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# Advances in Carpal Tunnel Syndrome: Anatomy, Ultrasound Diagnostics and Modern Treatment Strategies - review

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Abstract:

*Introduction*

Carpal Tunnel Syndrome (CTS) is a prevalent compressive neuropathy affecting the wrist, leading to motor and sensory dysfunctions primarily in the hand. With the advent of high-resolution ultrasound (US) as an alternative to the traditional nerve conduction

studies (NCS), the approach to diagnosing and treating CTS has evolved. This review covers the anatomical foundation, diagnostic advancements, particularly through ultrasound, and compares current therapeutic interventions, both conservative and surgical.

*Purpose of Work*

This review synthesizes current research on the diagnostic value of ultrasound compared to NCS, ultrasound-based parameters for diagnosing CTS, and the role of ultrasound in guiding surgical techniques. The aim of this review is to synthesize recent findings on CTS, focusing on anatomy, the role of ultrasound in diagnosis, and evaluating the effectiveness of various treatment methods.

*Material and Methods*

A comprehensive literature search was conducted using PubMed and Google Scholar databases. We reviewed peer-reviewed articles from 2010 to 2024, focusing on CTS diagnostics, clinical efficacy, and advancements in ultrasound-based assessments. Keywords included “carpal tunnel syndrome,” “ultrasound,” “nerve conduction studies,” and “surgical techniques.”

*Summary*

Carpal Tunnel Syndrome (CTS) is a common neuropathy resulting from compression of the median nerve in the carpal tunnel, causing motor and sensory issues in the hand. This review examines current diagnostic and treatment approaches, with a focus on high-resolution ultrasound (US) as a non-invasive alternative to nerve conduction studies (NCS). Anatomical considerations and US-based diagnostic criteria are reviewed, along with a comparison of diagnostic accuracy between US and NCS. CTS treatments include conservative methods, such as splinting, nerve gliding, and medications, which can be effective for mild cases. In more severe cases, surgical options like open and endoscopic release, as well as ultrasound-guided carpal tunnel release, have shown improved recovery times and fewer complications. Recent studies emphasize ultrasound’s growing role in both diagnosis and management of CTS,

supporting a shift toward individualized treatment strategies to improve patient outcomes.

Keywords:
Carpal tunnel syndrome, Surgery, Anatomy, Ultrasound diagnosis

Introduction:

Carpal Tunnel Syndrome (CTS) is one of the most prevalent peripheral neuropathies, characterized by pain, numbness, and tingling in the hand and wrist due to compression of the median nerve within the carpal tunnel. This condition significantly impacts patients' quality of life, leading to decreased functional ability, disrupted sleep, and work limitations. With a growing incidence among various populations, especially those engaged in repetitive hand movements or with comorbid conditions like diabetes, CTS presents both a clinical challenge and an economic burden. Management of CTS ranges from conservative approaches, such as activity modification, splinting, and pharmacological interventions, to surgical procedures like open and endoscopic carpal tunnel release. Recent advances, including minimally invasive techniques and complementary therapies, offer promising alternatives that aim to enhance recovery and minimize complications. Understanding the nuances of these treatment options, alongside factors like patient comorbidities, anatomical variations, and surgical expertise, is critical for optimizing patient outcomes. This paper explores the latest evidence on conservative and surgical treatments for CTS, highlighting the efficacy, benefits, and limitations of each approach. Additionally, we examine emerging techniques, such as ultrasound-guided interventions and complementary therapies, to provide a comprehensive overview of current best practices in CTS management.

Methodology:

This literature review follows the PRISMA guidelines for systematic reviews. A detailed search was conducted across databases such as PubMed, Cochrane, and Web of Science. Keywords like “carpal tunnel syndrome,” “ultrasound,” “nerve conduction studies,” and “surgical techniques” were used to identify relevant articles. Inclusion criteria were peer-reviewed articles published between 2010 and 2024 that explored Carpal Tunnel Syndrome. After screening for relevance, 31 articles were selected for in-depth analysis.

Discussion:

Carpal Tunnel Syndrome (CTS) results from increased pressure within the carpal tunnel, leading to compression of the median nerve and associated sensory and motor deficits in the hand. Diagnosis primarily relies on Nerve Conduction Studies (NCS) due to their high sensitivity and specificity, yet high-resolution ultrasound (US) is emerging as a less invasive alternative, allowing direct visualization of structural abnormalities like nerve swelling and synovial hypertrophy. The potential for ultrasound to replace NCS in certain settings is supported by studies showing comparable accuracy, along with increased patient comfort and accessibility. Treatment of CTS typically begins with conservative options, such as activity modification, splinting, and pharmacological treatments. For more severe or refractory cases, surgical options like Open Carpal Tunnel Release (OCTR) or Endoscopic Carpal Tunnel Release (ECTR) are considered, each with similar long-term outcomes but differing in recovery time and invasiveness. The increasing use of ultrasound, both for diagnosis and in guiding minimally invasive treatments, points to promising advancements in CTS management, particularly with the development of techniques such as ultrasound-guided carpal tunnel release (CTR-US), which may reduce recovery time and healthcare costs.

1. Anatomy of the Carpal Tunnel

The carpal tunnel is an osseofibrous passage located on the volar aspect of the wrist, bordered by rigid anatomical structures. The floor and walls of the tunnel are formed by the carpal bones, specifically the scaphoid, lunate, triquetrum, and pisiform on the ulnar side, with the trapezium, trapezoid, capitate, and hamate contributing to the radial side. The roof of the tunnel is formed by the transverse carpal ligament (also known as the flexor retinaculum), a thick fibrous band that stretches between the pisiform and hamate on the ulnar side to the scaphoid and trapezium on the radial side. The carpal tunnel encloses the *median nerve* alongside the nine tendons of the extrinsic flexor muscles of the fingers, which include the four tendons of the *flexor digitorum superficialis*, four tendons of the *flexor digitorum profundus*, and the single tendon of the *flexor pollicis longus*. Due to the inelastic nature of the tunnel boundaries, the median nerve is particularly susceptible to compression when there is increased pressure within the tunnel, often due to edema, inflammation, or external mechanical forces. This can lead to the characteristic symptoms of Carpal Tunnel Syndrome, with sensory and motor

impairments in the nerve's distribution area. This compression leads to sensory disturbances in the first three fingers and radial half of the fourth, with motor effects including weakness in thumb abduction due to thenar muscle involvement (Murciano et al., 2023).

Anatomical variations in carpal bones, specifically in the hook of the hamate, have been shown to influence surgical outcomes in endoscopic carpal tunnel release (ECTR). Research by Saito et al. (2024) demonstrates that variations, such as hypoplastic hooks, can increase the risk of complications during ECTR, as these structures affect the device's placement and the safety of trocar insertion. The hypoplastic hook, in particular, was found in approximately 10.8% of CTS cases, and these patients experienced higher incidences of adverse events, including temporary nerve compression and altered nerve positioning within the carpal tunnel.

Moeller et al. (2024) identified variations in the anatomy of the thenar motor branch of the median nerve (TMB), which in approximately 20% of cases originated more ulnarly than expected. The presence of transverse carpal muscle (TCM) was associated with these atypical TMB origins, increasing the risk of iatrogenic injury during carpal tunnel release (CTR). They suggested that preoperative ultrasound could help identify TCM and, therefore, guide surgical decisions to minimize nerve injury risk. This research underscores the importance of anatomical awareness and potentially integrating ultrasound in surgical planning for safer CTR outcomes.

Recent evidence highlights the relationship between distal radius fractures (DRFs) and the subsequent development of carpal tunnel syndrome (CTS). Chung et al. (2024) analyzed data from 39,603 patients and observed a significantly higher incidence of CTS in those who received surgical treatment for DRFs compared to those managed non-operatively (12% vs. 3%). This suggests that surgical intervention for DRFs may place patients at increased risk for CTS, warranting closer postoperative monitoring for symptoms. Additionally, among patients who developed CTS after DRF surgery, a greater proportion required further surgical intervention - 63% underwent carpal tunnel release (CTR), compared to only 23% of non-surgically managed cases (Chung et al., 2024). These findings underscore the potential for escalated surgical intervention in

patients who develop CTS following DRF surgery and emphasize the need for cautious evaluation when considering operative management for DRFs.

## 2. Diagnosis of Carpal Tunnel Syndrome

### *Clinical Examination*

The diagnosis of Carpal Tunnel Syndrome (CTS) often begins with specific physical tests to provoke symptoms by stressing the median nerve within the carpal tunnel.

- Tinel's Sign: This test involves percussing (tapping) directly over the course of the median nerve at the level of the carpal tunnel. A positive response is indicated by paresthesia or tingling radiating into the distribution of the median nerve, typically affecting the thumb, index, middle, and radial half of the ring finger.
- Phalen's Test: In this provocative test, the patient is asked to hold both wrists in maximal flexion by pressing the dorsal surfaces of the hands together for 30 to 60 seconds. A positive Phalen's test is characterized by the reproduction of tingling, numbness, or pain in the distribution of the median nerve, indicating compression within the carpal tunnel.
- Durkan's Compression Test (also known as the Carpal Compression Test): This maneuver involves applying direct pressure over the transverse carpal ligament with the examiner's thumb for approximately 30 seconds. Elicitation of CTS symptoms—such as tingling or numbness within the median nerve's sensory distribution—suggests increased sensitivity of the nerve to mechanical compression.

These clinical signs provide useful initial screening for CTS, with Phalen's and Durkan's tests often yielding higher sensitivity. However, further diagnostic testing may be required to confirm the diagnosis and assess the severity of nerve compression.

### *Nerve Conduction Studies (NCS)*

NCS is the gold standard, evaluating the conduction speed across the median nerve. Sensitivity and specificity rates for NCS reach approximately 85% and 95%, respectively. However, it can be invasive, causing discomfort (Murciano et al., 2023).

*High-Resolution Ultrasound*

- Cross-Sectional Area (CSA): Enlargement of the median nerve, especially at the level of the pisiform bone, is a reliable diagnostic marker.
- Doppler Ultrasound: Used to detect hypervascularization, a sign of nerve inflammation in severe CTS.
- Dynamic Testing: Some studies examine nerve mobility during specific hand movements, though operator skill is critical for accuracy.

Ultrasound offers a promising diagnostic alternative with sensitivity comparable to NCS. It also provides real-time visualization, allowing for identification of structural anomalies, such as ganglia or synovial hypertrophy, which may exacerbate CTS. This non-invasive method has become increasingly accessible, and recent studies emphasize its accuracy and practicality as a first-line diagnostic tool. Current research efforts aim to establish standardized ultrasound parameters, such as CSA and Doppler uptake, to provide a reliable and accessible method for diagnosing CTS in diverse clinical settings (Smith et al., 2023; Murciano et al., 2023).

The use of high-resolution ultrasound as a diagnostic tool for CTS is increasingly supported due to its accessibility, lower cost, and non-invasive nature compared to Nerve Conduction Studies (NCS). Studies show ultrasound's high sensitivity and specificity when measuring the cross-sectional area (CSA) of the median nerve at the carpal tunnel inlet, particularly at the level of the pisiform bone. Meta-analyses have demonstrated that ultrasound can achieve sensitivity up to 94% and specificity up to 98%, comparable to NCS, especially in cases of mild and moderate CTS. These results indicate that ultrasound could serve as a reliable first-line confirmatory test, particularly for patients with clear clinical symptoms. Additionally, Doppler ultrasound can detect hypervascularization, a marker of nerve inflammation associated with severe CTS, which is not directly observable in NCS. This capability for real-time imaging allows clinicians to visualize structural anomalies like ganglia or synovial hypertrophy, making ultrasound a valuable complementary diagnostic method, especially for patients with atypical symptoms or negative NCS findings (Fowler et al., 2011; Fowler et al., 2014).

Ultrasound-based measurements of subsynovial connective tissue (SSCT) thickness

present a promising adjunct in diagnosing CTS, as SSCT thickening appears to correlate with CTS severity. Notably, SSCT thickening may occur prior to detectable electrodiagnostic (EDX) changes, positioning ultrasound as a valuable tool for early CTS detection, particularly in cases where EDX results remain inconclusive. Robben et al. (2023) found that SSCT thickness assessments via ultrasound offer high intra- and inter-rater reliability, although the SSCT thickness ratio was found to be less consistent. These findings highlight SSCT measurement as a potential early diagnostic marker for CTS, offering insight into structural changes that might help clinicians identify CTS in patients with mild or atypical symptoms. The retrospective review by Billakota et al. (2017) highlights the effectiveness of ultrasound (US) in screening for CTS. Their study, which involved over a thousand extremities, found that a cross-sectional area (CSA) threshold of >9 $mm^2$ at the wrist achieved a sensitivity of 97.6% for electrodiagnostically confirmed CTS cases. Symanski and Lee (2024) outline various ultrasound parameters, such as the nerve's CSA, flexor retinacular bowing, and Doppler blood flow, with CSA remaining the most reliable metric. They discuss that CSA measurements at the proximal carpal tunnel with a threshold of 10-12 $mm^2$ yield high sensitivity and specificity, potentially replacing the need for more invasive diagnostics like EDX in certain cases.

For cases involving anatomical anomalies, such as an accessory flexor digitorum superficialis (FDS) muscle belly within the carpal tunnel, neuromuscular ultrasound (NMUS) has become a valuable diagnostic tool. Hallwachs et al. (2023) describe a case in which NMUS successfully identified an aberrant muscle belly causing CTS. This case highlights the utility of NMUS in preoperative planning for patients with atypical CTS presentations, where standard imaging like MRI may fail to reveal structural variations that contribute to nerve compression. NMUS allowed for detailed visualization of the median nerve displacement due to the aberrant muscle, supporting its use as a supplementary diagnostic tool, particularly in patients presenting with atypical CTS symptoms or early-onset CTS.

## 3. Treatment Approaches for Carpal Tunnel Syndrome

### *Conservative Management*

- Activity Modification: Reducing repetitive wrist movements and ensuring proper ergonomic practices are first-line interventions.
- Splinting: Wrist splints worn at night help relieve symptoms by maintaining the wrist in a neutral position.
- Pharmacological Treatments: Nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroid injections reduce inflammation and provide temporary relief (Murciano et al., 2023). However, repeated injections may elevate risks of complications such as tendon rupture and chronic inflammatory responses. Studies suggest limiting injection frequency and adhering to precise injection techniques to avoid adverse outcomes (Hardie et al., 2024; Shang et al., 2023).

In recent years, complementary therapies have gained attention for their potential role in managing CTS symptoms, particularly for patients undergoing or recovering from surgical intervention. For instance, Li and Jordan (2023) emphasize the biomechanical factors within the carpal tunnel that contribute to median nerve compression, which directly affects CTS symptoms. They highlight that median nerve mobility is often reduced in CTS, particularly its transverse movement, potentially exacerbating compression and increasing the mechanical strain on the nerve. This mobility reduction suggests that therapeutic techniques targeting nerve gliding may improve symptoms by restoring some of the nerve's natural movement. Georgeto et al. (2024) demonstrated that a combined approach of myofascial mobilization (IASTM) and stretching can be beneficial for both surgical and non-surgical CTS cases. Their study found that patients who engaged in these therapies 30 days post-surgery showed improved grip and pinch strength, along with reduced pain levels, suggesting that structured physiotherapy can enhance surgical outcomes and potentially shorten the duration of postoperative recovery, thereby minimizing the need for extended immobilization periods (Georgeto et al., 2024).

Similarly, acupuncture has been explored as a non-invasive option for conservative CTS management. While Liu et al. (2024) found that acupuncture can effectively reduce pain intensity, its efficacy in improving overall symptom severity and functionality remains inconsistent when compared with other treatment modalities. However, due to its relatively low

risk of adverse effects compared to medications, acupuncture may serve as a complementary option, especially for patients seeking alternatives to steroid injections or splinting. This safety profile positions acupuncture as a promising, albeit supplementary, approach to traditional CTS therapies.

*Surgical Treatment Options*

For severe or persistent cases, surgery may be necessary to decompress the median nerve.

- Open Carpal Tunnel Release (OCTR): This traditional procedure involves incising the transverse carpal ligament to increase tunnel space. It remains effective but has a longer recovery time due to a larger incision.
- Endoscopic Carpal Tunnel Release (ECTR): ECTR is less invasive, requiring smaller incisions and allowing for quicker recovery. Modifications, such as single-portal and dual-portal techniques, offer flexibility based on surgeon preference. The Menon technique, for instance, involves cutting the ligament from proximal to distal, allowing for more controlled visualization. Studies indicate that ECTR, particularly the single-portal approach, may minimize the need for conversion to open surgery, provided surgeons have sufficient experience and understanding of anatomical variations (Chung DB et al., 2024). However, complications with ECTR, such as hypertrophic synovium, may still necessitate conversion to OCTR, underscoring the importance of anatomical precision and experience in minimizing intraoperative challenges.
- Ultrasound-guided Carpal Tunnel Release (CTR-US): This procedure led to sustained improvements in function and symptoms up to a year post-procedure, measured by reductions in the Quick Disabilities of the Arm, Shoulder, and Hand (QDASH), Boston Carpal Tunnel Questionnaire (BCTQ-SSS, BCTQ-FSS), and VAS scores (Aguila et al., 2024). This supports CTR-US as a viable, minimally invasive alternative, especially for patients with high baseline symptom severity or those requiring bilateral procedures.
- Mini-Open Carpal Tunnel Release (mOCTR): Outcomes with mOCTR were positively associated with smaller incisions, which reduced the risk of complications

such as pillar pain. This may provide insight into the importance of minimizing incision size across CTR techniques to optimize recovery (Hammert et al., 2024).

*Anesthetic Approaches:*

Recent studies have compared the efficacy of WALANT (wide-awake local anesthesia with no tourniquet) and locoregional distal nerve blocks in carpal tunnel release. WALANT, which avoids the need for a tourniquet, offers significant patient comfort, especially for those undergoing bilateral staged carpal tunnel release. Although WALANT is generally preferred by patients due to the lack of tourniquet pain, surgeons may encounter reduced visibility during endoscopic procedures due to the presence of anesthetic fluid in the surgical field, complicating visualization. The study suggests that while WALANT is effective, locoregional nerve blocks may be preferable for endoscopic procedures where clear visualization is critical for safety and precision (Verrewaere et al., 2024).

Fuchs and Rose (2024) report that ultrasound-guided hydrodissection of the median nerve, performed in emergency settings, serves as a promising, minimally invasive treatment option for Carpal Tunnel Syndrome (CTS). This technique involves injecting a fluid to separate the median nerve from surrounding structures, effectively reducing adhesions and nerve compression, which provides rapid symptom relief. The benefits of hydrodissection appear to be substantial, with symptom improvement lasting up to six months. Hydrodissection can act as an intermediate treatment option, especially beneficial for patients who have not responded to conservative therapies but prefer to avoid or delay surgical intervention. Its application in outpatient or emergency settings makes it a practical choice for managing acute CTS symptoms or providing relief until more definitive treatment is possible.

## 4. Efficacy of Surgical Techniques

Studies comparing OCTR and ECTR show similar long-term outcomes, but ECTR offers advantages in terms of postoperative pain and return to function. However, thorough anatomical knowledge of the carpal tunnel is essential to minimize risks during ECTR (Murciano et al., 2023). Increasing surgeon experience and refining surgical

techniques - such as the subligamentous extrabursal approach in ECTR - are associated with lower conversion rates and improved outcomes. In comparing open carpal tunnel release (OCTR) and endoscopic carpal tunnel release (ECTR), studies indicate that both procedures yield similar long-term outcomes. However, ECTR offers advantages in terms of reduced postoperative pain and faster recovery, provided that the surgeon has comprehensive anatomical knowledge and experience with the endoscopic technique. Complications, such as pillar pain or nerve compression, are reduced with increased surgeon expertise, particularly when using techniques like the single-portal approach or subligamentous extrabursal method (Saito et al., 2024).

There is growing evidence supporting the effectiveness of ultrasound-guided carpal tunnel release (CTR-US) compared to traditional open (OCTR) and endoscopic (ECTR) techniques. A recent long-term follow-up study of over 100 patients showed that CTR-US not only resulted in significant improvements in functional scores (Boston Carpal Tunnel Questionnaire and QuickDASH) but also reduced recovery time and postoperative discomfort compared to OCTR and ECTR (Cano et al., 2024). Studies demonstrate that CTR-US significantly reduces recovery time, with patients typically returning to work within 3 days post-procedure compared to 17.6 days for ECTR and 21.1 days for OCTR. This technique also minimizes the need for postoperative rehabilitation, thus lowering the overall societal cost. From an economic standpoint, CTR-US emerges as a cost-effective alternative, yielding superior QALY gains and reduced societal costs compared to both OCTR and ECTR. The total episode cost for CTR-US was $3,249, substantially lower than OCTR ($4,324) and ECTR ($4,978), with additional savings related to shorter recovery times (Ekhtiari et al., 2024).

The meta-analysis indicated that mini-open CTR (mOCTR) significantly improved function and reduced pain, with consistent improvements in QuickDASH, BCTQ-SSS, BCTQ-FSS, and VAS scores, which met clinical significance(carpal12). The mOCTR showed a relatively low complication rate (8.9%) with minimal reoperations (0.6%). These outcomes suggest mOCTR as an effective approach that minimizes recovery time while maintaining high efficacy. (Hammert et al., 2024)).

## 4. Critical Findings in the Care of Carpal Tunnel Syndrome Patients

### *Predictive Model for Pain Intensity*

Rezaee et al. (2024) developed a model to predict pain intensity in CTS patients using demographic, clinical, electrophysiological, and ultrasound findings. They found that compound motor action potential (CMAP) latency, nocturnal pain, and thenar weakness were the strongest predictors of pain intensity. The inclusion of the cross-sectional area (CSA) of the median nerve as a reliable ultrasound marker further underscores ultrasound's role not only in diagnosis but also in gauging symptom severity.

### *Diagnostic Considerations for Post-Traumatic CTS in Pediatric Patients*

While CTS is more commonly diagnosed in adults, post-traumatic CTS can present in pediatric patients following wrist injuries, particularly distal radius fractures. Lee et al. (2024) reported that urgent carpal tunnel release in children with acute CTS led to significant symptom relief in 81% of cases, underscoring the necessity of timely surgical intervention to prevent prolonged recovery. In pediatric populations, delayed intervention for acute CTS can lead to extended recovery periods, as demonstrated by Lee et al. (2024), where children who received delayed carpal tunnel release experienced a significantly longer recovery duration (28.0 vs. 2.4 weeks). These findings advocate for prompt surgical management in acute cases to optimize outcomes.

### *Genetic Contributions to Carpal Tunnel Syndrome Risk*

In addition to lifestyle factors, genetic predispositions play a significant role in CTS risk. A large genome-wide association study (GWAS) identified 53 genetic loci associated with CTS, suggesting skeletal muscle and bone tissue involvement in disease development. The study implicated skeletal muscle regulatory genes, such as BZW2, which may influence myocyte differentiation, potentially impacting tissue structure around the median nerve and increasing susceptibility to compression. These genetic insights suggest that CTS risk may be partly due to inherent tissue characteristics that predispose individuals to nerve compression. Understanding these genetic factors could

open avenues for targeted therapies that address structural vulnerabilities in CTS-prone populations (Pahl et al., 2024).

*Role of Connective Tissue in CTS Pathogenesis*

Aliev et al. examined the connective tissue surrounding the median nerve, referred to as the median nerve connective tissue system (MC), which extends from the pronator teres to the carpal tunnel. The study found that this connective tissue system creates subspaces within the carpal tunnel, which can become fibrotic and may play a significant role in CTS pathogenesis. These findings support the theory that connective tissue inflammation and fibrosis contribute to nerve compression in CTS cases that were previously categorized as idiopathic, thereby providing a structural framework for understanding CTS pathophysiology (Aliev et al., 2024).

*Relationship between Diabetes Medications and CTS Risk*

Patients with type 2 diabetes mellitus (T2DM) face elevated risks of CTS due to metabolic and inflammatory factors. Su et al. (2024) compared sodium-glucose cotransporter 2 inhibitors (SGLT2is) and glucagon-like peptide-1 receptor agonists (GLP-1RAs), finding that SGLT2is significantly reduced both CTS incidence and the need for carpal tunnel release surgery. This neuroprotective effect, attributed to anti-inflammatory properties and potential modulation of hypoxia-inducible factors, may offer new prevention strategies in diabetic populations. Choo et al. (2023) examine the impact of diabetes and smoking on short-term pain outcomes following open carpal tunnel release. They found that diabetic and smoking patients had significantly less improvement in pain scores two weeks post-surgery than non-diabetic, non-smoking counterparts. Specifically, among those with moderate EDX findings preoperatively, smokers and diabetic patients showed only minimal improvements, indicating that these comorbidities can compromise pain outcomes following carpal tunnel surgery.

*Sleep Disturbances in Carpal Tunnel Syndrome*

A recent meta-analysis revealed that sleep disruption is a common and underrecognized symptom of carpal tunnel syndrome (CTS). Many patients with CTS report frequent sleep disturbances, often due to nocturnal hand pain and numbness, with as many as 80%

affected. Surgical intervention, particularly carpal tunnel release, significantly improved sleep quality as measured by validated patient-reported outcomes, including the Pittsburgh Sleep Quality Index (PSQI) and Insomnia Severity Index (ISI). On average, PSQI scores improved by 4.43 points within three months post-surgery and by 6.02 points at six to twelve months, indicating sustained relief. These findings underscore the importance of addressing sleep issues when assessing CTS severity and determining treatment pathways, as untreated sleep disruption may lead to adverse health outcomes such as hypertension and increased diabetes risk (Warren et al., 2024).

*Role of ChatGPT in Patient Education*

With the growing use of online sources for medical information, a study by Casey et al. (2024) compared ChatGPT to traditional Google searches in answering common patient questions about carpal tunnel syndrome. The findings indicate that ChatGPT's responses are generally as accurate and complete as those from the top Google search results but are notably more concise. However, the study advises against relying on ChatGPT as a primary medical resource due to its lack of access to updated academic information, suggesting instead that patients refer to trusted medical websites for the most current data.

Conclusion:

The management of Carpal Tunnel Syndrome (CTS) has advanced with a mix of conservative and surgical approaches tailored to improve patient outcomes. Conservative treatments like activity modification, splinting, and NSAIDs are foundational, while complementary therapies, including nerve gliding and acupuncture, offer additional symptom relief. Surgical techniques, particularly minimally invasive options like ultrasound-guided carpal tunnel release (CTR-US), demonstrate faster recovery and reduced costs compared to traditional methods. Innovative anesthetic techniques, such as WALANT, and emerging treatments like hydrodissection, expand the options for effective symptom management, especially in refractory cases. Research into genetic factors, connective tissue involvement, and systemic influences like diabetes further enhances our understanding of CTS, paving the way for personalized

treatment strategies. A multifaceted approach remains essential to optimize outcomes and address both immediate and long-term patient needs.

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