are pain that is predominantly nocturnal—associated with reduced sensation in the fingers on the radial side of the hand, decreased grip strength, and the involuntary dropping of objects. Classic clinical signs include the Tinel, Phalen, and Durkan signs. The Tinel sign is considered positive when tapping over the carpal tunnel elicits nerve-related symptoms associated with the median nerve. Meanwhile, the Phalen test yields a positive result if the patient experiences pain, discomfort, or paresthesia in the median nerve's distribution area after holding the wrist in 90-degree flexion for more than one minute (7,8).

The author considers ultrasound an ideal imaging modality for assessing upper-extremity peripheral nerves, particularly regarding soft-tissue conditions within and around the carpal tunnel. Wrist radiography offers limited utility in most cases, serving primarily to rule out traumatic sequelae or calcifications at the distal radius; however, the axial view (or carpal tunnel view) can also help rule out traumatic causes involving the carpal bones. Magnetic resonance imaging (MRI) is another imaging modality used in select cases; it allows for the clear visualization of soft tissues, tendons, and nerves, and can readily identify abnormal tendon inflammation. It is an expensive test, and not all facilities have the capability to perform it.

Electromyography (EMG) results are essential diagnostic tools for carpal tunnel syndrome, measuring muscle electrical activity, while nerve conduction studies (NCS) assess signal transmission speed along the median nerve. These tests guide therapeutic decisions and inform modern management approaches, ranging from conservative therapy to advanced surgical options. The authors believe that understanding these diagnostic tools leads to better outcomes and improved long-term hand health. For instance, in mild STC (slow conduction, normal EMG), 80% to 90% of patients improve with splinting and injections; in moderate STC (significant slowing with mild EMG changes), injections provide temporary relief, whereas surgery offers lasting improvement; and in severe STC (very slow conduction with abnormal EMG showing denervation), there is a high risk of permanent damage, making surgery strongly recommended (9).

The therapeutic approach to STC encompasses both conservative and surgical treatments. Initial measures include anti-inflammatory drugs, analgesics, vitamins, splinting, and physical therapy—employing a variety of techniques—all of which have a statistically significant impact on symptom reduction, functional capacity, and cost savings. However, these management options often fail, leading to the use of local steroid injections—which some studies have shown to be superior for symptom relief—or platelet-rich plasma injections (10).

Conservative management of carpal tunnel syndrome may involve various physical therapy procedures—such as thermotherapy, electrotherapy, ultrasound, laser therapy, and magnetotherapy—as the foundation of rehabilitation, although there is no consensus regarding the combined use of these physical modalities for this condition.

Neurodynamic mobilization techniques have influenced the development of physical rehabilitation for Carpal Tunnel Syndrome; considered an effective form of manual therapy, they aim to reduce pain, improve nerve conduction, and enhance functional status by restoring nervous system plasticity and the extensibility of nerve tissue. This leads to increased median nerve mobility, enhanced blood flow, and reduced mechanosensitivity of the nervous system (11).

Corticosteroid injections aim to reduce the volume of the peritendinous synovial tissues surrounding the finger flexor tendons; while patients often experience significant symptom relief, 15% of those treated with injections undergo surgery within a year, and 33% do so within five years. These injections show no notable difference in outcomes compared to anti-inflammatory drugs; however, a meta-analysis demonstrated that platelet-rich plasma (PRP) injections offer benefits regarding functional recovery and pain improvement in mild to moderate cases (12,13).

Surgical release of the median nerve is considered the gold standard for treating STC. It is a rapid and effective intervention with a low incidence of complications and high success rates, regardless of the specific surgical method employed. The choice of approach depends on the surgeon's experience and preference, patient information, the severity and etiology of the condition, and the availability of equipment (14,15,16).

## Conclusions

Carpal tunnel syndrome frequently presents in individuals aged 40 to 59. Clinically, nocturnal pain and sensory disturbances (hypoesthesia) are the most common findings; physical examination reveals a positive Phalen's test in the majority of cases, and women are affected more often than men. While ancillary studies may be used to establish a precise etiological diagnosis or confirm underlying causes, no obvious anatomical etiology is found in most patients. Therapeutic management varies, but surgical intervention is generally required for the majority of cases.

## Conflict of interest

The authors declare that they have no conflicts of interest regarding the arguments presented in the article.

## Author contributions

- **Conceptualization:** Leonardo Martínez Aparicio, Lázaro Martín Martínez Estupiñán.
- **Data curation:** Leonardo Martínez Aparicio, Lázaro Martín Martínez Estupiñán.
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- **Investigation:** Leonardo Martínez Aparicio, Lázaro Martín Martínez Estupiñán, Yunier Fernández Rodríguez, Lenier García Lira, Sandra Espino Santos.
- **Methodology:** Lázaro Martín Martínez Estupiñán, Leonardo Martínez Aparicio, Yunier Fernández Rodríguez.
- **Project administration:** Leonardo Martínez Aparicio.
- **Visualization:** Leonardo Martínez Aparicio, Yunier Fernández Rodríguez.
- **Writing – original draft:** Leonardo Martínez Aparicio, Lázaro Martín Martínez Estupiñán.
- **Writing – review and editing:** Leonardo Martínez Aparicio.

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