Ultrasound-Guided Carpal Tunnel Release with UltraGuideCTR®: Clinical Summary

Jay Smith, M.D.
Chief Medical Officer, Sonex Health, Inc.
October 2026

Introduction

Carpal tunnel syndrome is the most common compression neuropathy and affects approximately 13 million adults and up to 7% of manual labor workers.[1,2] Over 600,000 carpal tunnel releases (CTR) are performed annually in the United States to treat patients with severe or refractory symptoms.[3] The primary goal of surgical intervention is to transect or divide the transverse carpal ligament (TCL) to reduce median nerve compression and thereby reduce symptoms and improve function.[4-6]

Traditional open carpal tunnel release (OCTR) using a blade, knife and/or scissors to transect the TCL is relatively safe and effective but can be associated with large and sometimes painful scars, pillar pain, and often a prolonged recovery course.[6-10] During endoscopic carpal tunnel release (ECTR) the TCL is transected using a small internal camera in combination with blades, knives or instruments incorporating them.[6-8,11-13] ECTR improves early postoperative outcomes but utilizes significant equipment, limits visualization of the carpal tunnel contents, incurs a greater risk of transient postoperative nerve symptoms, and cannot be easily performed outside of the operating room.[6,8,11-13]

Ultrasound-guided carpal tunnel release (UGCTR) with intracarpal balloon dilation (CPT 64728) is a minimally invasive CTR technique during which the TCL is transected through a small (~5mm), non-palmar incision.[6,13,14] UGCTR combines the minimal invasiveness of ECTR with the wide field of OCTR.[6,13,14] In addition, intracarpal balloon dilation creates and maintains space during the procedure, similar to an internal retractor. Sonex Health's patented UltraGuideCTR was specifically designed to provide physicians with a simple, elegant, safe, and effective tool to perform UGCTR (Figure 1). Please see the Instructions for Use for a complete listing of the indications, contraindications, warnings and precautions.

UltraGuideCTR consists of an ergonomic handpiece and a working tip containing a retractable retrograde cutting knife (TCL Blade®) and inflatable balloons along both sides of the tip (Stealth MicroGuards®). Using ultrasound guidance, the UltraGuideCTR tip is passed through a small wrist incision in the proximal carpal tunnel region and positioned within the carpal tunnel. Once the position of the device is confirmed relative to the TCL and surrounding neurovascular structures, the balloons are deployed to create space in the carpal tunnel. This is achieved by increasing the diameter of the device as well as the distance between the balloon edges and centrally located cutting knife. The retrograde cutting knife is then activated to divide the ligament under direct US visualization. Following ligament transection, the cutting knife is recessed, the balloons deflated, and the ligament probed using US guidance to ensure a complete release. The fascia and skin are typically closed with adhesive strips (e.g., Steri-Strip™) and/or sutures. UGCTR using UltraGuideCTR can be performed in a variety of clinical settings, including a clinic procedure room using only local anesthesia.[14-18]



Figure 1. UltraGuideCTR (Sonex Health, Inc., Eagan, MN).

Clinical Experience – UGCTR using UltraGuideCTR

Over 55,000 UGCTR procedures have been completed using UltraGuideCTR, including many simultaneous bilateral procedures performed in the office.[13-15,17-22] In addition, the safety and effectiveness of UGCTR using UltraGuideCTR have been documented in 21 peer-reviewed publications reporting clinical results on over 2100 unique patients/2800 unique hands.[13-33] These publications include the results of 2 randomized controlled trials, a prospective, multicenter, office-based study, and 2 large, real-world registries, the most recent of which enrolled over 1400 patients, including patients treated with ECTR and OCTR (MISSION Registry). Publication highlights:

- Consistent results across multiple study designs and sites of service, including the office[13-18]
    - Rapid improvements in validated patient-reported outcomes (Figures 2-3).
    - Return to normal activities in 2-3 days (median) and return to work in 3-5 days (median) (Figures 4-5). Patients are generally allowed to resume activities as tolerated (at physician's discretion).
    - Includes recently published 6-month results of 887 patients/1082 hands treated at 22 centers in the MISSION Registry.[15]

- Durability – long-term studies demonstrate improvements maintained at up to 6 years[21]
    - 5 studies reporting 1-year endpoints.[14,20,25,26,33]
    - 3 additional studies reporting minimum 2-year results, including 1 RCT, a prospective, multicenter office-based study, and a large case series of over 102 patients with a mean 46-month follow-up (range 2-6 years).[16,17,21]

- Compared to ECTR, UGCTR was associated with significantly smaller incisions, less opioid use, and higher 3-month overall satisfaction and wound satisfaction. In addition, results statistically favored UGCTR with respect to 3-month improvements in BCTQ-SSS/-FSS, pain, and quality of life scores.[13]

- Compared to OCTR, UGCTR was associated with significantly smaller incisions, less opioid use, and higher 3-month wound satisfaction. In addition, results statistically favored UGCTR with respect to 3-month improvements in BCTQ-SSS/-FSS and pain scores.[23]

- Large number (>500) of simultaneous bilateral procedures (including office-based simultaneous bilateral release) with similar results to unilateral procedures.[13-15,17,18,20-22,27,32]

- Generalizability - published studies include the clinical results of:
    - Over 65 different physicians with diverse experience performing UGCTR.
    - Diverse patient groups, including those with comorbidities (e.g., diabetes, inflammatory arthritis) and/or treated with concomitant procedures.[13-15,19,20,23-25]

- Postoperative discomfort typically managed with acetaminophen or NSAIDs as necessary: no opioids required.[13-16,23]

- MRI-documented carpal tunnel decompression including TCL transection, a 22% increase in carpal tunnel cross-sectional area at the hamate, and a 52% increase in median nerve cross-sectional area at the hamate.[32]

- High long-term patient satisfaction (including over 95% at 2 years).[17,20,21,25,33]

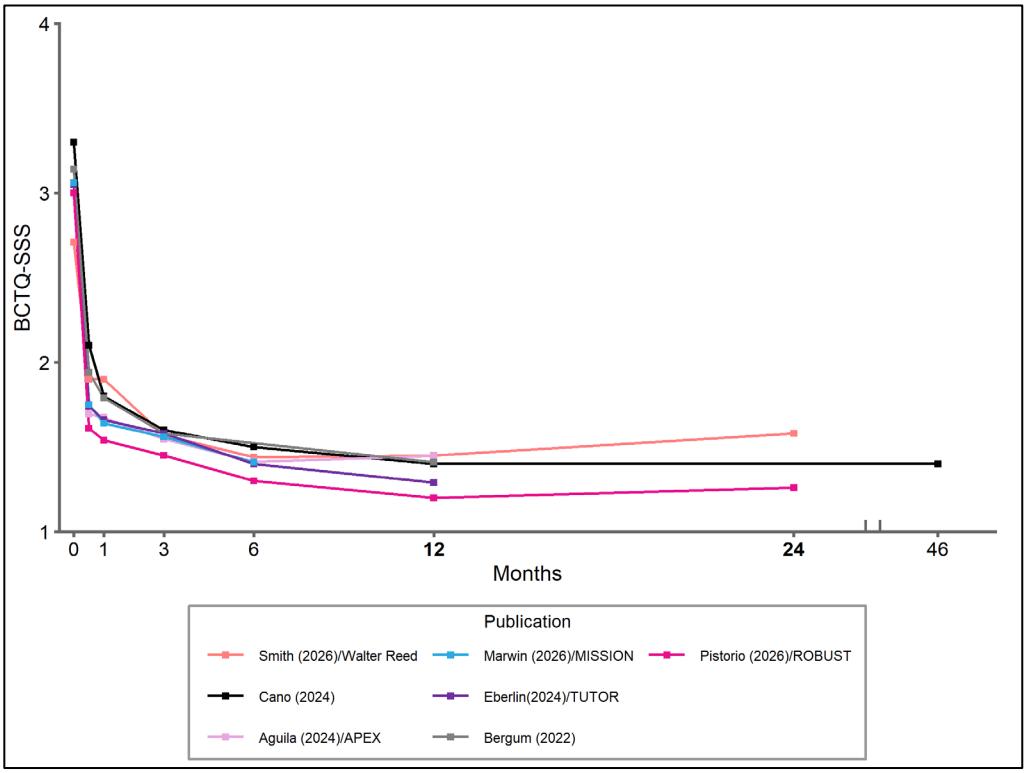


Figure 2. Mean BCTQ-SSS scores post-UGCTR using UltraGuideCTR as reported by Smith et al. (single center, prospective RCT of 21 patients/21 hands), Marwin et al. (MISSION, multicenter, post-market registry of 887 patients/1082 hands), Pistorio et al. (ROBUST, multicenter, prospective, single arm trial of 138 patients/210 hands patients treated in the office), Cano et al. (single center case series of 102 patients/162 hands), Eberlin et al. (TUTOR, multicenter, prospective RCT of 80 patients/80 hands), Aguila et al. (APEX, multicenter, post-market registry of 300 patients/341 hands), and Bergum and Ciota (single center case series of 88 patients/123 hands treated in the office). In total, these 7 studies report on over 1600 patients/over 2000 hands. In each study, statistically significant improvements in BCTQ-SSS scores were reported vs. baseline that were maintained at final follow-up. Note consistency and durability of results across study designs and populations.

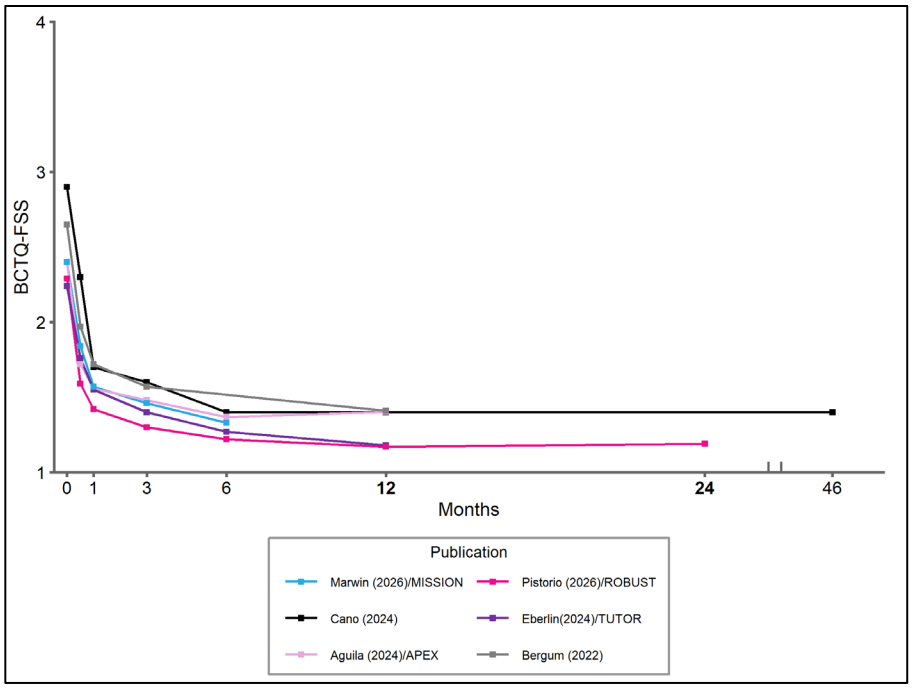


Figure 3. Mean BCTQ-FSS scores post-UGCTR using UltraGuideCTR. Similar to Figure 2, in each study statistically significant improvements in BCTQ-FSS scores were reported vs. baseline that were maintained at final follow-up. Note consistency and durability of results across study designs and populations.

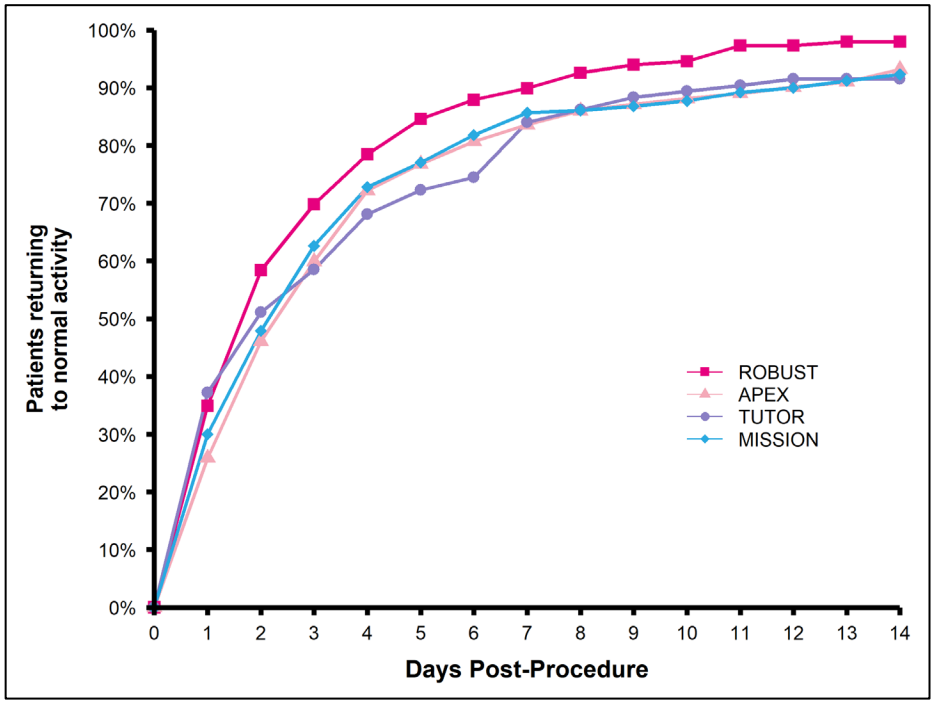


Figure 4. Percentage of patients returning to normal daily activities (RTA) following UGCTR using UltraGuideCTR as reported by Pistorio et al. (ROBUST, multicenter, prospective single arm trial of 149 patients treated in the office), Paterson et al. (APEX, multicenter, post-market registry of 544 patients. Unpublished data on file, Sonex Health), Eberlin et al. (TUTOR, multicenter, prospective RCT of 94 patients), and Marwin et al. (MISSION, prospective, post-market registry of 887 patients). In total, these 4 studies report a median RTA of 2-3 days for over 1600 patients. Note consistency and durability of results across study designs and populations.

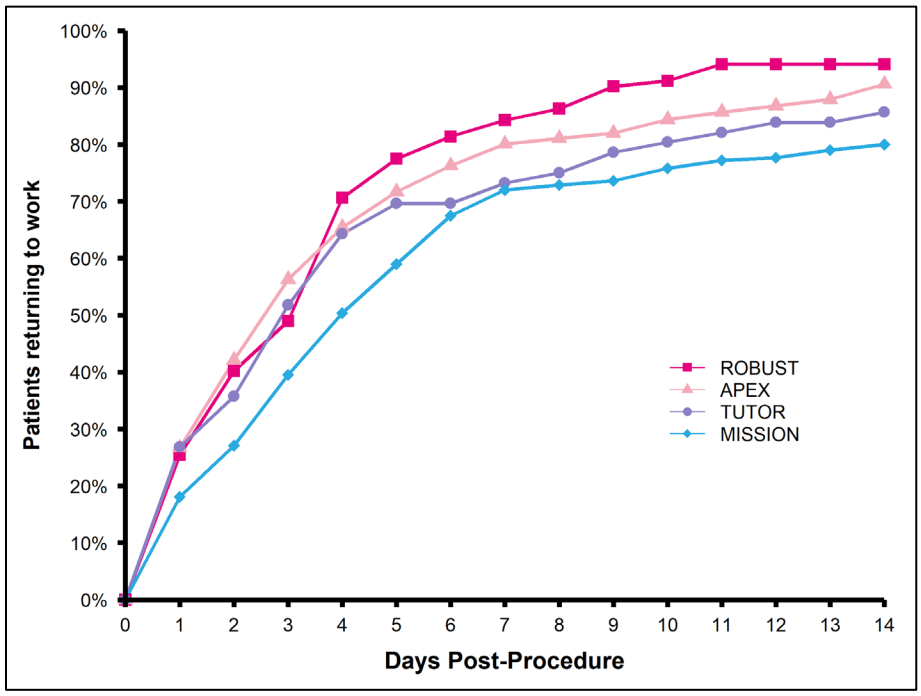


Figure 5. Percentage of employed patients returning to work (RTW) following UGCTR using UltraGuideCTR as reported by Pistorio et al. (ROBUST, multicenter, prospective, single arm trial including 102 employed patients treated in the office), Paterson et al. (APEX, multicenter, post-market registry including 544 employed patients), Eberlin et al. (TUTOR, multicenter, prospective RCT including 56 employed patients), and Marwin et al. (MISSION, prospective, post-market registry including 576 employed patients). In total, these 4 studies report a median RTW of 3-5 days for over 1200 employed patients. Note consistency and durability of results across study designs and populations.

Conclusion

UltraGuideCTR provides a unique combination of safety and usability features to facilitate UGCTR with intracarpal balloon dilation. Over 55,000 procedures have been completed, and the safety and effectiveness of UltraGuideCTR have been documented in 21 peer-reviewed publications reporting on over 2100 patients/over 2800 hands. Results have been consistent across diverse study designs (e.g., RCTs, prospective, multicenter office-based study, real-world registries, and case series), patient populations, physician backgrounds, and sites of service, including the clinic setting.

Selected Manuscripts Reporting Clinical Results of UGCTR using UltraGuideCTR

- **Pistorio AL, Paterson PD, Watt JF, et al. Final 2-year results from the ROBUST trial of office-based ultrasound-guided carpal tunnel release. Plast Reconstr Surg Glob Open. 2026;14:e8054. doi:10.1097/GOX.0000000000008054.** *Two-year results of a prospective, multicenter, single-arm study of office-based UGCTR performed at 7 centers. The primary purpose was to document the long-term results of the previously published 6-month paper (Pistorio et al. JHS-GO 2024). 2-year follow-up was available on 92.6% of patients (138 patients/210 hands) and demonstrated durability of improvements at 2-years, 95.7% satisfaction, and no revisions for recurrence. Sub-analysis demonstrated similar long-term results for simultaneous bilateral releases and unilateral releases. This follow-up publication also reported that 51.7% of patients had sonographically severe disease, and the 7 investigators had performed a median of 11 procedures prior to the study, with over half having no or little office-based UGCTR experience (3/7 had no experience and 1/7 had performed 1 office-based UGCTR procedure).*

- **Smith MS, Yuan X, Deal JB Jr, Nanos GP 3rd, Tintle SM, Hager NA, Reece DE, Miller ME. Carpal tunnel release using ultrasound guidance: two-year outcomes of a randomized controlled trial within the military. J Hand Surg Glob Online. 2026 Jun 29;8(5):101078. doi: 10.1016/j.jhsg.2026.101078. PMID: 42404100; PMCID: PMC13331985.** *Prospective, randomized, controlled trial from the Walter Reed National Military Center comparing 21 patients treated with CTR-US in a clinic setting to 20 patients treated with mOCTR. CTR-US procedures represented the first clinical procedures performed by trained PM&R physicians, whereas all mOCTR procedures were performed by experienced hand surgeons. Follow-up at 2-years was 100%. CTR-US patients had significantly smaller incisions (5.4mm vs. 28.0mm) and used less opioids in the early postoperative period (although few opioids were used in either group). Both groups exhibited significant and clinically meaningful improvements in BCTQ-SSS, QDASH, and pain scores by 1-month which were sustained at 2-years, without significant between-group differences. The CTR-US group reported significantly less incisional pain and functionally limiting incisional pain during the first 3-4 weeks post-procedure. One infection was reported in a CTR-US patient. The authors concluded that CTR-US and mOCTR both resulted in significant and clinically meaningful improvements in symptoms and function that were durable at 2-years in a military population. CTR-US provided early advantages with respect to wound pain and functionally limiting wound pain.*

- **Marwin VM, Hilliard SM, Watt JF, Callahan JJ, Perry PE, Micev AJ, Miller LE, Nelson JT. Real-world outcomes of ultrasound-guided carpal tunnel release in 1,082 hands: 6-month results from the MISSION registry. J Hand Surg Glob Online. 2026 Jun 5;8(4):101063. doi: 10.1016/j.jhsg.2026.101063. PMID: 42292900; PMCID: PMC13264358.** *Large case series from the MISSION post-market registry. 887 patients/1082 hands with both baseline and 6-month postoperative data following UGCTR using UltraGuideCTR performed by 22 different physicians. Nearly 50% of patients had symptoms for 2 years or longer, 57.2% had sonographically severe CTS, and many patients had comorbidities. Wide-awake local anesthesia was used in 82.1% of patients, average incision size was 5mm, and 22% (195 patients) had simultaneous bilateral releases. Median return to normal activities was 3 days and median return to work was 4 days, including 115 heavy manual laborers who returned to work at a median of 5 days. At 6 months, BCTQ-SSS/-FSS, pain, and EQ-5D-5L significantly improved versus baseline, with 89.9% patient satisfaction. One patient was revised at 6 months for scar tissue, and no major adverse events were reported. Results of simultaneous bilateral releases were similar to unilateral releases. Overall results were consistent with previous studies, including Aguila et al. (APEX-CTR Registry).*

- **Marwin VM, Nelson JT, Watt JF, Verheyden JR, Perry PE, Warhold LG, Carl DJ, Palmer MJ, Niedermeier SR, Miller LE, Godfrey JM. Prospective multicenter propensity score-matched comparison of ultrasound-guided versus endoscopic carpal tunnel release. J Hand Surg Glob Online. 2026 Feb 27;8(3):100974. doi: 10.1016/j.jhsg.2026.100974. PMID: 41799667; PMCID: PMC12966659.** *Propensity-matched comparison of 186 UGCTR patients and 186 ECTR patients from the MISSION post-market registry. Compared to ECTR, UGCTR was more likely to be performed using only local anesthesia (85.5% vs. 57.5%) and was associated with smaller incisions (5mm vs. 12mm), less suture closure (11% vs. 100%), less opioid use (10.3% vs. 39.7%), and superior 3-month BCTQ-SSS/-FSS scores, pain scores, quality of life scores, overall satisfaction and wound satisfaction. One ECTR patient was revised due to an incomplete release. No serious adverse events occurred in either group during the 3-month follow-up.*

- **Marwin VM, Lincoski CJ, Nelson JT, Watt JF, Moeller AT, Perry PE, Bontempo NA, Niedermeier SR, Miller LE, Moyles KJ. Propensity score-matched comparison of ultrasound-guided versus open carpal tunnel release: three-month outcomes from the MISSION registry. J Hand Surg Glob Online. 2026 Jan 21;8(2):100931. doi: 10.1016/j.jhsg.2025.100931. PMID: 41624979; PMCID: PMC12859246.** *Propensity-matched comparison of 178 UGCTR patients and 178 OCTR patients from the MISSION post-market registry. Compared to OCTR, UGCTR was more likely to be performed using only local anesthesia (84.8% vs. 19.1%) and was associated with smaller incisions (5.2mm vs. 16.5mm), less suture closure (14.6% vs. 100%), less opioid use (10.2% vs. 49.1%), and superior 3-month BCTQ-SSS/-FSS scores, pain scores, and wound satisfaction. No serious adverse events or reoperations occurred in either group during the 3-month follow-up.*

- **Cano L, Leiby BM, Shum LC, Ward MG, Joseph AE. Clinical results of carpal tunnel release using ultrasound guidance in over 100 patients at two to six years. J Hand Surg Glob Online. 2024. doi: https://doi.org/10.1016/j.jhsg.2024.02.004.** *Case series reporting the results of 102 patients/162 hands at a minimum of 2-years following carpal tunnel release using ultrasound guidance (CTR-US) and UltraGuideCTR performed by a single physician in a community-based practice. Over 50% of the patients were treated with simultaneous bilateral releases. At a mean final follow-up of 46 months (range 2-6 years) BCTQ-SSS/-FSS and QDASH scores remained significantly improved vs. baseline (P<0.001) and improvements exceeded minimal clinically important differences. Mean patient satisfaction scores were 4.6 (1-5 scale) with 91.2% of patients reported being satisfied or very satisfied with the procedure. There were no re-operations for recurrence. Results were similar for patients treated with unilateral vs. simultaneous bilateral releases.*

- **Eberlin KR, Amis BP, Berkbigler TP, Dy CJ, Fischer MD, Gluck JL, Kaplan FTD, McDonald TJ, Miller LE, Palmer A, Perry PE, Walker ME, Watt JF. Final 1-year results of the TUTOR randomized trial comparing carpal tunnel release with ultrasound guidance to mini-open technique. Plast Reconstr Surg Glob Open. 2024 Mar 4;12(3):e5665. doi: 10.1097/GOX.0000000000005665. PMID: 38440365; PMCID: PMC10911521.** *One-year results of a multicenter, prospective randomized trial of CTR-US using UltraGuideCTR vs. mOCTR. Primary purpose was to report the final, one-year outcomes in follow-up to the previous publication of Eberlin et al. (Expert Rev Med Devices 2023). One-year follow-up was available in 80/94 and 27/28 subjects treated with CTR-US and mOCTR, respectively. At 1-year, mean improvements in BCTQ-SSS/-FSS, numerical pain, and EQ-5D-5L scores remained significantly improved vs. baseline (P<0.001) and exceeded minimal clinically important differences. 95% of CTR-US subjects reported satisfaction with the procedure vs. 92.6% of mOCTR subjects. Incisions were significantly smaller for the CTR-US group (mean 6mm in the wrist vs. 22 mm in the palm, P<0.001) and at year significantly more CTR-US subjects reported freedom from scar pain or sensitivity (95% vs. 74.1%, P=0.005). There were no recurrences or late complications in either group.*

- **Paterson PD, Kirsch MJ, Miller LE, Aguila DJ 3rd. Early return to work after carpal tunnel release with ultrasound guidance. Plast Reconstr Surg Glob Open. 2024 Feb 27;12(2):e5647. doi: 10.1097/GOX.0000000000005647. PMID: 38415102; PMCID: PMC10898665.** *Case series from the APEX-CTR multicenter, post-market registry reporting return to work (RTW) for 544 patients/655 hands treated with CTR-US using UltraGuideCTR at 24 centers. In this real-world, pragmatic study, over half of patients (52%) had symptoms for >2 years and there were no restrictions based on maximum patient age, comorbidities (e.g., anxiety 21%, depression 19%, thyroid disease 12%) or tobacco use status (12% current tobacco use). All patients were employed at the time of surgery (49% desk-based, 28% light-manual, 23% heavy manual), with 45% reporting regular lifting of 20lbs or more, 19% reporting regular use of vibrating equipment and 18% reporting regular use of heavy equipment. Median RTW was 3 days and was 2-4 days for all job duty groups, including heavy manual laborers. Males and those in desk-based positions had a statistically significantly higher chance of returning to work within 5 days (P=0.01 and P<0.001, respectively). Complications included 2 deep infections, 2 revisions for persistent symptoms and one suspected tendon injury lost to follow-up (some complications reported in previous publications from the same registry).*

- **Pistorio AL, Marwin VM, Paterson PD, Alexander RD, Nelson JT, Miller LE. Office-based carpal tunnel release with ultrasound guidance: 6-month outcomes from the multicenter ROBUST trial. J Hand Surg Glob Online 2024. DOI: https://doi.org/10.1016/j.jhsg.2023.12.005.** *Six-month results of a prospective, multicenter, observational study reporting clinical outcomes of 149 subjects/226 hands treated with CTR-US using UltraGuideCTR in an office-based setting. All procedures were completed in the office using only local anesthesia (79% with epinephrine), >50% of subjects had simultaneous bilateral releases, and 3 of the 7 hand surgeons had no previous experience performing CTR-US in the office setting. All procedures were completed as planned, the mean intra-operative pain score was 1.9 (79% of subjects identified the needle stick as most painful), the mean incision length was 5 mm, and over 98% of wounds were closed without sutures. Median return to normal daily activities was 2 days and median return to work was 4 days (104 employed subjects), including heavy manual laborers. BCTQ-SSS/-FSS, MHQ, pain, and EQ-5D-5L scores rapidly improved and at 6-months remained significantly improved vs. baseline (P<0.001) and exceeded minimal clinically important differences. 94% of subjects were satisfied at 6 months and results were similar for simultaneous bilateral vs. unilateral procedures. No infections or revision surgeries for persistent or recurrent symptoms. One subject with increased paresthesias was explored, treated for a nerve contusion with a small epineurial injury, and had "complete recovery of median nerve function and minimal residual ring finger tingling" at 7 weeks.*

- **Aguila D, Kirsch M, Kindle B, Paterson P. Long-term clinical results of carpal tunnel release using ultrasound guidance: a multicenter pragmatic study. J Hand Surg Glob Online. 2023 Nov 22;6(1):79-84. doi: 10.1016/j.jhsg.2023.10.001. PMID: 38313613; PMCID: PMC10837292.** *Reports the final, 1-year results from the APEX-CTR post-market registry in follow-up to the previous publication of Fowler et al. (Expert Rev Med Devices 2022). 300 patients/341 hands had both pre-operative and 1-year postoperative data following CTR-US using UltraGuideCTR performed by 25 different physicians. At 1-year post-CTR-US, BCTQ-SSS/-FSS and QDASH scores remained significantly improved vs. baseline (P<0.001) and improvements exceeded minimal clinically important differences. 87.7% of patients were satisfied with the procedure, and the mean procedure recommendation score was 8.9 (0-10 scale). Females had a quantitatively small but statistically significantly greater improvement in BCTQ and QDASH scores. No other factors, including treatment with simultaneous releases or concomitant procedures (e.g., trigger finger release, cubital tunnel release), significantly affected 1-year outcomes. Complications included two revisions (one of which was also reported in Fowler et al.), 1 deep infection and 1 suspected tendon injury lost to follow-up.*

- **Nicholas GE, Galloway J, Hawley J, McGinley JC. Carpal tunnel release with ultrasound guidance: intermediate-term clinical outcomes and magnetic resonance imaging findings. J Hand Surg Glob Online. 2023 Jun 7;5(5):595-600. doi: 10.1016/j.jhsg.2023.05.002. PMID: 37790816; PMCID: PMC10543793**. *Consecutive case series of 65 patients/96 hands treated with CTR-US using UltraGuideCTR in a procedure room setting, including 13 patients/17 wrists with pre- and postoperative MRI scans at a mean of 3 months post-op. No complications. Statistically significant improvements in BCTQ and QDASH scores occurred by 2 weeks, were maintained at 3–6-month follow-up, and exceeded MCIDs. All 38 employed patients with return to work data had returned to work by 2 weeks, including 21 manual laborers. MRI revealed complete TCL transection in all 17 wrists, and statistically significant changes in MRI parameters consistent with carpal tunnel decompression – 22% increase in carpal tunnel cross sectional area at the hamate, 52% increase in median nerve cross sectional area at the hamate, 18% reduction in median nerve T2 signal intensity, and 38% reduction in median nerve flattening (i.e., flattening ratio).*

- **Eberlin KR, Amis BP, Berkbigler TP, et al. Multicenter randomized trial of carpal tunnel release with ultrasound guidance versus mini-open technique. Expert Rev Med Devices. 2023;20(7):597-605. doi:10.1080/17434440.2023.2218548.** *Three-month outcomes of a multicenter, prospective randomized trial of CTR-US using UltraGuideCTR vs. mOCTR. Both procedures at each site were performed by the same surgeon. Surgeon experience was significantly greater for mOCTR (median 1,000 procedures) versus CTR-US (median 12 procedures). Thirteen patients randomized to mOCTR refused treatment and 46 declined to consent due to the possibility of randomization to mOCTR. Postoperative care was standardized. Mean incision length (6 mm vs. 22 mm) and freedom from wound sensitivity (61% vs. 18%) favored CTR-US. Both groups experienced statistically significant and clinically meaningful improvements in BCTQ, pain, and Euro-QOL scores, with no significant differences between the groups. The adverse event rate was also similar between the two groups (2.1% CTR-US vs. 3.6%).*

- **Bergum RA, Ciota MR. Office-based carpal tunnel release using ultrasound guidance in a community setting: long-term results. Cureus. 2022 Jul 23;14(7):e27169. doi: 10.7759/cureus.27169. PMID: 35898805; PMCID: PMC9308387.** *Prospective case series of 88 patients (123 hands) with minimum 1-year follow-up following CTR-US using UltraGuideCTR. All procedures were confirmed by electrodiagnostic studies, and 2/3 of hands were moderately-severe or severe. All procedures were performed in an office-based procedure room using only local anesthesia and 46% of hands were treated as simultaneous bilateral procedures. Patients experienced statistically and clinically significant improvements in BCTQ-SSS, BCTQ-FSS and QDASH scores by 1-2 weeks post-procedure that persisted at 1 year. No intra-operative complications occurred; no conversions or supplementary analgesic medications were required. There were no neurovascular injuries, infections, or recurrences. One patient developed complex regional pain syndrome in the early postoperative period which was successfully treated; the patient subsequently had the contralateral hand treated with CTR using ultrasound guidance without complication.*

References

1. Papanicolaou GD, McCabe SJ, Firrell J. The prevalence and characteristics of nerve compression symptoms in the general population. J Hand Surg Am. 2001 May;26(3):460-6. doi: 10.1053/jhsu.2001.24972.

2. Dale AM, Harris-Adamson C, Rempel D, et al. Prevalence and incidence of carpal tunnel syndrome in US working populations: pooled analysis of six prospective studies. Scand J Work Environ Health. 2013 Sep 1;39(5):495-505. doi: 10.5271/sjweh.3351.

3. Fajardo M, Kim S, Szabo R. Incidence of carpal tunnel release: trends and implications within the United States ambulatory care setting. J Hand Surg Am. 2012;37:1599-1605. doi: 10.1016/j.jhsa.2012.04.035.

4. Graham B, Peljovich AE, Afra R, et al. The American Academy of Orthopaedic Surgeons evidence-based clinical practiceguidelines on management of carpal tunnel syndrome. J Bone Joint Surg Am. 2016;98A:1750-4.

5. Kim PT, Lee HJ, Kim TG, Jeon IH. Current approaches for carpal tunnel syndrome. Clin Orthop Surg. 2014;6:253-7. doi: 10.4055/cios.2014.6.3.253.

6. Jobe CM, Nazarian LN, Kindle BJ, Miller LE, Fowler JR. The role of ultrasound across the continuum of care for carpal tunnel syndrome. J Ultrasound Med. 2026 Jul;45(7):1369-1378. doi: 10.1002/jum.70196.

7. Vasiliadis HS, Nikolakopoulou A, Shrier I, Lunn MP, Brassington R, Scholten RJ, Salanti G. Endoscopic and open release are similarly safe for the treatment of carpal tunnelsyndrome: a systematic review and meta-analysis. PLoS One. 2015;10:e0143683. doi: 10.1371/journal.pone.0143683.

8. Murthy PG, Goljan P, Mendez G, Jacoby SM, Shin EK, Osterman AL. Mini-open versus extended open release for severe carpal tunnel syndrome. HAND. 2015;10:34-9. doi: 10.1007/s11552-014-9650-x.

9. Rojo-Manaute JM, Capa-Grasa A, Chana-Rodríguez F, et al. Ultra-minimally invasive ultrasound-guided carpal tunnel release: a randomized clinical trial. J Ultrasound Med. 2016;35:1149-57. doi: 10.7863/ultra.15.07001.

10. Sayegh ET, Strauch RJ. Open versus endoscopic carpal tunnel release: a meta-analysis of randomized controlledtrials. Clin Orthop Relat Res. 2015;473:1120-1132. doi: 10.1007/s11999-014-3835-z.

11. Zhang S, Vora M, Harris AHS, Baker L, Curtin C, Kamal RN. Cost-minimization analysis of open and endoscopic carpal tunnel release. J Bone Joint SurgAm 2016;98:1970-7. doi: 10.2106/JBJS.16.0012.

12. Zhang X, Huang X, Wang X, Wen S, Sun J, Shao X. A randomized comparison of double small, standard, and endoscopic approaches for carpal tunnel release. Plast Reconstr Surg. 2016 Sep;138(3):641-647. doi: 10.1097/PRS.0000000000002511.

13. Marwin VM, Nelson JT, Watt JF, et al. Prospective multicenter propensity score-matched comparison of ultrasound-guided versus endoscopic carpal tunnel release. J Hand Surg Glob Online. 2026;8(3):100974. doi: 10.1016/j.jhsg.2026.100974.

14. Bergum RA, Ciota MR. Office-based carpal tunnel release using ultrasound guidance in a community setting: long-term results. Cureus. 2022 Jul 23;14(7):e27169. doi: 10.7759/cureus.27169.

15. Marwin VM, Hilliard SM, Watt JF, et al. Real-world outcomes of ultrasound-guided carpal tunnel release in 1,082 hands: 6-month results from the MISSION registry. J Hand Surg Glob Online. 2026;8(4):101063. doi: 10.1016/j.jhsg.2026.101063.

16. Smith MS, Yuan X, Deal JB, et al. Carpal tunnel release using ultrasound guidance: two-year outcomes of a randomized controlled trial within the military. J Hand Surg Glob Online. 2026;8(5):101078. doi: 10.1016/j.jhsg.2026.101078

17. Pistorio AL, Paterson PD, Watt JF, et al. Final 2-year results from the ROBUST trial of office-based ultrasound-guided carpal tunnel release. Plast Reconstr Surg Glob Open. 2026;14:e8054. doi: 10.1097/GOX.0000000000008054.

18. Pistorio AL, Marwin VM, Paterson PD, Alexander RD, Nelson JT, Miller LE. Office-based carpal tunnel release with ultrasound guidance: 6-month outcomes from the multicenter ROBUST trial. J Hand Surg Glob Online. 2024. doi: 10.1016/j.jhsg.2023.12.005.

19. Paterson PD, Kirsch MJ, Miller LE, Aguila DJ. Early return to work after carpal tunnel release with ultrasound guidance. Plast Reconstr Surg Glob Open. 2024 Feb 27;12(2):e5647. doi: 10.1097/GOX.0000000000005647.

20. Aguila D, Kirsch M, Kindle B, Paterson P. Long-term clinical results of carpal tunnel release using ultrasound guidance: a multicenter pragmatic study. J Hand Surg Glob Online. 2023 Nov 22;6(1):79-84. doi: 10.1016/j.jhsg.2023.10.001.

21. Cano L, Leiby BM, Shum LC, Ward MG, Joseph AE. Clinical results of carpal tunnel release using ultrasound guidance in over 100 patients at two to six years. J Hand Surg Glob Online. 2024. doi: 10.1016/j.jhsg.2024.02.004.

22. Joseph AE, Leiby BM, Beckman JP. Clinical results of ultrasound guided carpal tunnel release performed by a primary care sports medicine physician. J Ultrasound Med. 2020;39: 441-52. doi: 10.1002/jum.15120.

23. Marwin VM, Lincoski CJ, Nelson JT, et al. Propensity score-matched comparison of ultrasound-guided versus open carpal tunnel release: three-month outcomes from the MISSION registry. J Hand Surg Glob Online. 2026. doi: 10.1016/j.jhsg.2026.100931.

24. Fowler JR, Chung KC, Miller LE. Multicenter pragmatic study of carpal tunnel release with ultrasound guidance. Expert Rev Med Devices. 2022 Mar;19(3):273-280. doi: 10.1080/17434440.2022.2048816.

25. Leiby BM, Beckman JP, Joseph AE. Long-term clinical results of carpal tunnel release using ultrasound guidance. HAND. 2022;17(6):1074-1081. doi: 10.1177/1558944720988080.

26. Kamel SI, Fried B, Pomeranz C, Halpern EJ, Nazarian LN. Minimally invasive ultrasound-guided carpal tunnel release improves long-term clinical outcomes in carpal tunnel syndrome. AJR Am J Roentgenol. 2021 Aug;217(2):460-468. doi: 10.2214/AJR.20.24383.

27. Chappell CD, Beckman JP, Baird BC, Takke AV. Sonographic changes in median nerve cross sectional area following microinvasive ultrasound guided carpal tunnel release. J Ultrasound Med. 2020;39: 693-702. doi: 10.1002/jum.15146.

28. Henning PT, Yang L, Awan T, Lueders D, Pourcho AM. Minimally invasive ultrasound-guided carpal tunnel release: preliminary clinical results. J Ultrasound Med. 2018; 37: 2699-706. doi: 10.1002/jum.14618.

29. Latzka EW, Henning PT, Pourcho AM. Sonographic changes following ultrasound-guided release of the transverse carpal ligament: a case report. PM R 2018; 10: 1125-9. doi: 10.1016/j.pmrj.2018.02.018.

30. Henning PT, Lueders D, Chang K, Yang L. Ultrasound-guided carpal tunnel release using dynamic expansion of the transverse safe zone in a patient with post-polio syndrome: a case report. PM R 2018; 10(10): 1115-8. doi: 10.1016/j.pmrj.2018.02.016.

31. Eberlin KR, Dy CJ, Fischer MD, et al. Trial of ultrasound guided carpal tunnel release versus traditional open release (TUTOR). Medicine. 2022 Oct 14;101(41):e30775. doi: 10.1097/MD.0000000000030775.

32. Nicholas GE, Galloway J, Hawley J, McGinley JC. Carpal tunnel release with ultrasound guidance: intermediate term clinical outcomes and magnetic resonance imaging findings. J Hand Surg Glob Online. 2023 Jun 7. doi: 10.1016/j.jhsg.2023.05.002.

33. Eberlin KR, Amis BP, Berkbigler TP, et al. Final 1-year results of the TUTOR randomized trial comparing carpal tunnel release with ultrasound guidance to mini-open technique. Plast Reconstr Surg Glob Open. 2024 Mar 4;12(3):e5665. doi: 10.1097/GOX.0000000000005665.