International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 3 May–June 2025, pp: 1356-1362 www.ijprajournal.com ISSN: 2456-4494

From Conservative to Surgical Management in Bilateral CTS: A Case-Based Approach

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Date of Submission: 01-06-2025 Date of Acceptance: 10-06-2025

ABSTRACT: Carpal Tunnel Syndrome (CTS) is a common entrapment neuropathy that occurs when the median nerve is compressed while passing through the narrow osteofibrous carpal tunnel in the wrist. Middle-aged people, especially women, are more likely to have this ailment, which can be linked to work variables, systemic comorbidities, or anatomical differences. In this case report, a 46-year-old right-handed female described six months of steadily deteriorating numbness and tingling in both upper limbs, with more severe symptoms on the left side. The symptoms greatly impacted her everyday activities, particularly at night. Clinical examination confirmed positive Phalen's test, Tinel's sign, and Durkan's compression test, indicating median nerve entrapment. Nerve conduction testing indicated bilateral CTS, with greater severity on the left. Initially, conservative treatments included corticosteroid injections, vitamin B12 and D3 supplements, wrist splinting, and activity restriction. Despite adherence, the patient's symptoms continued to worsen over time. She received surgical decompression through open carpal tunnel release. Postoperative recovery included physiotherapy to improve wrist mobility, grip strength, and reduce the chance of recurrence. This case demonstrates the diagnostic problems and therapeutic implications in addressing CTS, particularly in individuals with bilateral involvement and coexisting nutritional deficits. It also highlights the value of a gradual therapeutic approach, beginning with non-surgical techniques and moving to surgical intervention when needed. Early diagnosis and extensive management, including rehabilitation, are critical for attaining positive functional results and maintaining quality of life in patients with CTS.

KEYWORDS: Carpal Tunnel Syndrome (CTS), Median Nerve Compression, Bilateral CTS, Nerve Conduction Studies (NVS), Open Carpal Tunnel Release, Wrist Splinting, Entrapment Neuropathy

I. INTRODUCTION

The most widespread peripheral nerve entrapment, Carpal Tunnel Syndrome, is triggered by compression of the median nerve in the carpal tunnel of the wrist. Sensory signs include discomfort, tingling, and numbness in the radial digits of the hand (thumb, index, middle, and radial part of the ring finger). Severe cases may also show with motor weakness or atrophy [1]. These symptoms often worsen at night or during repetitive hand movements, negatively impacting functional ability, sleep quality, and overall quality of life [2].

The disorder has a multifactorial etiology. Occupational and non-occupational risk factors include repeated wrist motion, vigorous hand exertion, use of vibrating tools, obesity, pregnancy, diabetes, hypothyroidism, and rheumatoid arthritis [3, 4]. Hormonal fluctuations and anatomical variations lead to a higher frequency in women, especially around middle age and peripartum [5]. Occupational exposure poses a significant risk, particularly for assembly line workers, typists, and those performing manual labour with repeated hand movements [6].

CTS is recognized as a significant contributor to occupational musculoskeletal disorders, with substantial implications for both public health and the economy. In the United States alone, CTS accounts for a large proportion of work-related disability claims, resulting in millions of dollars in lost productivity and compensation annually [7]. It is associated not only with direct medical costs but also with absenteeism, reduced work capacity, and even permanent job loss in severe or recurrent cases [8].

Epidemiological studies have sought to determine the prevalence of CTS among the general population. In a Swedish population-based investigation, 14.4% reported symptoms of CTS, with 3.8% verified clinically and 4.9% by nerve conduction testing [9]. Only 2.7% had both clinical

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Volume 10, Issue 3 May–June 2025, pp: 1356-1362 www.ijprajournal.com ISSN: 2456-4494

and electrophysiological confirmation, emphasizing the need for extensive diagnostic examination [9]. A Dutch study found 5.8% prevalence of CTS in women and 0.6% in males, indicating gender-specific risk [10].

Diagnosis of CTS is primarily clinical, supported by history and physical examination findings such as a positive Tinel's sign or Phalen's maneuver. However, these signs may lack specificity and are influenced by examiner technique and patient characteristics [11]. Electrodiagnostic testing, including nerve conduction studies (NCS), remains the gold standard for confirmation, especially in cases with atypical presentation, comorbid neuropathies, or when surgical intervention is considered [12]. Imaging techniques such as ultrasonography and MRI can also aid in diagnosis and preoperative planning, particularly when space-occupying lesions or anatomical variations are suspected [13].

Treatment of CTS spans a spectrum from conservative to surgical interventions. Mild to moderate cases may respond well to wrist splinting, nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroid injections, and activity modification [14]. In contrast, persistent or severe cases with electrodiagnostic confirmation often require surgical decompression of the transverse carpal ligament, which has been shown to produce favourable long-term outcomes [15].

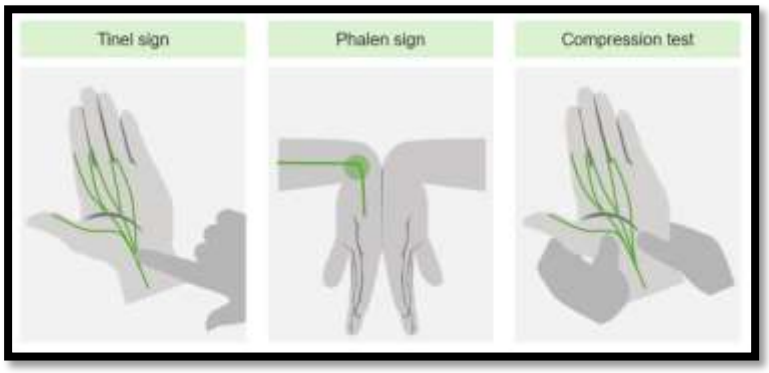

Figure 1: Clinical Tests for CTS

Adopted from: https://www.lecturio.com/concepts/carpal-tunnel-syndrome/

This report aims to contribute to the growing body of literature on CTS by presenting a unique clinical case, its diagnostic process, management approach, and follow-up outcomes in the context of existing evidence.

II. CASE SUMMARY: -

A 46-year-old right-handed female presented to the outpatient clinic with a 6-month history of worsening paraesthesia and numbness in both upper limbs, predominantly affecting her left hand. The patient reported a severe deterioration in hand function, including the inability to grasp objects for more than a minute, which interfered with her everyday tasks. The symptoms were notably aggravated during night. There was no history of trauma, chronic illness, diabetes, or thyroid trouble. Her medical history was significant for documented deficiencies in vitamin B12 and vitamin D3, for which she had been previously treated.

Fig 1 demonstrates Tinel's sign, Phalen's test, and the carpal compression test—commonly used to diagnose carpal tunnel syndrome clinically.

A clinical examination identified classic symptoms of median nerve compression. Phalen's test, Tinel's sign, and Durkan's compression test were all positive, indicating carpal tunnel involvement. A complete neurological assessment and nerve conduction investigation verified the diagnosis of Carpal Tunnel Syndrome (CTS). Initially, oral vitamin supplements and corticosteroid injections gave temporary symptom alleviation. Despite medical therapy and lifestyle changes, the patient's symptoms increased, including sensory abnormalities and decreasing grip strength in their left hand.

Due to the refractory nature of her disease and advancement of functional impairment, she had surgical decompression of the median nerve via carpal tunnel release. The surgery was completed effectively without difficulties.

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Figure 2: Intraoperative Image

Figure 2. Intraoperative exposure of the transverse carpal ligament during carpal tunnel release.

Following surgery, the patient had systematic physiotherapy rehabilitation to improve hand function, range of motion, and prevent recurrence. The patient was recommended to follow-up every 7 days for clinical monitoring and therapy adjustments. During follow-up, the patient experienced significant improvement in symptoms, hand strength, and quality of life.

III. DISCUSSION

Among peripheral nerve compression disorders, Carpal Tunnel Syndrome is the most prevalent, stemming from entrapment of the median nerve within the carpal tunnel of the wrist [16]. The carpal tunnel is a thin, osteofibrous canal surrounded by the carpal bones on the dorsal side and the transverse carpal ligament (flexor retinaculum) on the vertical side. It housesthe median nerve and nine flexor tendons [17]. Due to the confined nature of this tunnel, even minor changes in the size or content can significantly impact the median nerve, resulting in CTS symptoms. The pathophysiological hallmark of CTS is increased intracarpal pressure, which can result from a variety of causes including synovial hyperplasia, fibrosis, and thickening of the flexor tendon sheaths due to repetitive wrist movements or inflammatory changes [16]. These alterations reduce the available space within the carpal tunnel, leading to mechanical compression of the median nerve [16].

Compression disrupts the venous outflow of the nerve, resulting in venous congestion and subsequent endoneurialedema. This leads to local ischemia, impairing axoplasmic flow and initiating segmental demyelination of the myelinated sensory fibers[19]. If compression persists, axonal degeneration can occur, producing more severe and often irreversible symptoms [16].

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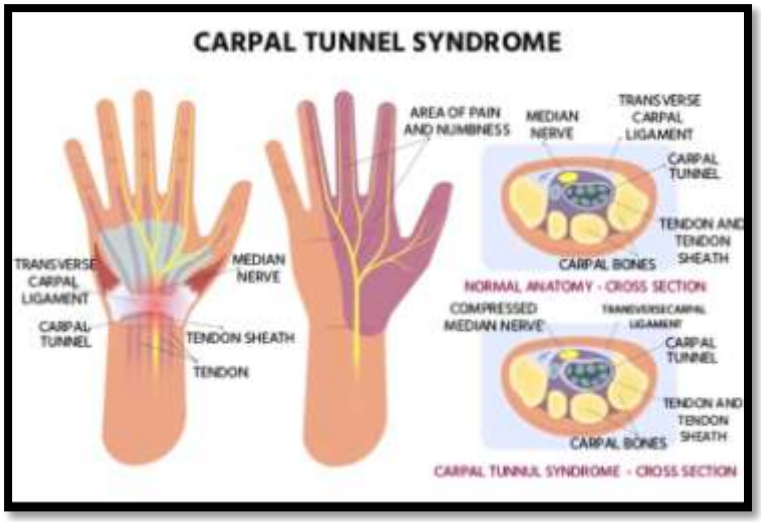

Figure 3: Pathophysiology of Carpal Tunnel Syndrome

Adopted from: https://www.medicoverhospitals.in/diseases/carpal-tunnel-syndrome/

Figure3: Illustration showing compression of the median nerve within the carpal tunnel, leading to pain and numbness in the hand. Cross-sectional views compare normal and compressed anatomy.

CTS symptoms include numbness, tingling, burning pain, and paraesthesia in the thumb, index, middle, and radial half of the ring finger, which are innervated by the median nerve [16]. Symptoms tend to worsen at night or during wrist flexion activities. Long-term or severe cases can cause motor fiber damage, resulting in weakness in thumb abduction and opposition, as well as thenar muscle atrophy [21].

Histopathological studies have demonstrated various chronic changes including epineuraland perineural fibrosis, demyelination, and myelin sheath fragmentation in the affected nerve segments [21]. These findings reflect both the mechanical injury and the nerve's attempt at repair. Additionally, hyperplastic synovium and inflammatory infiltrates are often noted in patients with systemic inflammatory conditions [22].

Several risk factors contribute to the development of CTS. Repetitive wrist motions, aggressive hand use, uncomfortable wrist placement, and vibration exposure are all factors to consider [23]. Systemic diseases such diabetes, hypothyroidism, rheumatoid arthritis, pregnancy, and obesity can cause fluid retention, nerve ischemia, and tissue oedema [24]. Anatomical variations, such as a bifid median nerve, persistent median artery, or space-occupying diseases (e.g., ganglion cysts or tumors), might worsen tunnel narrowing and nerve compression [25].

Electrodiagnostic investigations can corroborate the diagnosis of CTS by finding prolonged distal motor latency, slower sensory conduction velocity, and significant latency discrepancies between the median and ulnar nerves [16]. Some patients with early or mild CTS may have normal findings, requiring a focus on clinical symptoms and physical evaluation [16]. The treatment of CTS is dependent on severity, duration, and patient response to conservative measures. Non-surgical management is generally the first-line approach in mild to moderate cases. Wrist splinting, especially at night, is effective in maintaining the wrist in a neutral position, thus reducing nocturnal symptoms and preventing further compression [20]. Non-steroidal anti-inflammatory drugs (NSAIDs) may offer short-term symptom relief but do not significantly alter the course of the disease [26].

Local corticosteroid injections into the carpal tunnel have shown good short-term efficacy, particularly when administered under ultrasound guidance for greater accuracy. These injections reduce synovial inflammation, thereby relieving nerve pressure. However, recurrence is common, and repeated injections may carry risks such as tendon rupture or skin atrophy [20].

In patients with persistent or severe symptoms, surgical decompression becomes necessary. The most widely performed procedure is open carpal tunnel release, which involves

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transecting the transverse carpal ligament to decompress the median nerve [27].

Endoscopic carpal tunnel release is a minimally invasive approach with shorter recovery times and comparable efficacy. Patients typically get significant alleviation from sensory complaints and progressive improvement in motor function after surgery. Advanced nerve injury or long-term symptoms may restrict total healing [23]. Early identification and quick treatments are crucial for avoiding irreversible nerve injury and improving functional outcomes. A multidisciplinary strategy combining clinical assessment, electrodiagnosis, and tailored therapy improves prognosis and patient satisfaction.

Comparison of Conservative vs. Surgical Management in Carpal Tunnel Syndrome:

Aspect	Conservative Management	Surgical Management
Indication	Mild to moderate symptoms; early-stage CTS	Severe or refractory CTS; failure of conservative treatment
Examples of Treatment	Wrist splinting, NSAIDs, corticosteroids, vitamins	Open or endoscopic carpal tunnel release
Mechanism of Action	Reduces inflammation, minimizes nerve compression	Physically decompresses the median nerve by cutting the transverse carpal ligament
Onset of Relief	Short-term (days to weeks), often temporary	Rapid sensory improvement (weeks), long-term relief
Risks / Limitations	Recurrence, incomplete relief, steroid side effects	Surgical risks, scar sensitivity, downtime
Post-Treatment Care	Activity modifications, supplementation	Physiotherapy, wound care, hand strengthening
Effectiveness	Variable; best for early CTS	High success for advanced cases.
Recurrence Risk	Higher	Lower (especially with rehab)
Cost & Accessibility	Lower initial cost; may require repeated care	Higher one-time cost; definitive treatment
References	[14], [20], [26]	[15], [20], [27]

IV. CONCLUSION

Carpal Tunnel Syndrome (CTS) continues to be a prevalent and disabling peripheral neuropathy, significantly affecting patients' functional capabilities and overall well-being. The presented case of a 46-year-old female with bilateral CTS and associated vitamin deficiencies exemplifies the complex interplay of systemic, occupational, hormonal, and anatomical factors that can influence disease onset and progression.

The patient's clinical course emphasizes several important aspects of CTS management. Initial conservative strategies—including corticosteroid administration, splinting, and vitamin supplementation—were appropriately implemented based on symptom severity and functional limitations. However, as the symptoms advanced and conservative therapies failed to provide sustained benefit, surgical intervention became necessary. The favourable postoperative recovery, aided by structured physiotherapy, underscores the effectiveness of decompression surgery in advanced or refractory CTS.

This case reinforces the importance of a personalized and multidisciplinary approach to CTS. Timely diagnosis through thorough clinical assessment and confirmatory nerve conduction studies enables early intervention, which is vital to prevent irreversible nerve damage, muscle atrophy, and long-term disability. Additionally, the consideration of nutritional deficiencies, hormonal variations, and lifestyle factors is crucial, especially in female patients or those without obvious occupational risk factors.

From a clinical and public health perspective, this report illustrates the broader implications of CTS—not only as an individual health concern but also as a condition with substantial socioeconomic burden due to its impact on work productivity and quality of life. Integrating patient education, ergonomic modifications, and access to early treatment pathways can mitigate the long-term consequences of the disease.

Finally, a stratified, evidence-based therapeutic plan that changes according on symptom intensity and patient response remains the foundation of effective CTS care. Surgical

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decompression, when required, has a high success rate, especially when paired with adequate postoperative therapy and long-term monitoring. This holistic therapy paradigm gives affected patients the best opportunity of regaining hand function, alleviating symptoms, and improving their overall quality of life

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