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CURRENT TREATMENT STRATEGIES FOR CARPAL TUNNEL SYNDROME. A LITERATURE REVIEW

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ABSTRACT

Introduction: Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment, which significantly affects patients' quality of life. Recent reports revealed many new aspects of treatment. It is necessary to continuously improve diagnostic and therapeutic procedures.

Aim: The aim of this article is to review the latest research on CTS. The article briefly describes diagnostic methods, focusing primarily on conservative and surgical treatments used for CTS.

Material and methods: A literature review was conducted using the PubMed and Google Scholar databases. The focus was on studies published between 2016 and 2026.

Results: Objective diagnostic methods, such as electrodiagnostic studies (EDX), combined with clinical evaluation, are essential for selecting the appropriate treatment for CTS. Although previous studies on conservative treatment yielded inconsistent outcomes, its effectiveness has been demonstrated in the early stages of the disease. Surgical treatment proves more effective in more advanced cases. Both open and endoscopic surgical techniques yield comparable long-term results. However, less invasive methods result in less tissue damage and a faster recovery for the patient.

Conclusions: Effective treatment of CTS requires a thorough evaluation of the disease severity during the diagnostic phase. Conservative treatment plays a significant role in the early stages of CTS. However, surgical decompression of the median nerve remains the mainstay of causal treatment. Further standardized studies are needed to determine the best therapeutic strategies.

KEYWORDS

Carpal Tunnel Syndrome, Carpal Tunnel Release, Carpal Tunnel Syndrome Treatment, Open Carpal Tunnel Release, Median Nerve Decompression

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Introduction

Carpal tunnel syndrome (CTS) is considered the most prevalent focal mononeuropathy. It is a neuropathic syndrome caused by compression of the median nerve within the carpal tunnel, beneath the transverse carpal ligament. CTS is a serious health and social problem. Its prevalence ranges from 1% to 3% in the typical population. It leads to a significant reduction in quality of life and hand function, and is also associated with absenteeism from work and economic costs. (Alrayes et al., 2024; Hidayati et al., 2022)

This is a work-related disease that affects both men and women when their occupational tasks are similar. (Cazares-Manríquez et al., 2020) Recurrent exposure to vibrations or forceful angular motions plays a key role in the etiology. (Osiak et al., 2022) In addition, other risk factors include female gender, older age, obesity, pregnancy, chronic diseases, and medications. (Alrayes et al., 2024) Moreover, there has recently been an increased emphasis on the role of habits in the development of CTS, including increased daily dependence on smartphones. (Karaçorlu et al., 2022)

The diagnosis is based mainly on the presence of typical symptoms such as pain, tingling, and nocturnal paresthesia within the median nerve distribution. However, for a more accurate diagnosis and objective assessment, electrophysiological studies (EDX), such as nerve conduction studies (NCS) and electromyography (EMG), are performed. (Osiak et al., 2022) Imaging modalities such as ultrasound and MRI may also be helpful. (Yunoki et al., 2017)

In recent years, the understanding and treatment of CTS have advanced significantly. If symptoms are not severe, non-surgical methods are used, such as immobilizing the wrist joint in a splint or orthosis, local injections, physiotherapy, nerve and tendon mobilization, as well as ultrasound, laser, and shockwave therapies. (Żyluk & Żyluk, 2024) In more advanced cases, surgical treatment is required. Management of CTS traditionally relies on the open release (OCTR) procedure. However, less invasive methods have gained prominence in recent years. The goal is to cause minimal tissue damage and ensure a quick recovery. These techniques include mini-open carpal tunnel release, endoscopic carpal tunnel release (ECTR), and ultrasound-guided carpal tunnel release. (Alrayes et al., 2024; Dilvesi et al., 2026) There is a lot of research on CTS, but its treatment remains a challenge in the medical field. Despite its high prevalence in the general population, care for patients with CTS is not one-size-fits-all and requires a personalized approach. (Joshi et al., 2022) For many years, there has been an ongoing debate about the effectiveness of various treatment methods. Despite numerous evidence of the effectiveness of the proposed therapies, there is still no widely accepted standardization. (Alrayes et al., 2024)

The purpose of this article is to review the latest research on current conservative and surgical treatments for CTS.

Material and Methods:

A comprehensive literature search was performed using the PubMed and Google Scholar databases. The review focuses on the pathophysiology, diagnosis, and treatment methods of CTS. The search covered publications from 2016 to 2026, and was limited to English-language articles. Search terms included combinations of the following keywords: “carpal tunnel syndrome,” “median nerve compression,” “carpal tunnel release,” “diagnosis,” “electrodiagnostic testing,” “conservative treatment,” “corticosteroid injection,” and “surgical release.” Additionally, further relevant studies were identified through a manual review of the reference lists of selected articles. This review utilizes the most recent original articles, review publications and meta-analyses, providing a thorough picture of the current CTS mechanisms, diagnostics, and interventions.

Pathophysiology, signs and risk factors

The carpal tunnel is an osteofibrous channel that connects the inside part of the palm and forearm. It is formed by the bones of the wrist and the intercarpal ligaments situated on the lateral, medial, and dorsal sides. The carpal tunnel contains the median nerve, the nine tendons of the extrinsic flexors of the thumb and fingers. It also includes connective tissue. (Hidayati et al., 2022; Z. M. Li & Jordan, 2022)

The exact pathophysiology of CTS has not been identified. It can be simplified as compression of the median nerve in the carpal tunnel. It is suggested that this condition may be caused by a combination of several mechanisms, including increased interstitial pressure within the carpal tunnel and synovial tissue hypertrophy resulting from prolonged wrist movements, wrist injuries, or other causes of joint inflammation. Consequently, this leads to compression and damage to the median nerve. (Joshi et al., 2022; Malakootian et al., 2022) Repetitive wrist movements can cause significant fluctuations of the pressures in the carpal tunnel. (Osiak et al., 2022) This leads to localized ischemia and, as a result, demyelination of both small and large fibers of the median nerve. In addition, swelling of the nerve tissue develops and fibrosis occurs, which is associated with chronic inflammation that increases pressure within the carpal tunnel. (Rotaru-Zavaleanu et al., 2024) Ultimately, this leads to a slow nerve conduction and increased latency. (Osiak et al., 2022)

Various predisposing factors for the development of CTS have been identified. It is more commonly reported in women, and its prevalence increases with age. Occupational risk factors have also been determined, such as exposure to vibrations, repetitive flexion and extension of the wrist, and gripping with excessive force. (Osiak et al., 2022)

Medical risk factors for CTS can also be identified and are divided into four categories. These include neuropathic factors, intrinsic factors, and extrinsic factors that alter the contour of the tunnel or increase the volume within the tunnel on either side of the nerve. Neuropathic factors include alcoholism, diabetes, toxins, or vitamin deficiencies. Intrinsic factors cause an increase in the volume within the tunnel and are caused by tumors or result from injuries to the radius. Extrinsic factors that alter the fluid equilibrium within the body contribute to an increase in volume within the tunnel. These include obesity, kidney failure, hypothyroidism, menopause, and congestive heart failure. (Cazares-Manríquez et al., 2020; Genova et al., 2020)

Interestingly, CTS can also occur during pregnancy, which may be due to fluid retention and hormonal changes. (Joshi et al., 2022) In the etiology of CTS, a genetic predisposition has also been suggested, linked to mechanisms involving the synthesis and breakdown of collagen compounds, as well as certain proteins that protect against oxidative stress. However, further research is needed to understand the exact mechanisms. (Malakootian et al., 2022; Zyluk, 2020)

Symptoms reported by patients include tingling, numbness, and an aching or burning pain in the hand, wrist, or forearm, which worsen at night. Weakness, fluctuations in the temperature, and stiffness are also common. These symptoms mainly affect the thumb, the second and third fingers, and the radial half of the fourth finger. The pain may also radiate up the arm toward the shoulder. Sometimes the so-called “flick sign” occurs, which involves the relief of pain when the hand is flicked. In addition, as the disease progresses, extensive axonal damage leads to muscle weakness and eventually muscle atrophy, which is particularly noticeable in the thenar eminence. As a result, motor tasks are impaired, the ability to perform precise hand movements is limited, and problems with holding objects or making a fist become apparent. (Hidayati et al., 2022; Rotaru-Zavaleanu et al., 2024)

There are three stages of CTS, depending on the symptoms. The first stage involves sleep disturbances due to tingling and numbness in the hand, without noticeable swelling. In the second stage, patients experience symptoms during the day. They also have difficulty holding objects. In the third stage, atrophy of the thenar eminence muscles is present, and sensory disturbances sometimes occur. (Yunoki et al., 2017)

Diagnosis

The diagnosis of CTS is based on clinical evaluation, symptoms, and diagnostic tests. Specific diagnostic guidelines show differences depending on the region and the availability of tests and specialized medical services. (Rotaru-Zavaleanu et al., 2024; Shapiro & Kamal, 2024)

The clinical evaluation includes a thorough medical history to assess and characterize the symptoms, as well as a physical examination. Many physical examination techniques have been described. One of these maneuvers is the Phalen test. It involves flexing the wrists to 90 degrees by bringing the dorsal surfaces of the hands together for 60 seconds. The test is positive when typical symptoms of CTS occur. (Dabbagh et al., 2023; Dilvesi et al., 2026; Joshi et al., 2022; Zhang et al., 2020)

Another sign assessed during a physical examination is Tinel sign. This test involves gently tapping the area of the carpal tunnel and is positive if paresthesia occurs along the course of the median nerve. (Zhang et al., 2020)

Another common test is the Durkan test. It involves applying moderate pressure with both thumbs to the transverse carpal ligament for 15–30 seconds, while the patient's forearm is in a supine position. The test is positive if paresthesia occurs. (Dabbagh et al., 2023; Zhang et al., 2020)

The diagnosis also involves diagnostic tests such as EDX, including NCS and EMG. NCS measures latency and amplitude by comparing them between the median nerve in the carpal tunnel and other nerves. In the case of CTS, there is impaired conduction of the median nerve. An EMG, on the other hand, involves inserting thin, needle-like electrodes into the muscles to record their electrical activity. This test evaluates pathological changes in the muscles innervated by the median nerve, in this case the abductor pollicis brevis muscle. (Dong et al., 2026; Rosario & Jesus, 2023) CTS can be classified into four groups based on electrophysiological findings: CTS without median neuropathy at the wrist, mild, moderate, and severe. (Sonoo et al., 2018)

Imaging examinations, particularly ultrasound, can also be helpful in diagnosis. Ultrasound reveals the morphology and increased cross-sectional area in the median nerve. It also helps to exclude compression of the median nerve by ganglia, tumors, or tenosynovitis. The advantages of this method include its low cost, non-invasive nature, and easily availability. (Hidayati et al., 2022; Yoshii et al., 2020) Another useful test is MRI, which helps to assess the soft tissues of the carpal tunnel. It also allows for the evaluation of rare causes of CTS, such as hemangioma, ganglion or bone deformity, which may alter surgical intervention. (Yunoki et al., 2017) Another use of MRI is the assessment of the severity of CTS, as described by Ng et al. (2020). They used an MRI image of the median nerve analyzing the circumferential surface area, relative median nerve signal intensity, flattening ratio, retinacular bowing. (Ng et al., 2020)

Other useful tools used in the diagnosis and evaluation of CTS are diagnostic questionnaires that assess symptoms. One of these is the CTS-6, which is used to rate the severity of the main symptoms and consists of six items. Another questionnaire is the BCTQ, which assesses symptoms and disability and consists of 11 items. (Schulze et al., 2021; Shapiro & Kamal, 2024)

When diagnosing CTS, it is important to consider other conditions that present with similar symptoms. The differential diagnosis must include conditions such as: carpometacarpal arthritis of the thumb, cervical radiculopathy (especially C6–C7), de Quervain's tendinopathy, Raynaud's syndrome, pronator syndrome (compression of the median nerve at the elbow), and peripheral neuropathy associated with a history of diabetes. It is necessary to pay attention to characteristic symptoms. In the case of cervical radiculopathy, there is neck pain and a lack of sensation only in the thumb and index finger. De Quervain's tendinopathy manifests as pain and tenderness in the distal radial styloid area. Additionally, in Finkelstein's test, tenderness and typically pain are present on the radial side of the wrist when the thumb is flexed toward the palm and the wrist is ulnar deviated. Pronator syndrome is characterized by forearm pain, lack of sensation on top of the thenar eminence, and weakness when flexing the thumb and extending the wrist. In turn, symptoms of thumb carpometacarpal joint arthritis include soreness during thumb movement, findings on radiographic studies, and a positive result of grind test. Laboratory tests for comorbidities such as diabetes or hypothyroidism should also be considered if there are other symptoms suggesting disease. (Genova et al., 2020; Hidayati et al., 2022)

There are many methods to help diagnose carpal tunnel syndrome, and the final diagnosis is based on the patient's medical history, a physical examination, and additional tests. (Hidayati et al., 2022)

Non-operative methods of treatment

Treatment for CTS may involve various methods. Surgical methods are most commonly used, but other non-surgical methods are also considered effective, such as immobilization of the wrist joint in a splint or orthosis and local injections. In recent years, conservative approaches have also emerged, such as nerve and tendon mobilization as well as ultrasound, laser and shockwave therapies. (Wielemborek et al., 2022; Żyluk & Żyluk, 2024) Conservative treatment is considered in the early stages CTS, when symptoms are not severe and in cases where the condition is temporary, such as during pregnancy. (Osiak et al., 2022)

When diagnosing CTS, it is important to properly educate the patient and help them develop healthy habits. To reduce median nerve stress it is recommended to use ergonomic work tools and limit excessive wrist movements. (Hidayati et al., 2022)

One of the most common conservative treatment methods is wrist immobilization. It involves wearing a wrist splint, usually at night. This helps maintain a neutral wrist position, reducing pressure on the median

nerve and preventing excessive wrist flexion. However, it is important to educate the patient on the proper use of the splint and ensure that it fits correctly. (Đilvesi et al., 2026; Wielemborek et al., 2022) The potential benefits of immobilization are not entirely convincing and the results of previous research are inconsistent. A meta-analysis by Karjalainen et al. found a possible improvement in CTS symptoms following the use of splints. However, the authors emphasized the need for further research. (Karjalainen et al., 2023) Some studies also suggest potential long-term benefits, but it is unclear whether the splint should be worn only at night or all the time. However, this method is safe and simple, so it is recommended for patients who wish to avoid surgery. (Karjalainen et al., 2023; Lusa et al., 2024)

Another common treatment for CTS is injection therapy. Various types of injections are used, including those containing corticosteroids, platelet-rich plasma, hyaluronic acid, and an irritant-usually dextrose. (Yang et al., 2024)

Corticosteroid injections are commonly used. They are injected into the carpal tunnel under ultrasound guidance or using anatomical landmarks. The local effects of the steroids include reducing inflammation and oedema. (Osiak et al., 2022; Roh et al., 2019) This procedure is usually performed on an outpatient basis under local anesthesia and takes a few minutes. (Đilvesi et al., 2026) These injections are effective in providing short-term relief of symptoms in the early stages of CTS and carry a low risk of side effects. In their study, Ashworth et al. conducted a Cochrane database systematic review of studies examining the efficacy of corticosteroid injections in the treatment of CTS. They included 14 trials with 994 participants and the final conclusion was that this treatment is effective for mild and moderate CTS. Additionally, a low risk of adverse effects was observed, along with a reduction in the need for surgical intervention within 12 months. (Ashworth et al., 2023) In another study, Kaile et al. presented the results of a study that assessed the risks associated with corticosteroid injections in CTS. After 6 weeks, side effects were observed in 33% of patients, with the most common (13%) being short-term local pain that resolved after 3 weeks. However, out of 9515 injections, 4 serious complications were reported. (Kaile & Bland, 2018)

Injections of platelet-rich plasma, which contains high concentrations of platelets and growth factors, are also used. They promote tissue regeneration and help control inflammation, which may reduce symptoms. (Wielemborek et al., 2022; Yang et al., 2024) A 2022 meta-analysis included eight randomized controlled studies involving 220 patients who received platelet-rich plasma injections. Some of the studies suggest that this treatment is effective in alleviating CTS symptoms. However, further research is needed to standardize this therapy and assess its side effects. (Jiang et al., 2022; Wu et al., 2017)

Another treatment option involves local injections of an irritant (usually a dextrose solution). The exact mechanism is not fully understood, but some studies suggest that this therapy is effective in relieving CTS symptoms. However, further research is needed to assess its long-term effectiveness and potential side effects. (Lin et al., 2020)

In addition, it has been suggested that local injections of hyaluronic acid may be effective in alleviating the symptoms of CTS. However, further studies are needed to evaluate the effectiveness of this procedure. (Yang et al., 2024)

Other, less common forms of non-surgical treatment include low-level laser therapy. The mechanism of action remains unclear, but it is suggested that it may increase myelin production, have an anti-inflammatory effect, or selectively inhibit nociceptive activation of peripheral nerves. (Wielemborek et al., 2022) The results of studies on this therapeutic method remain inconclusive. In a meta-analysis of placebo-controlled studies (2016), Li et al. demonstrated a short-term beneficial effect of laser therapy in the treatment of CTS. However, the results were inconsistent, and further research is needed to more accurately determine the role of laser therapy in the treatment of CTS. (Z. J. Li et al., 2016)

Another treatment method under consideration is ultrasound therapy. This treatment has the potential to reduce inflammation, promote tissue healing, and stimulate nerve regeneration. However, there has been a lack of recent research in this area. Page et al. (2013) presented the results of a Cochrane review of studies on the treatment of CTS with ultrasound therapy. They concluded that there is only low-quality evidence suggesting that ultrasound therapy may be more effective than placebo in terms of short- or long-term improvement of symptoms in CTS patients. (Page et al., 2013)

Extracorporeal shock wave therapy (ESWT) is a relatively new and little-known treatment for CTS. The mechanism of action is unknown, but it is believed that this method has anti-inflammatory effects and promotes nerve regeneration. The results of studies on the efficacy of ESWT in CTS are inconsistent and limited in number. (Żyluk & Żyluk, 2024) Xu et al. presented the results of a randomized study comparing the effects of ESWT and steroid injections on the relief of CTS symptoms. The authors conclude that ESWT is an effective,

non-invasive, short-term treatment for mild to moderate CTS and provides more effective recovery than local steroid injections. However, further studies of ESWT are needed to verify the clinical effects of this therapy. (Xu et al., 2020) In turn, Kim et al. presented the results of a meta-analysis of randomized controlled trials examining the effects of ESWT on CTS. The authors identified 6 studies meeting the analysis criteria, involving a total of 261 patients. They demonstrated that ESWT alleviates CTS symptoms. However, they found no difference in efficacy between ESWT and local corticosteroid injections. (Kim et al., 2019)

Another method is mobilization, which combines various techniques, including nerve gliding and nerve stretching. The goal is to facilitate the gliding of tendons and nerves within the carpal tunnel, thereby maximizing the excursion of nerves and tendons and improving axonal transport and nerve conduction. However, due to the limited number of studies and the lack of standardized techniques, it is currently not possible to definitively determine the effectiveness of this therapy. (Żyluk & Żyluk, 2024) Some studies have reported improvements and symptom relief in CTS. However, the evidence supporting the benefits of all interventions involving exercise and mobilization has been highlighted as limited and of low quality. Further research is needed to more accurately determine the role of mobilization in the treatment of CTS. (Bittencourt et al., 2024; Page et al., 2012)

Surgical intervention

Surgery is recommended for severe cases of CTS and when symptoms persist. The goal is to decrease the pressure or decompress the tension from the median nerve. However, it is important to identify any primary cause of CTS and treat them first. Eligibility for surgery is not straightforward and is based on various classification systems for the severity of CTS, as well as an analysis of symptoms and the results of additional tests. (Alrayes et al., 2024) Surgical methods are widely used and are considered effective. A meta-analysis published in 2018, which compared the effectiveness of surgical and conservative treatment, found that surgical treatment was more effective in improving symptoms and neurophysiological parameters at six months. However, the need for further research into how both methods work and for a comparison of their long-term effectiveness was emphasized. (Klokkari & Mamais, 2018)

There are currently several surgical treatment methods. The procedures include traditional OCTR, a modified version known as mini-open carpal tunnel release, ECTR, and ultrasound-guided carpal tunnel release. (Alrayes et al., 2024; Dilvesi et al., 2026)

OCTR is a traditional surgical treatment for CTS. This involves making an incision in the palm of the hand, usually 4–5 centimeters long, allowing direct access to the transverse carpal ligament. The ligament is then divided, which reduces pressure on the underlying median nerve. This technique also allows for easier assessment of the surgical site and identification of factors that should also be taken into account during the procedure. (Dilvesi et al., 2026; Osiak et al., 2022) OCTR offers direct visual guidance, a lower risk of temporary nerve damage, and lower costs. (Rajapandian et al., 2024) At the same time, a drawback of this method is that the larger incision results in a scar, which may affect the appearance of the hand. In addition, a common complication is pillar pain, which is more prevalent with this surgical method. Patients describe it as diffuse pain and tenderness in the thenar and hypothenar area. (Hidayati et al., 2022; Mujadzic et al., 2021)

A modification of the open method is the mini-open carpal tunnel release. It involves making a smaller incision, typically 1.5–2 centimeters long, while ensuring direct visualization and the ability to cut the transverse carpal ligament. (Dilvesi et al., 2026) This technique results in reduced damage of soft tissues while preserving adjacent structures attributed. (Schwarz et al., 2022) This may potentially lead to a faster recovery and reduced postoperative pain. In addition, this method is associated with a shorter surgery time. (Dilvesi et al., 2026) Previous studies have confirmed the effectiveness of this technique in both the short and long term. (Schwarz et al., 2022; van den Broeke et al., 2019)

Another alternative to the open method is ECTR. This technique involves inserting an endoscope and specialized cutting tool through small incisions, allowing the carpal tunnel to be visualized on a video monitor. There are several variations of this method, such as the single-portal and two-portal methods, which differ in the number of incisions made. (Dilvesi et al., 2026) The advantages of this method, since it avoids a large incision, include a quicker recovery and minimal scar formation. However, limited space and indirect viewing can increase the risk of accidentally injuring a nerve or tendon. (Woo et al., 2026)

Another, less common method is ultrasound-guided percutaneous carpal tunnel release. This technique allows for the visualization and monitoring of neurovascular structures and the instruments during the procedure. In addition, this method involves a small incision and faster wound healing. (Lam et al., 2023) Previous studies

have demonstrated the effectiveness of this method in alleviating CTS symptoms. However, further research is needed to establish its therapeutic efficacy. (Aguila et al., 2023; Lam et al., 2023; Woo et al., 2026)

Several surgical methods and their variations are available for the treatment of CTS, but ECTR and OCTR are commonly used. Many previous studies have examined the effectiveness of these techniques in treating CTS. A systematic review conducted in 2024 compared these two methods and found that the outcomes and complications were comparable. They are equally effective in relieving symptoms and improving patient functionality. ECTR is associated with less scar-related complications and a faster recovery, but carries a higher risk of transient nerve injuries. In contrast, OCTR demonstrates a lower satisfaction rate and is associated with a higher incidence of scar-related complications, but carries a lower risk of transient nerve injuries. The choice of method should take into consideration both the patient's preferences and the surgeon's experience. (Rajapandian et al., 2024)

In a study conducted by Hu et al., conventional open surgery was compared with mini-open incision. It has been shown that both methods achieve the same nerve decompression effect, although the mini-open carpal tunnel release is associated with a shorter operation time and a sooner recovery. In addition, this method is characterized by mild postoperative pain and a good scar appearance. (Hu et al., 2022)

Surgical release of the carpal tunnel is relatively safe and effective, but like any procedure, it carries some risks. One of the common complications following carpal tunnel release surgery is pillar pain. Its etiology is unclear, but it is suspected that small nerve branches of palmar cutaneous branches of median nerve are damaged and that the nerves become entrapped in scar tissue at the incision site. (Mujadzic et al., 2021) Other factors to consider include periostitis of the hamate and scaphoid tubercles, widening of the carpal arch, and intrinsic muscle pain from tension in the released transverse carpal ligament (TCL). (Woo et al., 2026) This pain results in a delayed return to health and work and should be treated effectively. Various strategies are used in treatment, such as limiting hand use, splinting, symptomatic superficial heat and cold therapy, massage, or extracorporeal shock wave therapy. (Turgut et al., 2021; Woo et al., 2026) Other common surgical complications include postoperative wound infection, hematoma formation, or, less commonly, injury to the median nerve or its branches. (Dilvesi et al., 2026)

Persistent CTS refers to the continuing presence of symptoms that do not resolve after surgery. It may result from irreversible nerve damage, incomplete release, or concomitant proximal neural compression. Another condition is recurrent CTS, which is the reappearance of symptoms at least 6 months after surgery. It may result from excessive scarring and perineural adhesion, or, less commonly, from an infection or hematoma. (Jones et al., 2024; Woo et al., 2026)

The cause of the adverse effects remains unclear, but one theory is that biomechanical changes occur as a result of the disruption of the flexor retinaculum. (Alrayes et al., 2024) A meta-analysis by Lai et al. (2019) compared carpal tunnel release with and without flexor retinaculum reconstruction. An improvement in long-term functional status was observed following surgical release with reconstruction. However, no advantages of this method were observed in terms of grip strength, symptom severity, or safety compared to the method of individual release of the carpal tunnel. (Lai et al., 2019)

Discussion

This literature review outlines the challenges in the diagnosis and treatment options for CTS based on the current state of knowledge. There is a noticeable shift toward modern diagnostic and therapeutic techniques. The focus is on personalized treatment and minimizing the invasiveness of procedures. (Dilvesi et al., 2026)

Effective treatment relies on a thorough understanding of the pathophysiology and etiology of CTS. Although the exact mechanism is not fully understood, the key factor is increased pressure within the carpal tunnel, leading to compression of the median nerve. (Joshi et al., 2022) This understanding highlights the role of certain risk factors. Particularly, the importance of occupational factors such as exposure to vibrations, repetitive wrist flexion and extension, and forceful gripping has been confirmed. (Osiak et al., 2022) Previous studies have also highlighted the role of medical factors such as obesity and hormonal disorders. (Genova et al., 2020) The mechanisms involved in the genetic predisposition to CTS have also been described. However, further research is needed to fully clarify these pathways. (Zyluk, 2020) The multifactorial etiology necessitates a multifaceted diagnostic approach, which often complicates the treatment process.

The literature highlights that effective management requires a thorough patient history, physical examination, EDX studies if necessary, and personalized treatment. Provocative maneuvers remain crucial in the clinical evaluation. A 2022 meta-analysis of 37 observational studies evaluating the diagnostic value of

various provocation confirmed their good accuracy in screening for CTS. (De Arenas-Arroyo et al., 2022) EDX remains the classic diagnostic modality, and its efficacy in CTS evaluation is well established. However, researchers emphasize that awareness of potential technical and physiological pitfalls in the test that could lead to a misdiagnosis. (Alanazy, 2017) Other methods, such as ultrasound and MRI, are also gaining prominence. To date, research shows that ultrasound, NCS, and EMG effectively diagnose CTS with good sensitivity. (Pimentel et al., 2018; Zaki et al., 2022) However, further studies are needed to determine the clinical value of these imaging modalities.

One of the key issues in the literature remains the choice between conservative and surgical treatment for CTS. For patients with mild to moderate CTS, non-surgical methods are recommended. (Osiak et al., 2022) Traditional methods include wrist immobilization and local corticosteroid injections. The variable outcomes reported by many authors (Ashworth et al., 2023; Kaile & Bland, 2018; Karjalainen et al., 2023; Lusa et al., 2024) suggest that this treatment yields satisfactory results primarily in patients with a mild form of the syndrome. This raises the question of whether it is appropriate to prolong conservative therapy at the expense of delaying surgery.

In the reviewed literature, it is worth noting the new methods of conservative treatment. Some studies have demonstrated the effectiveness of methods such as platelet-rich plasma injections (Jiang et al., 2022), irritant (dextrose) injections (Lin et al., 2020), laser therapy (Z. J. Li et al., 2016), ultrasound therapy (Page et al., 2013), ESWT (Xu et al., 2020), and neural mobilization. (Page et al., 2012) However, such studies are few and far between, and despite reports of the beneficial effects of these methods in alleviating CTS symptoms, there is a need for larger randomized trials with long-term follow-up to more accurately determine their role in the treatment of the condition.

In severe cases of CTS and when symptoms persist, surgical treatment becomes necessary. In the reviewed medical literature, a comparison of the classic OCTR method with less invasive techniques, primarily ECTR, appears to be key. A 2024 systematic review indicates comparable outcomes and complications between ECTR and OCTR. The authors outline the advantages and disadvantages of each method, emphasizing that the final choice should take into account various factors, including availability, patient preference, and the surgeon's experience. (Rajapandian et al., 2024)

In recent years, less invasive methods have gained prominence. Studies have described the benefits of minimally invasive carpal tunnel release techniques, which include a shorter recovery time, less scarring, and a lower risk of iatrogenic injury. Furthermore, the effectiveness of these methods has been confirmed in both the short and long term. (Bassil et al., 2024; Schwarz et al., 2022; van den Broeke et al., 2019)

Although a review of the available literature demonstrates the effectiveness of the proposed treatments for CTS, it also reveals that the therapeutic process requires a flexible approach and precise diagnosis. Furthermore, there is insufficient evidence to indicate that any one technique is superior to the others, making it currently impossible to establish a uniform standard of care.

Conclusions

CTS is one of the most common and well-understood compressive neuropathies. It results from compression of the median nerve at the level of the carpal tunnel. However, the exact pathophysiology has not been determined. In recent years, new findings have emerged regarding the epidemiology, diagnosis, and potential treatment options. Various risk factors for the development of CTS have been identified to date, including environmental and medical factors. However, occupational risk factors such as exposure to vibrations or repetitive flexion and extension of the wrist are highlighted. The multifactorial etiology of CTS requires an interdisciplinary approach to patient care.

Optimal treatment of CTS requires correlating clinical symptoms with EDX findings. The specific guidelines are not consistent and show differences depending on the region. Among the complementary diagnostic methods described is the use of imaging tests such as ultrasound and MRI. However, these are not routinely used, and their clinical utility and feasibility require further study.

In recent years, the treatment of CTS has advanced significantly, and there are now many treatment options available. Management should be personalized, taking into consideration the severity of each case. Conservative methods such as immobilization of the wrist joint in a splint or orthosis, local corticosteroid injections, and physiotherapy, provide significant benefits in the early and mild stages of the disease. Recently, other less common non-surgical techniques have also emerged, such as ultrasound, laser, and shockwave therapies, nerve and tendon mobilization, and injections of platelet-rich plasma, irritants, and hyaluronic acid.

Previous studies on the effectiveness of these methods in alleviating CTS symptoms have yielded inconsistent results. Further research is needed to assess the validity of using these procedures to treat CTS.

In more advanced cases of CTS, surgical treatment is required. It is widely used and considered effective. The traditional method is OCTR, but less invasive methods have been gaining prominence in recent years. The following procedures can be distinguished: mini-open carpal tunnel release, ECTR, and ultrasound-guided carpal tunnel release. These techniques are characterized by less tissue damage and a quick recovery. However, further research is needed to demonstrate their therapeutic efficacy.

Despite the availability of many therapeutic methods and numerous evidence of their effectiveness, there is still a lack of universally accepted standardization. Long-term studies comparing surgical and nonsurgical treatment methods are needed to evaluate the effectiveness of each of these approaches. This will help improve the clinical decision-making process.

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