Carpal Tunnel Release with UltraGuideCTR™ and Real-time Ultrasound Guidance: Clinical Summary

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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 400,000 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.[4,5]

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.[6-9] During endoscopic carpal tunnel release (ECTR) the TCL is transected using a small internal camera in combination with blades, knives or instruments incorporating them.[6,7,10-12] ECTR improves early post-operative outcomes but utilizes significant equipment, limits visualization of the carpal tunnel contents, incurs a greater risk of transient post-operative nerve symptoms, and cannot be easily performed outside of the operating room.[7,10-12]

Carpal tunnel release using ultrasound guidance (CTR-US) was initially described by Nakamichi in 1997.[13,14] Since then over 30 peer reviewed publications have reported clinical results on over 3000 hands (>2500 patients) treated with CTR-US using blades, knives or instruments incorporating them.[9,14-22] These publications have documented the safety and effectiveness of CTR-US, including a collective clinical success rate of >95%, an excellent safety profile, and the ability to perform the procedure in the office-based setting.[9,14-22] In addition, a single surgeon, prospective randomized trial (Level 1 study) comparing CTR-US to mini-OCTR without US guidance demonstrated that patients treated with CTR-US recovered significantly faster.[9]

Sonex Health's patented UltraGuideCTR was specifically designed to provide physicians with a simple, elegant, safe, and effective tool to perform CTR with or without US guidance (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 US 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 using 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. CTR-US using UltraGuideCTR can be performed in a variety of clinical settings, including an office procedural room using only local anesthesia.[17,19]

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

Clinical Experience – CTR-US using UltraGuideCTR

The first CTR with UltraGuideCTR and real-time US guidance was performed 2/17/2017.

- Over 30,000 procedures completed, including many simultaneous bilateral releases performed in the office.[15-22]
- Procedures performed in the ASC, OR and clinic office setting – most procedures performed using only local anesthesia/WALANT technique.[15,17,19-22]
- Post-operative discomfort typically managed with acetaminophen or NSAIDs as necessary: no opioids required.[15,17-22]
- Patients are generally allowed to resume activities as tolerated (at physician's discretion).
- 16 peer reviewed clinical publications, including 3 multicenter studies (see Manuscripts):
    - Over 1700 hands/1300 patients treated by over 45 different physicians.
    - Three publications from a real-world registry reporting clinical results and return to work on a diverse group of patients, including those with comorbidities (e.g., diabetes, inflammatory arthritis) and/or treated with concomitant procedures.[20,21]
    - Statistically and clinically significant improvements in PROMs (e.g., QDASH, BCTQ, MHQ) as early as 1-2 weeks post-procedure and sustained at up to 6 years post-procedure.[15,16,18,19,21,22]
    - Consistent results across study designs, sites of service, and physician experience with ultrasound (Figures 2-4).[15-21]
    - Median return to normal activity of 2-3 days and return to work of 3-5 days across multiple studies including a prospective, randomized trial, a

prospective, multicenter, office-based study, and a large real-world registry (Figures 5 and 6).[16,19,20]

- High number of simultaneous bilateral releases with similar results.[15,17,19-22]
- High long-term patient satisfaction (minimum 1-year).[18,21,22]
- 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.[17]

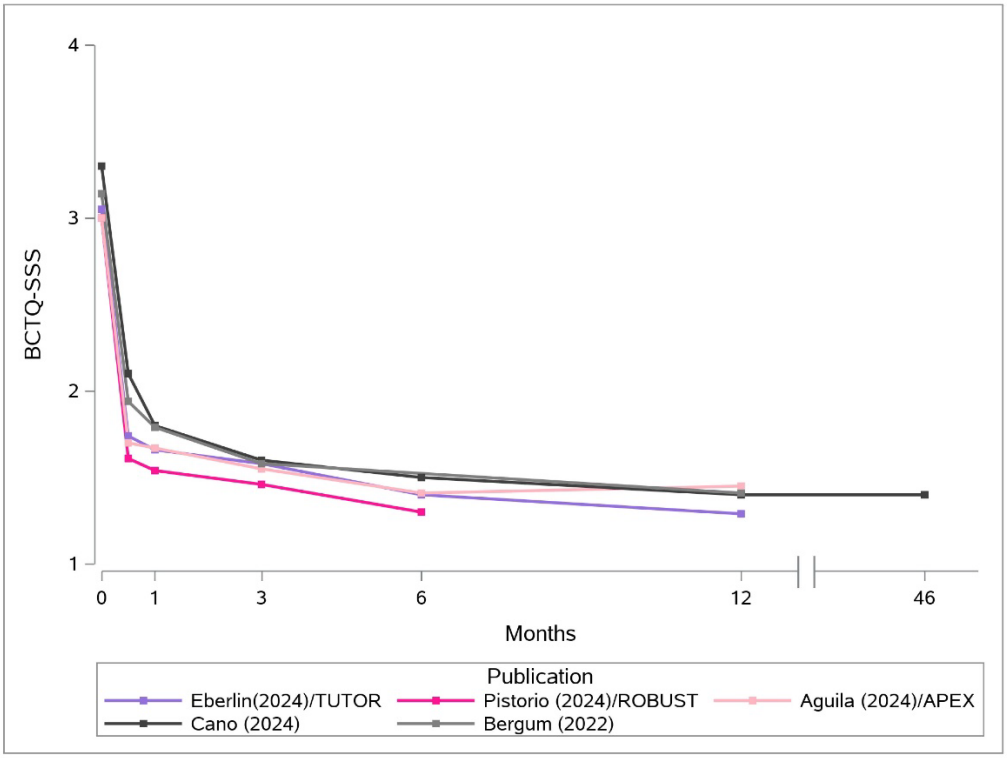

Figure 2. Mean BCTQ-SSS scores post-CTR-US using UltraGuideCTR as reported by Eberlin et al. (multicenter, prospective RCT reporting on 80 hands/80 patients at 1-year), Pistorio et al. (multicenter, prospective observational trial reporting on 226 hands/149 patients treated in the office at 6 months), Aguila et al. (multicenter, post-market registry reporting on 341 hands/300 patients at 1-year), Cano et al. (single center case series reporting on 162 hands/102 patients at minimum 2 year/mean 46 months), and Bergum and Ciota (single center case series reporting on 123 hands/88 patients treated in the office at 1-year). In total, these 5 studies report on 786 hands/759 patients treated by over 45 different physicians. In each study, statistically significant improvements in BCTQ-SSS scores were reported vs. baseline that were maintained at final follow-up and exceeded minimal clinically important differences. Note consistency and durability of results across study designs and populations.

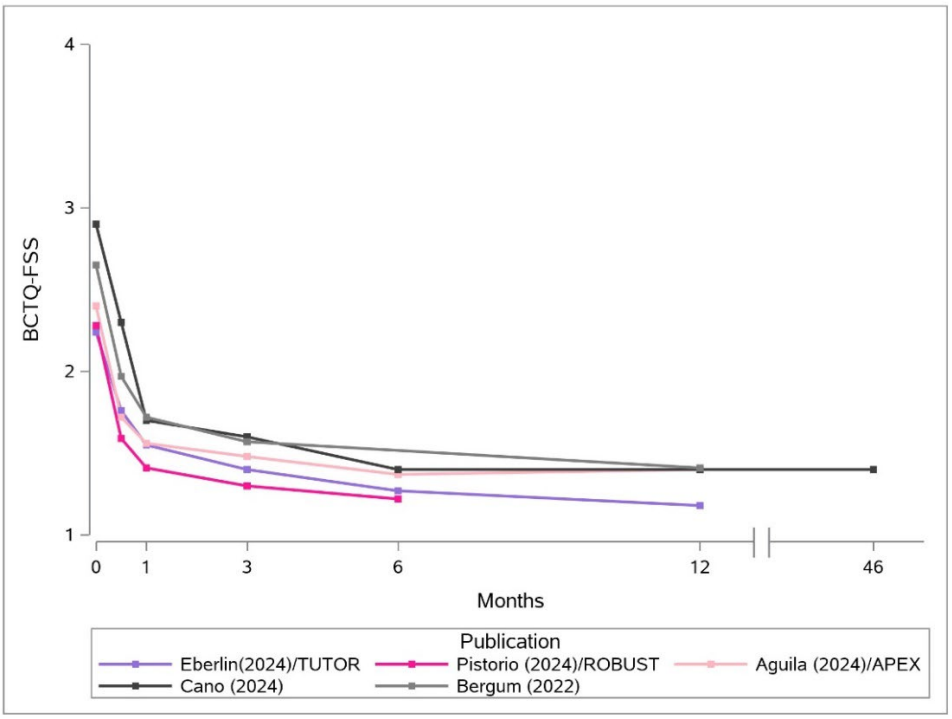

Figure 3. Mean BCTQ-FSS scores post-CTR-US using UltraGuideCTR. Similar to Figure 2, in each study statistically significant improvements in BCTQ-FSS scores were reported vs. baseline that were maintained at final follow-up and exceeded minimal clinically important differences. Note consistency and durability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

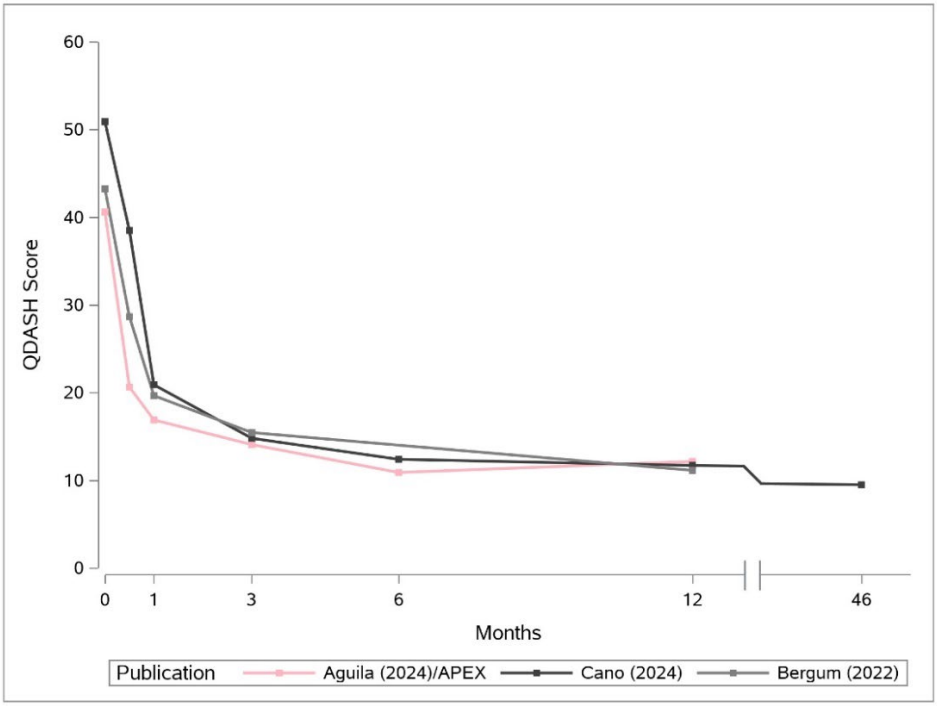

Figure 4. Mean QDASH scores post-CTR-US using UltraGuideCTR as reported by Aguila et al., Cano et al., and Bergum and Ciota (QDASH not reported in Eberlin et al. or Pistorio et al.). In total, these 3 studies report on 626 hands/530 patients treated by over 25 different physicians. Similar to BCTQ scores, in each of the three studies statistically significant improvements were reported vs. baseline that were maintained at final follow-up and exceeded minimal clinically important differences. Note consistency and durability of results across study designs and populations.

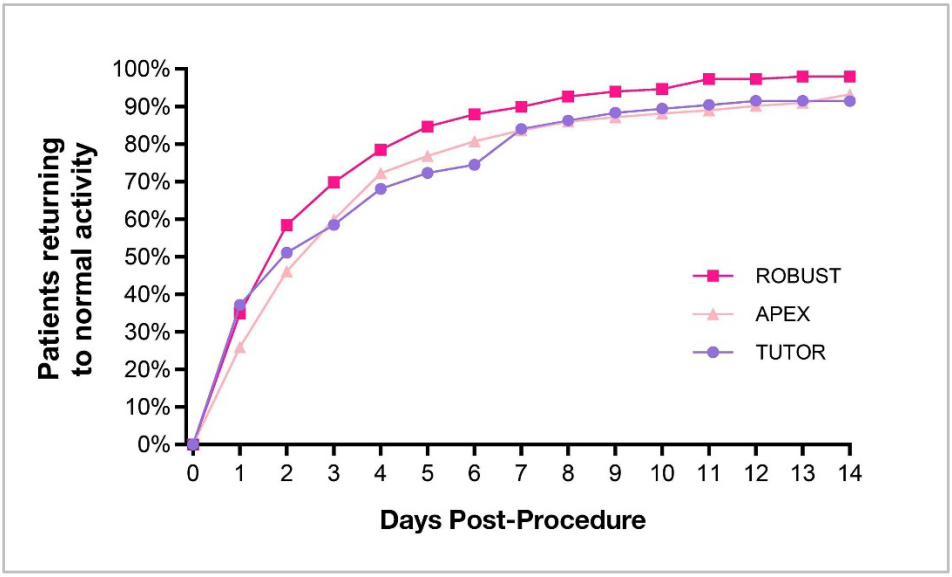

Figure 5. Percentage of patients returning to normal daily activities (RTA) following CTR-US using UltraGuideCTR as reported by Eberlin et al. (TUTOR, multicenter, prospective RCT reporting on 94 patients), Pistorio et al. (ROBUST, multicenter, prospective observational trial reporting on 149 patients treated in the office), and Paterson et al. (APEX, multicenter, post-market registry reporting on 544 patients). In total, these 3 studies report a median RTA of 2-3 days for 787 patients treated by over 40 different physicians (Eberlin et al. = 2 days, Pistorio et al. = 2 days, and Paterson et al. = 3 days). Note consistency and durability of results across study designs and populations.

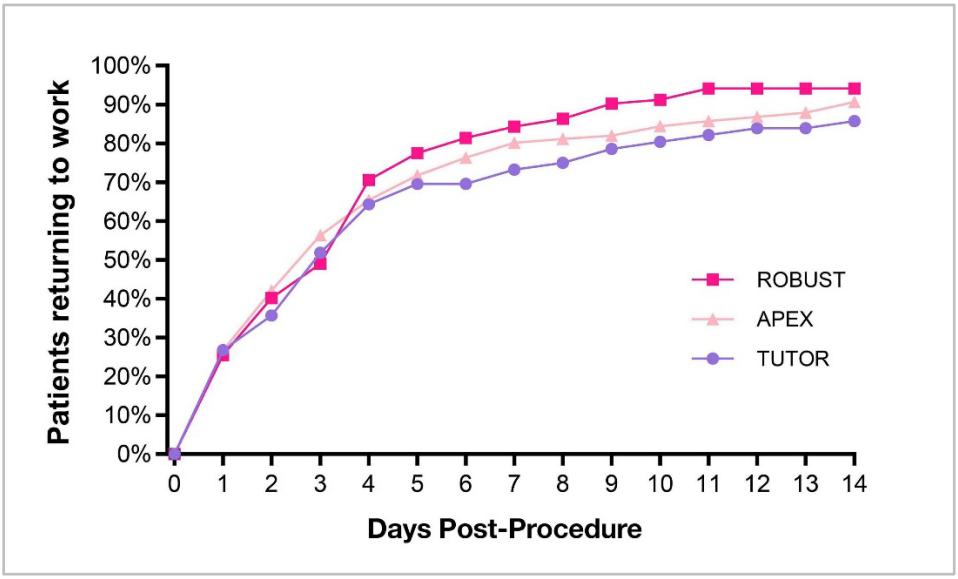

Figure 6. Percentage of employed patients returning to work (RTW) following CTR-US using UltraGuideCTR as reported by Eberlin et al. (TUTOR, multicenter, prospective RCT reporting on 56 employed patients), Pistorio et al. (ROBUST, multicenter, prospective observational trial reporting on 102 employed patients treated in the office), and Paterson et al. (APEX, multicenter, post-market registry reporting on 544 employed patients). In total, these 3 studies report a median RTW of 3-4 days for 702 employed patients treated by over 40 different physicians (Eberlin et al. = 3 days, Pistorio et al. = 4 days, and Paterson et al. = 3 days). Note consistency and durability of results across study designs and populations. Over 70% of patients RTW (73%-84%) within 7 days and over 85% within 14 days (86%-94%).

Conclusion

CTR-US has an established track record of safety and effectiveness in the peer-reviewed literature (over 30 studies, 3000 hands and 2500 patients), including a Level 1 study documenting superior earlier outcomes compared to traditional mini-OCTR without US guidance. UltraGuideCTR provides a unique combination of safety and usability features to facilitate CTR-US and over 30,000 procedures have been completed to date. The published clinical experience consists of 16 publications reporting on over 1700 hands/1300 patients, and results have been consistent across diverse study designs (e.g., prospective RCT, real-world registry, case series), patient populations, user backgrounds, and sites of service, including the office setting.

Selected Manuscripts Reporting Clinical Results of CTR-US using UltraGuideCTR

- **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 less 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 post-operative 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 post-operative 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. Post-operative 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 post-operative period which was successfully treated; the patient subsequently had the contralateral hand treated with CTR using ultrasound guidance without complication.*

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