

Carpal Tunnel Syndrome Surgery: What You Should Know

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Summary: Carpal tunnel release (CTR) surgery continues to evolve. Carpal tunnel syndrome remains a primarily clinical diagnosis, although ultrasound has supplemented electrodiagnostic testing as a confirmatory tool. Magnetic resonance imaging of the carpal tunnel has also showed some promise as an alternative method for the examination of the median nerve. Open CTR surgery remains the traditional, and most popular, method of CTR. Wide-Awake, with Local Anesthesia only, and No Tourniquet CTR has emerged as a means to decrease cost and improve pain control and convenience for patients. Endoscopic CTR is increasing in popularity due to its more rapid recovery. The safety profile of endoscopic CTR has improved, and recent studies show similar rates of major complications between open and endoscopic techniques. Nonsurgeon operated ultrasound-guided techniques for release of the transverse carpal ligament have emerged. While promising in early studies, the current evidence in their favor is limited in terms of patient numbers and direct comparison with other techniques. The outcomes of CTR continue to be excellent. Recent research has demonstrated that nerve conduction continues to recover postoperatively over a longer period of time than previously believed. Patient psychological factors play a significant role in outcomes after surgery but do not appear to limit the improvement provided by intervention. (*Plast Reconstr Surg Glob Open* 2020;8:e2692; doi: [10.1097/GOX.0000000000002692](https://doi.org/10.1097/GOX.0000000000002692); Published online 19 March 2020.)

Carpal tunnel syndrome is the most common compressive neuropathy of the upper extremity, affecting an estimated 3.1% of the population aged 18–64 each year.¹ Over 400,000 carpal tunnel releases (CTRs) are performed each year—representing approximately 0.1% of the US population annually—with direct costs of greater than 2 billion dollars per year.^{2,3} Risk factors for carpal tunnel syndrome requiring surgery include increasing age and body mass index (odds ratio [OR] = 1.04/year for both) and female sex (OR = 2.26 versus males).⁴

Surgical release of the carpal tunnel was first described by Galloway in 1924 (cited by Amadio)⁵ and later popularized by Phalen.⁶ Over time it has evolved to become the most common and among the safest hand surgeries. A 2015 meta-analysis found complication rates of only 3.2% for endoscopic CTR and 2.6% for open CTR.⁷ Despite the high degree of efficacy and safety already demonstrated

in current CTR techniques, new technologies and data continue to change practice. These advances include new diagnostic techniques, new less-invasive surgical techniques, and new studies of outcome and complications.

DIAGNOSIS OF CARPAL TUNNEL SYNDROME

Traditionally, the diagnosis of carpal tunnel syndrome (CTS) has been a clinical one. However, electrodiagnostic studies (EDX) have become common place in the diagnosis of CTS as they can provide objective parameters that can better aide in prognostication, as well as evaluate other possible causes of nerve dysfunction. EDX is inclusive of the duo of tests most commonly performed by electromyographers consisting of a nerve conduction study and electromyogram. Multiple studies comparing clinical impression or validated scoring systems with EDX have demonstrated that EDX adds minimal to no sensitivity or specificity to the diagnosis.^{8–11} In a seminal 2008 study, Graham⁸ demonstrated that routine use of EDX provided only a 2%–6% increase in the probability of CTS versus from the use of a clinical checklist alone. Further research has demonstrated a false-positive rate of 16% in a general population of Japanese and American workers.¹² Nonetheless, a 2016 study of 62,894 American patients

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found that 58% had a preoperative EDX performed before CTR surgery.¹³

In response to this mounting body of evidence, the American Academy of Orthopaedic Surgeons (AAOS) changed its Clinical Practice Guidelines (CPG) in 2016. The AAOS now states that “moderate evidence supports that...electrodiagnostic studies could be used to aid the diagnosis” of CTS¹⁴ in its 2016 CPG.

Ultrasound (US) has emerged as an alternative to EDX. A 2011 meta-analysis with a total sample size of 3,131 wrists calculated a sensitivity and specificity of 77.3% and 92.8%, respectively, versus clinical findings.¹⁵ Reliability improved with user experience.¹⁶

Cross-sectional area (CSA) of the median nerve is a highly reproducible US parameter indicative of CTS. A 2018 study found that CSA provides sensitivity and specificity of 75% and 87.5% respectively in diagnosing CTS¹⁸ (Fig. 1). The CSA of the median nerve correlates moderately with EDX findings.¹⁸ Short periods of training can result in acceptable levels of accuracy in imaging the carpal tunnel, even in novice US operators.^{19,20} Despite these promising studies, however, there remained some question as to the optimal CSA cutoff for CTS diagnosis, as well as the optimal site for measurement. As a result, the 2016 AAOS CPG for CTS

states: “limited evidence supports not routinely using US for the diagnosis of carpal tunnel syndrome.”¹⁴

Magnetic resonance imaging (MRI) is a diagnostic alternative to EDX for CTS. A 2002 study using nerve conduction studies (NCS) and a hand pain diagram as a gold standard demonstrated that MRI of the carpal tunnel has up to a 96% sensitivity to detect CTS, but only 33% specificity.²¹ A 2019 study directly comparing US and MRI in healthy volunteers and patients with a known diagnosis of CTS found that CSA of the median nerve is both sensitive and specific, with receiver operator curve area of 0.874–0.997 (statistically indistinguishable from US-measured CSA).²² The 2016 AAOS CPG on CTS states that “moderate evidence supports not routinely using MRI for the diagnosis of carpal tunnel syndrome.”¹⁴

There remains no perfect modality for the diagnosis of CTS. All modalities including clinical examination, questionnaire-based tests, EDX, US, and MRI have potential value in the diagnosis of CTS.

Clinical impression has been augmented with the use of diagnostic scoring systems for CTS. The CTS-6 diagnostic tool has been compared with NCS and US and demonstrated 95% sensitivity and 91% specificity for diagnosis of CTS.²³ Likewise, specific examination maneuvers have well-defined sensitivities—89% for Durkan’s test, and

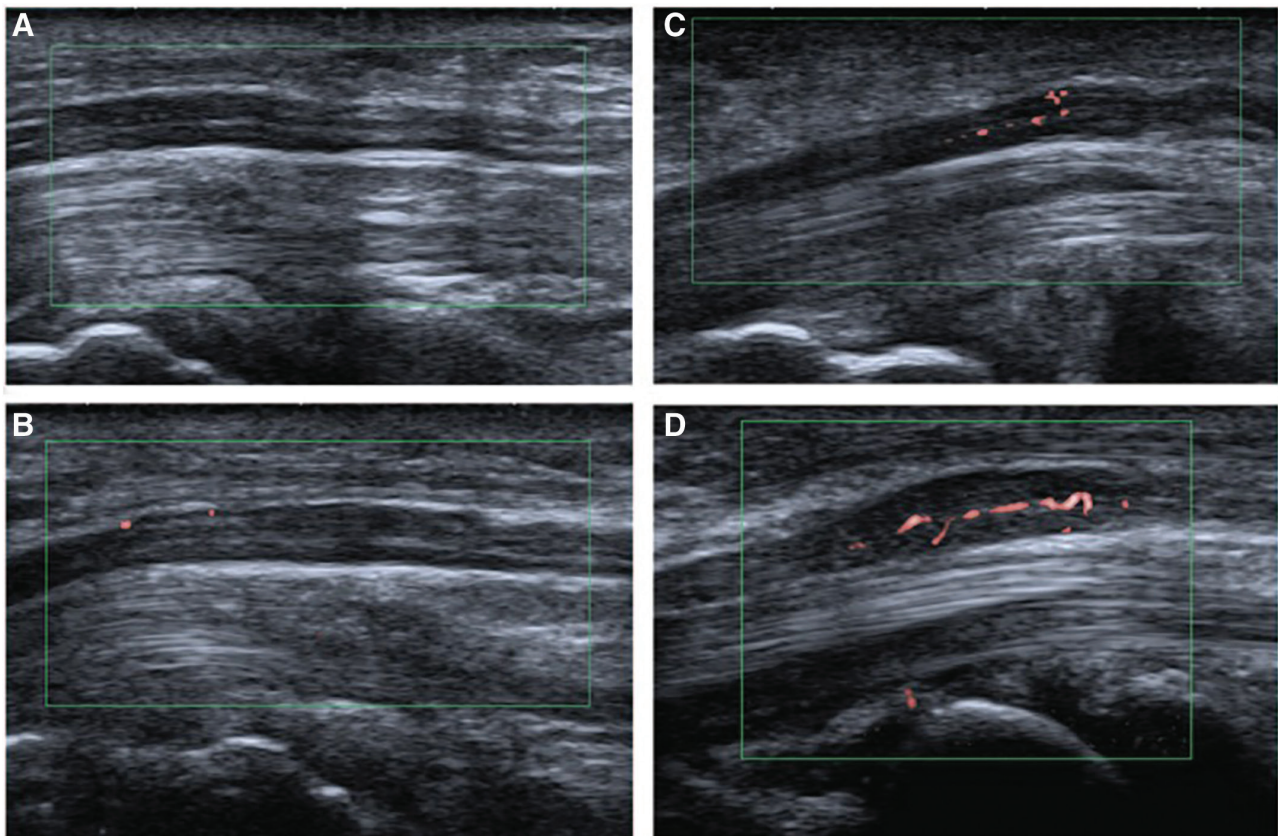


Fig. 1. Other studies have also demonstrated improved diagnostic accuracy of US when nerve hypervascularity⁷⁸ or morphology⁷⁹ is factored into consideration. This image demonstrates different levels of vascularity as detected in the median nerve by color Doppler US, from grade 0 (A, no flow) to grade 3 (D, best flow). Adapted with permission from Med (United States). 2017;96;e6862 © 2013 Chen et al.⁷⁰

83% for Semmes-Weinstein monofilament testing after Phalen's maneuver.²⁴ These diagnostic scoring systems have the advantage of minimal additional cost, when compared with EDX, MRI, or US.

In certain situations, one diagnostic technique may have clear advantages over the alternatives. In diabetic patients, or those with amyloid or postchemotherapy neuropathy, for example, polyneuropathy can mimic the symptoms of CTS. In other patients, cervical radiculopathy can mimic CTS. EDX can distinguish between mono- and poly-neuropathy^{25,26} and radiculopathy in these patients. In patients with amyloid deposition syndromes, like those on hemodialysis, imaging modalities like MRI and US can demonstrate increased CSA²⁷ or altered mechanical properties²⁸ of the median nerve.

Nonoperative Management of CTS

Nonoperative management remains the first-line treatment for CTS. The 2016 AAOS CPGs state that “strong evidence supports that the use of immobilization should improve patient-reported outcomes.”¹⁴ Likewise, corticosteroid injection is recommended as a nonoperative means of treating CTS. A 2019 study found that nerve conduction studies performed 3 months after corticosteroid injection show improvement in conduction velocity, motor latency, and sensory latency following injection with methylprednisolone.²⁹ Direct head-to-head comparison of splinting versus steroid injection was performed in the INSTINCTS trial, an open-label trial of 234 patients. This trial demonstrated a statistically significant increased improvement in outcomes in the corticosteroid group, as measured by the Boston Carpal Tunnel Questionnaire (BCTQ) at 6 weeks in the injection group than the splinting group.³⁰

OPEN CTR

Open CTR surgeries continue to be routinely performed and include extensile, standard, and mini-open techniques. A 2015 meta-analysis found a 1.1% reoperation rate and a 1.0% major complication rate for open CTR.³¹ Because >50% of patients presenting with CTS present with bilateral disease, there has been research into the risks and benefits of simultaneous bilateral open CTR. A 2014 prospective cohort study found no difference between bilateral and unilateral CTR groups in terms of ability to perform self-care postoperatively and only demonstrated increased difficulty opening jars, cooking, and conducting household chores in the bilateral group on postoperative days 1 and 2.³² Performing bilateral CTR has been demonstrated to have lower total costs than staged release.³³

A study on the outcomes of CTR in end-stage median nerve dysfunction demonstrated that patients with unrecordable sensory and motor nerve potentials nonetheless demonstrated excellent outcomes following CTR, with average BCTQ symptom scores of 1.4 after 5–9 years.³⁴ A study of patients with diabetes evaluated EDX studies in patients with and without diabetes at 1 and 5 years after CTR and found that nerve conduction velocity continues

to improve from years 1–5 after release.³⁵ This is consistent with prior research demonstrating complete resolution of numbness at 9 years after surgery in 94% of patients with severe CTS³⁶ and indicates that CTR may result in nerve function improvements beyond the traditionally stated 1- to 2-year time frame after surgery.

Recent research has emphasized the effect on patient characteristics and experience on postoperative outcomes. A study of 1,607 patients demonstrated that a more positive patient experience (including communication, information provided, facilities, etc.) was correlated with improved BCTQ scores after surgery.³⁷ Another study, of 809 patients, found a correlation between poor 12-item short form health survey mental health scores and worsened postoperative quick disabilities of the arm, shoulder, and hand (QuickDASH) scores and satisfaction (although total satisfaction remained high).³⁸ A similarly focused study identified patients with depression before and after CTR and found higher BCTQ scores in depressed patients both before and after surgery, but that both depressive symptoms and carpal tunnel symptoms are improved after CTR in these patients.³⁹ New research has also reinforced preexisting data that CTR significantly improves sleep quality, generally within 24 hours of surgery.⁴⁰

In summary, despite copious evidence that CTS symptom severity correlates with depression, catastrophization, and other patient psychological factors, CTR has nonetheless been demonstrated to be effective in this group of patients.

WIDE-AWAKE, WITH LOCAL ANESTHESIA ONLY, AND NO TOURNIQUET ECONOMICS AND SAFETY WITH CTR SURGERY

More recently, significant research is being put forward examining hand surgeries performed Wide-Awake, with Local Anesthesia only, and No Tourniquet (WALANT), including for CTR surgeries. When compared with sedation, the WALANT technique has been demonstrated to be significantly less expensive saving \$1,320 to \$1,613 per CTR case when performed in an operating room,⁴¹ while also being equally effective.⁴⁴ Moreover, a 2019 study found improved pain control for 24 hours postoperatively with WALANT versus standard anesthesia.⁴³ Performing open CTR surgery using the WALANT method in the office setting provides even further savings, with a 2017 study reporting 85% cost savings in a military population.⁴⁴ Moreover, performing CTR in the office under WALANT anesthesia and field sterility has also been demonstrated to be safe. A multicenter study of 1,504 consecutive CTRs performed in the office with WALANT from 2008 to 2010 found a superficial infection rate of only 0.4% and a deep infection rate of 0%, which was comparable to the CTR being performed in an operating room.⁴⁵ The cost savings, convenience to the patient, and convenience for the surgeon have led to wide-awake surgery becoming the method of choice for the majority of CTRs performed in Canada.⁴⁶

The traditional argument against WALANT—that the use of epinephrine in the hand and fingers risks ischemic necrosis—has essentially been refuted through a number

of recent studies.⁴⁷ A 2005 study of 3,110 consecutive cases using local anesthesia alone with epinephrine found no incidents of tissue ischemia.⁴⁸ A similar 2018 study of 488 cases using local anesthesia alone with epinephrine similarly found no incidents of tissue ischemia.⁴⁹ A 2007 literature review of digits injected with high-dose (1:1,000) epinephrine also found no incidents of tissue necrosis.⁵⁰ Yet, recent case reports have reported on cases of digital necrosis after epinephrine injection.^{51–53} These case reports have emphasized the importance of obtaining an adequate preprocedure history to evaluate for the presence of vascular disorders including Raynaud's syndrome, and the importance of having phentolamine available as a reversal agent.

ENDOSCOPIC CTR

Endoscopic CTR continues to evolve as a surgical technique and continues to grow in popularity. A 2017 study of the Medicare database found an annual growth rate of 5% in endoscopic CTR from 2005 to 2012, versus 0.9% for open CTR.⁵⁴ Prior studies noted increased rates of nerve injury in endoscopic CTR,⁵⁵ and more recent population-level data have supported a 125% increase in risk of nerve injury requiring repair following endoscopic CTR versus open CTR.⁵⁶ However, data are conflicted regarding the safety of endoscopic CTR versus open CTR. A 2014 Cochrane systematic review demonstrated a 45% lower rate of complications with endoscopic CTR versus open CTR.⁵⁷ A recent database study of over 571,000 American patients between 2000 and 2014 found no statistically significant increase in reported complications with endoscopic CTR.⁵⁸ Morphometric studies have also failed to demonstrate differences in postoperative carpal tunnel volume following open versus endoscopic CTR, reducing concerns that the endoscopic technique does not allow for full release of nerve constriction.⁵⁹ Despite this evidence of equivalence, some experienced caution against endoscopic CTR in situations of aberrant anatomy, including nerve variants, cysts, amyloidosis, and rheumatoid tenosynovitis.⁶⁰

Endoscopic CTR continues to demonstrate advantages in terms of immediate postoperative pain. A prospective study of patients undergoing bilateral CTR, with open and endoscopic techniques compared in each patient as an internal control, found that 80% of patients preferred the endoscopic surgery, citing postoperative pain as the reason.⁶¹ The subjectively improved patient experience following endoscopic CTR is of particular interest, as it contradicts a prior meta-analysis of intraindividual endoscopic CTR and open CTR comparisons that found similar pain scores between the two groups,⁶² instead being in keeping with prior research demonstrating improved pain and decreased analgesia requirements following endoscopic CTR versus open CTR.⁶³ Ultimately, as surgeons have become more familiar with endoscopic technique for CTR, the weight of the evidence demonstrates that endoscopic techniques now rival open techniques for safety and likely provide an easier early postoperative recovery. However, studies examining differences in pain

experience are challenged by the generally low pain in either endoscopic or open techniques and variations in the surgical technique employed for the endoscopic and open arms of the various studies.

PERCUTANEOUS CTR

In the effort to further reduce the invasiveness and cost of CTR surgery, recent research has examined percutaneous or US-guided techniques. An open-label study of 129 patients examined the safety and efficacy of US-guided percutaneous CTR performed by an interventional radiologist. At 1 month, the average BCTQ symptom severity score had decreased from 3.3 to 1.7 in these patients. No complications were reported.⁶⁴ A separate study of 20 patients using an alternative percutaneous release technique also demonstrated improved BCTQ and electrophysiologic measurements without complications up to 6 months postoperatively.⁶⁵ A similar technique was used in a 2017 industry-funded study on 159 hands and demonstrated rapid improvement of BCTQ scores, with a 5% rate of pillar pain-type symptoms and a zero reported rate of neurovascular injuries.⁶⁶ Proponents of this technique have emphasized a short learning curve, with junior radiologists able to perform the technique adequately on cadavers after training on just 4 specimens.⁶⁷ Given the push toward removing CTR from the operating room and for nonsurgical physicians to perform CTR procedures, it is likely that more research will continue to accumulate regarding the safety and efficacy of these percutaneous techniques, including much-needed head-to-head comparisons with established techniques as well as larger series powered to evaluate the risk of low-incidence, high-severity complications like nerve laceration or incomplete release.

CTS AND THE OPIOID EPIDEMIC

Given the severity of the opioid epidemic in the United States, a great deal of recent research has focused on pain control and minimizing opioid need after CTR surgery. A recent double-blinded, prospective, randomized trial examining postoperative pain experience and medication use demonstrated a trend toward patients consuming less pain medications after endoscopic compared with open CTR, although this was not statistically significant. The same study randomized patients to either receive an opioid (5 mg oxycodone), an NSAID (600 mg ibuprofen), or a nonopioid analgesic (500 mg acetaminophen) and found that patients used similar numbers of pills (less than 5 pills on average) regardless of the type with no difference in total consumption, pain experience, or need for refills whether they contained a non-steroidal antiinflammatory drug (NSAID), acetaminophen, or an opioid.⁶⁸ A separate trial randomizing patients to opioid versus nonopioid postoperative regimens demonstrated that no patients in the nonopioid group required supplementation with opioids and that the nonopioid group had lower early postoperative pain scores and improved quickDASH scores.⁶⁹ A third recent study compared acetaminophen/hydrocodone with acetaminophen/ibuprofen in soft tissue hand procedures

and found no statistical difference in pain between groups, although medication side effects were more common in the acetaminophen/hydrocodone group.⁷⁰ Although treatment must be tailored to the individual patient, these studies serve as strong evidence that opioids are not required following CTR surgeries and may in fact be less effective than an NSAID or acetaminophen regimen.

Revision CTR

Revision CTR may be required for persistent, recurrent, or new symptoms. A study of 97 revision surgeries found that symptoms were persistent in 43%, recurrent in 19%, and new in 37%. In those with persistent or recurrent symptoms, scarring of the median nerve to the flexor retinaculum and incomplete release were the most common findings. In those with new symptoms, nerve injuries were a common finding.⁷¹ These nerve injuries, while potentially severe, occur in only 0.2%–0.3% of cases.⁷²

Although likely underreported, estimated recurrence rate after CTR ranges from 3% to 25%.⁷³ A prospective single-center study of 14 patients found a median time to revision of 13.3 years (range: 3.9–35.4 years).⁷⁴

Surgical procedure in revision CTR varies greatly with the findings in each individual case. Providing vascularized coverage for the median nerve is often recommended. A prospective study of the hypothenar fat flap in 34 patients found high rates of paresthesia resolution and pain improvement and persistent effects at 5-year follow-up.⁷⁵ Alternative coverage methods include an abductor digiti minimi flap⁷⁶ or a radial artery perforator fascial flap.⁷⁷ Due to the etiological heterogeneity—and relative rarity—of failed CTR, large-scale studies are currently lacking in this field.

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