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Technique-specific outcomes of ultrasound-guided carpal tunnel release: a systematic review and meta-analysis of uncontrolled before–after series

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 2 September 2026 and was last updated on 2 September 2026.

INTRODUCTION

Review question / Objective To describe technique-specific outcomes and safety profiles among adults with carpal tunnel syndrome undergoing percutaneous ultrasound-guided carpal tunnel release (UGCTR) across the three most extensively studied release mechanisms: thread transection, hook knife, and commercial retractable knife systems.

Rationale Ultrasound-guided carpal tunnel release (UGCTR) is increasingly performed as a micro-invasive alternative to open and mini-open release. However, UGCTR is not a single uniform procedure. Distinct release mechanisms—thread transection, hook knife, and commercial retractable knife systems—differ in cutting mechanics, instrumentation, procedural workflow, and tissue disruption. Previous systematic reviews have generally pooled UGCTR without mechanism subgrouping, which may obscure clinically relevant differences. Characterizing technique-specific outcomes is essential for clinical decision-making and technique selection.

Condition being studied Carpal tunnel syndrome (CTS) is the most common compressive peripheral neuropathy, resulting from median nerve entrapment beneath the transverse carpal ligament. Patients experience hand pain, numbness, nocturnal paresthesia, and impaired function, which in severe cases can lead to irreversible axonal injury and thenar muscle atrophy.

METHODS

Search strategy We systematically searched PubMed, Embase, CINAHL, and Web of Science from database inception to 28 June 2026. The search combined controlled vocabulary (MeSH/Emtree) and free-text terms for carpal tunnel syndrome, carpal tunnel release, and ultrasound guidance with mechanism- and device-specific terms (thread, thread carpal tunnel release, hook

knife, hook blade, SX-One MicroKnife, CTR-US, MICROi-Blade, ECTRA, percutaneous release). No language restrictions were applied. Reference lists of included studies and previous systematic reviews were hand-searched.

Participant or population Adults (≥18 years) with a clinical diagnosis of carpal tunnel syndrome, with or without electrodiagnostic or sonographic confirmation.

Intervention Percutaneous real-time ultrasound-guided carpal tunnel release (UGCTR) categorized by the three most extensively studied release mechanisms: thread transection, hook knife, and commercial retractable knife systems.

Comparator Single-arm UGCTR cohorts and individual UGCTR treatment arms analyzed as uncontrolled before–after series. No concurrent non-operative control or open/endoscopic surgical comparator was required, as the objective was to describe technique-specific outcomes.

Study designs to be included Prospective and retrospective cohort studies, registry studies, randomized controlled trials, and single-arm case series enrolling at least five patients.

Eligibility criteria Prospective and retrospective cohort studies, registry studies, and single-arm case series enrolling at least five patients.

Information sources Inclusion criteria: (1) adults aged ≥18 years with carpal tunnel syndrome; (2) percutaneous real-time UGCTR using thread transection, hook knife, or retractable knife; (3) reported paired preoperative and postoperative BCTQ scores or extractable secondary outcomes; (4) sample size ≥5 patients. Exclusion criteria: (1) case reports and series with <5 patients; (2) cadaveric or animal studies; (3) technical notes without clinical outcomes; (4) narrative reviews and conference abstracts; (5) studies of ultrasound-guided hydrodissection or hydrorelease without TCL transection; (6) reports with insufficient methodological detail for risk-of-bias assessment.

Main outcome(s) Uncontrolled within-group improvement in the Boston Carpal Tunnel Questionnaire Symptom Severity Scale (BCTQ-SSS), calculated as the preoperative score minus the score at the final follow-up window (6–12 months). Clinical relevance was benchmarked against the anchor-based minimal clinically important difference (MCID) threshold of 1.14 points.

Additional outcome(s) BCTQ Functional Status Scale (BCTQ-FSS) improvement (MCID 0.74 points); QuickDASH score improvement; quantitative return-to-work time (days); procedure duration; and safety events (any adverse event, serious adverse events, nerve/vascular/tendon injury, infection, and revision surgery).

Data management Search results were imported into EndNote and deduplicated. Two reviewers independently screened titles/abstracts and full-text articles. Data extractions were recorded in standardized electronic spreadsheets. Extracted variables included study design, cohort provenance, sample size, age, sex, release mechanism, device type, baseline and follow-up BCTQ scores, follow-up timing, and complication counts.

Quality assessment / Risk of bias analysis Risk of bias was evaluated using the ROBINS-I tool (Risk Of Bias In Non-randomized Studies of Interventions) for uncontrolled before–after estimates. Assessments covered seven bias domains: confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and selection of reported results. Two reviewers conducted assessments independently.

Strategy of data synthesis Within-group change scores (preoperative minus follow-up) were synthesized using random-effects meta-analysis models with restricted maximum-likelihood (REML) variance estimation. When change-score standard deviations were unreported, they were imputed assuming a pre–post correlation of r = 0.50. Heterogeneity was quantified using Cochran's Q, I^2, and τ^2. Prespecified mechanism subgrouping (thread transection, hook knife, retractable knife) and sensitivity analyses (correlation r = 0.25/0.75; cohort overlap control) were performed.

Subgroup analysis Prespecified subgroup analysis was conducted by release mechanism: (1) thread transection, (2) hook knife, and (3) commercial retractable knife systems. Between-mechanism differences were evaluated using exploratory subgroup Q tests.

Sensitivity analysis Sensitivity analyses evaluated: (1) varying the pre–post correlation coefficient for change-score SD imputation from r = 0.50 to r = 0.25 and r = 0.75; (2) controlling for cohort overlap by retaining versus excluding overlapping study arms (e.g., Park 2022 vs Kim 2024 family; Chern 2014 vs Chern 2015); (3) leaving out individual

trials (leave-one-out sensitivity analysis); and (4) comparing short-term (1–4 week) versus final follow-up (6–12 month) BCTQ change.

Language restriction No language restrictions were applied to the search.

Country(ies) involved Taiwan.

Other relevant information This protocol was prepared in accordance with the PRISMA-P statement. Protocol amendments, including the choice of the restricted maximum likelihood (REML) between-study variance estimator over DerSimonian-Laird, are documented.

Keywords Carpal tunnel syndrome; Ultrasonography, interventional; Decompression, surgical; Boston Carpal Tunnel Questionnaire; Minimal clinically important difference; Thread carpal tunnel release; Hook.

Dissemination plans Results will be submitted for publication in a peer-reviewed international journal.

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