Endoscopic Versus Open Cubital Tunnel Release: A Systematic Review and Meta-Analysis

HAND
2016, Vol. 11(1) 36–44
© American Association for
Hand Surgery 2016
DOI: 10.1177/1558944715616097
hand.sagepub.com

Salah Aldekhayel¹, Alexander Govshievich¹, James Lee¹,
Youssef Tahiri¹, and Mario Luc¹

Abstract

Background: Several surgical techniques exist for treatment of cubital tunnel syndrome. Endoscopic cubital tunnel release (ECTuR) has been recently reported as a promising minimally invasive technique. This study aims to compare outcomes and complications of open cubital tunnel release (OCTuR) and ECTuR in the treatment of idiopathic cubital tunnel syndrome. **Methods:** A systematic review of the literature (1980–2014) identified 118 citations. Studies including adults with idiopathic cubital tunnel treated exclusively by ECTuR or OCTuR were included. Outcomes of interest were postoperative grading, complications, number of reoperations, and the need for intraoperative conversion to another technique. Postoperative outcomes were combined into a uniform scale with 4 categories: “excellent,” “good,” “fair,” and “poor.” **Results:** Twenty studies met the inclusion criteria (17 observational and 3 comparative), representing 425 open and 556 endoscopic decompressions. In the open group, 79.8% experienced “good” or “excellent” results with 12% complication rate and 2.8% reoperation rate. In the endoscopic group, 81.8% experienced “good” or “excellent” results with 9% complication rate and 1.6% reoperation rate. Meta-analysis of 3 comparative studies demonstrated a significantly lower overall complication rate with ECTuR. Subgroup analysis of complications revealed a significantly higher incidence of scar tenderness and elbow pain with OCTuR. **Conclusions:** The current study demonstrates similar effectiveness between the endoscopic (ECTuR) and open (OCTuR) techniques for treatment of idiopathic cubital tunnel syndrome with similar outcomes, complication profiles, and reoperation rates.

Keywords: compression neuropathy, cubital tunnel, endoscopic, ulnar nerve

Introduction

Ulnar nerve entrapment at elbow represents the second most common entrapment syndrome in upper extremity after carpal tunnel syndrome with an annual incidence of 20.9/100 000.¹⁷ Various surgical techniques have been proposed to release ulnar nerve from the confines of cubital tunnel; however, no gold standard exists. Traditionally, surgical options ranged from simple open decompression with or without nerve transposition to open decompression with medial epicondylectomy. Several studies, including a recent Cochrane meta-analysis,⁴ showed comparable outcomes between simple decompression and transposition with a higher complication rate with ulnar nerve transposition.^{2,10,15} However, the evidence is still insufficient and the choice is largely left to the surgeon’s discretion.

In recent years, a minimally invasive technique has been introduced. First described by Tsai et al in 1995,²⁹ endoscopically assisted release of cubital tunnel has shown promising results similar to those reported for open

decompression. Furthermore, several authors have claimed that endoscopic approach has the additional benefits of smaller scar, reduced postoperative pain, and faster return to activities of daily living.^{1,8,9,11,25} To examine whether endoscopic cubital tunnel release (ECTuR) or open cubital tunnel release (OCTuR) would have superior outcomes with lower morbidity in patients with idiopathic cubital tunnel syndrome, we reviewed all studies that examined either endoscopic or open cubital tunnel release or compared both with regard to postoperative outcomes and complication profile in a systematic review design with meta-analysis.

¹McGill University Health Centre, Montreal, Québec, Canada

Corresponding Author:

Mario Luc, Assistant Professor, Division of Plastic and Reconstructive Surgery, McGill University Health Centre, Montreal General Hospital, 1650 Cedar Avenue, Room L9-317, Montreal, Québec, Canada H3G 1A4.

Email: drmluc@gmail.com

Materials and Methods

Study Selection

A systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. All articles describing open simple decompression or endoscopic simple decompression for idiopathic cubital tunnel syndrome between 1980 and 2014 were retrieved. Electronic databases of PubMed, Ovid MEDLINE, EMBASE, and SCOPUS were searched with medical subject headings and key words, including “cubital tunnel,” “ulnar neuropathy,” ulnar neuritis,” “ulnar nerve entrapment,” “open decompression,” “simple decompression,” “in situ decompression,” “endoscopic decompression,” and “arthroscopic decompression.” Furthermore, abstracts were searched from the archives of the American Society of Plastic Surgeons (2002-2014), Canadian Society of Plastic Surgeons (2007-2014), American Association of Plastic Surgeons (2006-2014), American Association of Hand Surgeons (2007-2014), American Society for Surgery of the Hand (2000-2014), American Association of Neurological Surgeons (2009-2014), and Canadian Orthopedic Association (2003-2014).

Inclusion/Exclusion Criteria

The following inclusion criteria were applied: (1) study population of adult patients (>18 years), (2) idiopathic ulnar nerve entrapment at elbow confirmed clinically and/or electrophysiologically, (3) surgical intervention either open simple decompression or endoscopic decompression, (4) study including objective and well-described outcomes, (5) study published in English or French, (6) year of publication between 1980 and 2014, and (7) sample size >10 patients. Exclusion criteria included any study that included surgical techniques other than open or endoscopic cubital tunnel release (eg, transposition, epicondylectomy, etc). Articles that met inclusion/exclusion criteria following title and abstract review were selected for full-text review. Inclusion criteria were applied once again and all remaining papers were reference checked to identify additional relevant studies. The review process was done by 2 reviewers independently, and any discrepancies were resolved by consensus.

Data Extraction/Collection Process

Data were collected from all selected studies using a standard data extraction sheet developed for this review. The following study characteristics were recorded: type of intervention, number of patients, number of arms operated, age, diagnostic criteria, inclusion/exclusion criteria, preoperative evaluation of severity of symptoms, postoperative complications, type and number of reoperations, postoperative evaluation of outcomes, and follow-up period. The level

Table 1. Level of Evidence for Primary Research Question: Therapeutic Studies.

Level of evidence	Qualifying studies
I	High-quality randomized controlled trial with statistically significant difference or no statistically significant difference but narrow confidence intervals, or systematic review of these studies
II	Lesser quality randomized controlled trial, prospective comparative study, or systematic review of these studies
III	Retrospective comparative study, case-control study, or systematic review of these studies
IV	Case series
V	Expert opinion

Source. Based on data from Oxford Centre for Evidence-Based Medicine—Levels of Evidence (March 2009).

of evidence from the Oxford Centre for Evidence-Based Medicine was used to grade all articles (Table 1).²³

Specific attention was given to the evaluation of preoperative clinical status and grading of postoperative outcomes. For each article, we recorded disease-specific instruments used by authors to classify disease severity prior to surgery and instruments used to evaluate surgical success. For preoperative severity assessment, McGowan's and Dellon's scales were used in nearly all studies. To simplify the analysis process, definitions of each scale were carefully examined and McGowan's scale was transformed into Dellon's scale in the following manner: Grade I McGowan is equivalent to “Mild,” Grade II is equivalent to “Moderate,” and Grade III is equivalent to “Severe” on Dellon's scale. For postoperative outcome assessment, several rating systems were used across all studies (see Table 3). Also, several studies used author-generated instruments to assess postoperative outcomes, which needed to be converted manually into the Wilson and Krout scale as it contains a broad definition for each category. Similarly, all scales used in postoperative assessment were analyzed individually. Despite their slight differences, they shared sufficient similarities with respect to postoperative results and status of clinical improvement and were unified for the purpose of statistical analysis. Therefore, they were combined into a single, uniform unit of measurement comprised of 4 categories as shown in Table 2.

Meta-Analysis

Data from 3 studies^{3,8,30} that compared ECTuR with OCTuR were pooled for meta-analysis. Analysis was done for 2 outcomes: (1) clinical improvement and (2) complications. (1) Clinical improvement was defined as either an “excellent” or “good” outcome on postoperative Bishop

Table 2. Definition of the Combined Postoperative Outcome Assessment System and Equivalence of Original Scales to the Combined System.

Combined system	Definition	Bishop	Messina	W & K	G & A	A & F	McGowan
Excellent	Complete resolution of symptoms	Excellent	Excellent	Excellent	Excellent	Excellent	0
Good	General resolution with mild residual intermittent symptoms	Good	Good	Good	Good	Good	I
Fair	Mild improvement with significant residual persistent symptoms	Fair	Fair	Fair	Fair	Poor	II
Poor	Lack of improvement or worsening of initial symptoms	Poor	Poor	Poor	Poor	Worse	III

Note. W & K, Wilson and Krout; G & A, Gabel and Amadio; A & F, Alnot and Frajman.

score^{3,8} or as subjective patient satisfaction measured on the Visual Analog Scale (VAS),³⁰ as those were the primary outcomes in those studies. (2) Overall complication rate was determined and a subgroup analysis was performed for each of the most frequently observed complications in each group: (1) scar tenderness/elbow pain, (2) hematoma, (3) ulnar nerve subluxation, and (4) reoperation. Data were dichotomized into “improved or not improved” for the clinical improvement outcome and into “present or absent” for the complications outcome. For each outcome, risk ratio (RR) was calculated with 95% confidence interval (CI), and effect sizes were weighted by the sample size of each study. Data were pooled and analyzed using random effect model based on the assumption that different studies are estimating different, yet related, intervention effects, and hence it is a more conservative approach to address intra- and interstudy differences as opposed to fixed effect. Random effect model was performed using inverse-variance statistical method. As clinical improvement is a desired outcome, RR of more than 1 is in favor of experimental group (ECTuR). In contrast, complications are undesired and therefore RR of less than 1 would favor the experimental group (ECTuR). A *P* value < .05 was considered statistically significant.

Heterogeneity was explored using the I-square test (I^2) and any sources of heterogeneity, if present, were examined. I^2 < 30% indicates no heterogeneity. We hypothesized sources of potential heterogeneity a priori, which include differences in surgical techniques, outcome measures reporting, and duration of postoperative assessment. Statistical analysis was performed using Review Manager (RevMan) software, Version 5.2 (Nordic Cochrane Centre, Cochrane Collaboration, Copenhagen).

Results

Study Selection

After eliminating nonrelevant and duplicate studies, the primary literature search identified 118 citations. A multistep

reviewing process is shown in Figure 1. A total of 17 studies were included. Cross-referencing added 3 more studies for a total of 20 studies included.

Study Characteristics

Among the studies selected, 17 were observational and 3 were comparative. Studies were grouped according to type of intervention into 2 groups; the OCTuR group was comprised of 11 studies, representing a total of 383 patients with 425 arms, and the ECTuR group was made up of 12 studies representing 529 patients with 556 arms (Table 3). The follow-up ranged from 5 to 51 months (average 15.1 months) in the OCTuR group and 6 to 37 months (average 18.8 months) in the ECTuR group. The mean age of patients was comparable in both groups, 48.1 years in the OCTuR group versus 48.9 years in the ECTuR group.

Open Cubital Tunnel Release

Of the 425 open decompressions, 243 were graded preoperatively (Table 4); 43 (17.7%) were graded as Grade I, 70 (28.8%) as Grade II, and 130 (53.5%) as Grade III. Postoperative outcomes were evaluated in 403 of the open cases; 257 (60.5%) were reported as “excellent,” 82 (19.3%) as “good,” 46 (10.8%) as “fair,” and 18 (4.2%) as “poor.” Watts et al³⁰ reported their 15 cases using patient satisfaction (9 patients satisfied; 60%) and median VAS for ongoing hand symptoms, which was 60% for OCTuR group.

The overall complication rate was 12% (51 cases), the most frequent being numbness due to medial antebrachial cutaneous (MABC) nerve injury (*n* = 20) and scar sensitivity (*n* = 10). Resolution of numbness along the MABC nerve distribution was not described. Twelve patients needed reoperations with either anterior transposition of the ulnar nerve (*n* = 9), medial epicondylectomy (*n* = 2), or redo open release (*n* = 1). No cases were converted to other techniques intraoperatively.

Figure 1. Study selection flowchart.

Endoscopic Cubital Tunnel Release

Of 556 endoscopic decompressions, 547 were graded pre-operatively; 95 (17.4%) were graded as Grade I, 257 (47%) as Grade II, and 195 (35.6%) as Grade III. Postoperative outcomes were evaluated in 519 cases; 302 (54.3%) were reported as “excellent,” 153 (27.5%) as “good,” 51 (9.2%) as “fair,” and 13 (2.3%) as “poor.” Eight cases (1.5%) were lost to follow up and were excluded from the original

results,^{22,25} and 1 case (0.2%) was converted to submuscular transposition and excluded as well.²² However, we included all missing and converted cases in our analysis in an intention to treat analysis. Watts et al did not use any of the outcome scales, rather they used patient satisfaction as their primary outcome (15 out of 19 patients were satisfied; 79%) and median VAS for ongoing hand symptoms which was 90% for the ECTuR group.³⁰

Table 3. Study Characteristics.

Author	Year	Study design	Level of evidence	Type of decompression	Patients operated	Arms operated	Preoperative severity scale	Postoperative severity scale
Tsai et al ²⁹	1999	Case series	IV	ECTuR	76	85	Dellon	Bishop
Hoffmann and Siemionow ¹⁰	2006	Case series	IV	ECTuR	75	76	Dellon	Bishop
Ahcan and Zorman ¹	2007	Case series	IV	ECTuR	36	36	McGowan	W & K
Yoshida et al ³¹	2009	Case series	IV	ECTuR	35	35	McGowan	McGowan
Oertel et al ²²	2010	Case series	IV	ECTuR	24	26	McGowan	McGowan
Stadie et al ²⁵	2010	Case series	IV	ECTuR	27	32	McGowan	McGowan
Cobb et al ⁶	2010	Case series	IV	ECTuR	94	104	Dellon	Bishop
Flores ⁹	2010	Case series	IV	ECTuR	13	13	Dellon	Bishop
Leclerc et al ¹³	2011	Case series	IV	ECTuR	55	55	Dellon	Bishop
Miller and Hummel ¹⁶	1980	Case series	IV	OCTuR	12	12	N/A	Author-generated
Nathan et al ²¹	1995	Case series	IV	OCTuR	131	164	McGowan	Author-generated
Taniguchi et al ²⁶	2002	Case series	IV	OCTuR	17	18	McGowan	Messina
Pavelka et al ²⁴	2004	Case series	IV	OCTuR	52	55	Dellon	Author-generated
Mondelli et al ¹⁸	2004	Case series	IV	OCTuR	18	19	McGowan	A & F
Cho et al ¹⁵	2007	Case series	IV	OCTuR	15	15	Dellon	Bishop
Karthik et al ¹²	2012	Case series	IV	OCTuR	30	30	Dellon	Bishop
Nagle et al ²⁰	2012	Case series	IV	OCTuR	12	16	McGowan	G & A
Bolster et al ³	2013	Prospective comparative study	III	ECTuR vs OCTuR	42	42	Dellon	Bishop
Dutzmann et al ⁸	2013	Retrospective comparative study	III	ECTuR vs OCTuR	114	114	McGowan	Bishop
Watts and Bain ³⁰	2009	Retrospective comparative study	III	ECTuR vs OCTuR	34	34	McGowan	Author-generated

Note. ECTuR, endoscopic cubital tunnel release; W & K, Wilson and Krout; OCTuR, open cubital tunnel release; A & F, Alnot and Frajman; G & A, Gabel and Amadio.

There were a total of 50 reported complications with an overall complication rate of 9%. The most frequent complication was hematoma ($n = 17$) that needed operative evacuation in 4 cases, the rest resolved spontaneously. Numbness along the MABC nerve distribution was the second common complication ($n = 10$), the majority of which resolved completely by 3 months (8 out of 10 cases). Nine cases (1.6%) required reoperation, 4 of which due to symptoms recurrence, 3 due to treatment failure, and 2 for subluxation of ulnar nerve. Three cases (0.5%) required intraoperative conversion to open decompression; 2 cases were converted to OCTuR due to a ganglion surrounding the ulnar nerve in the forearm in 1 case and the need for neurolysis in another. The third case was converted to anterior submuscular transposition due to ulnar nerve subluxation. There was 1 reported case (0.18%) of partial ulnar nerve injury (laceration of less than 5% of the nerve's cross-sectional area) during endoscopic release¹³ that was repaired intraoperatively with complete recovery.

Table 4 summarizes severity, outcomes, and complications of both groups.

Meta-Analysis

Three studies that compared ECTuR with OCTuR were included in meta-analysis with a total of 190 patients.^{3,8,30} Figures 2, 3, and 4 summarize results of the analysis. Although there was a trend in favor of ECTuR with regard to clinical improvement (RR 1.1), the results were not statistically significant ($P = .15$). Regarding overall complications, there was a significantly lower complication profile (hematoma, scar tenderness/elbow pain, ulnar nerve subluxation, reoperation) in ECTuR compared with OCTuR ($P = .01$). In a subgroup analysis of individual complications, there was a significantly higher incidence of scar tenderness/elbow pain in OCTuR group ($P = .002$; Figures 3 and 4), whereas there were no significant differences in the other complications such as hematoma

Table 4. Summary of Grading and Complications by Group.

Group	Combined preoperative grading	Combined postoperative grading	Complications	Reoperations	Converted to open
OCTuR (n = 425)	Grade I: 43 (17.7%) Grade II: 70 (28.8%) Grade III: 130 (53.5%)	Excellent: 257 (60.5%) Good: 82 (19.3%) Fair: 46 (10.8%) Poor: 18 (4.2%) Ungraded: 22	Hematoma: 2 MABC nerve lesion: 20 Scar sensitivity: 10 Diffuse elbow pain: 1 Subluxation: 4 Infection: 1 Reoperation: 13 Conversion: 0 Total: 51 (12%)	Recurrence: 1 Failure: 7 (AT) Subluxation: 4 (2 AT, 2 medial epicondylectomy) Total: 12 (2.8%)	None
ECTuR (n = 556)	Grade I: 95 (17.4%) Grade II: 257 (47%) Grade III: 195 (35.6%)	Excellent: 302 (54.3%) Good: 153 (27.5%) Fair: 51 (9.2%) Poor: 13 (2.3%) Missing/Converted: 9 (1.6%) Ungraded: 28	Hematoma: 17 (4 operative) MABC nerve lesion: 10 (8 resolved by 3 months) Diffuse elbow pain: 1 Subluxation of nerve: 4 Infection: 2 CRPS: 2 Thrombophlebitis: 1 Partial ulnar nerve injury: 1 Reoperation: 9 Conversion: 3 Total: 50 (9%)	Recurrence: 4 (MT) Failure: 3 (OCTuR) Subluxation of nerve: 2 (endoscopic AT) Total: 9 (1.6%)	Ganglion: 1 Subluxation: 1 Nerve adhesions: 1 Total: 3 (0.5%)

Note. OCTuR, open cubital tunnel release; MABC, medial antebrachial cutaneous; ECTuR, endoscopic cubital tunnel release; AT, anterior transposition; MT, submuscular transposition; CRPS, complex regional pain syndrome.

Figure 2. Forest plot of Comparison 1: Clinical improvement.

Note. ECTuR, endoscopic cubital tunnel release; OCTuR, open cubital tunnel release; CI, confidence interval.

Figure 3. Forest plot of Comparison 2: Complications, outcome: 2.1 overall complications.

Note. ECTuR, endoscopic cubital tunnel release; OCTuR, open cubital tunnel release; CI, confidence interval.

Figure 4. Forest plot of Comparison 2: Complications, outcome: 2.2 scar tenderness/elbow pain.

Note. ECTuR, endoscopic cubital tunnel release; OCTuR, open cubital tunnel release; CI, confidence interval.

(RR 3.64 [95% CI, 0.4-31.9]; $P = .24$), ulnar nerve subluxation (RR 9.64 [95% CI, 0.53-175.07], $P = .13$), and reoperation (RR 5.36 [95% CI, 0.26-109.17]; $P = .28$).

Discussion

ECTuR has been introduced as an alternative treatment modality for cubital tunnel syndrome since the 1990s. In theory, it offers outcomes similar to open cubital tunnel release (OCTR) while providing the additional benefits of a minimally invasive approach. It aims to minimize incision size, reduce potential risk of MABC nerve injury, and provide better visualization of the entire course of ulnar nerve both proximal and distal to the elbow.

Our systematic review demonstrated an overall weighted average of excellent outcomes of 54.3% and 60.5% in ECTuR and OCTuR, respectively. Good outcomes were observed in 27.5% and 19.3% of ECTuR and OCTuR cases, respectively. Together, good and excellent results were achieved in 81.8% of patients in the OCTuR group and 79.8% in the ECTuR group. Statistical comparison was not performed due to significant heterogeneity in outcome measures across included studies. Similarly, inconsistency in data reporting including details of preoperative severity scales further complicated any attempt at data pooling and determining if a correlation exists between the severity of nerve compression and the treatment outcomes. Although more severe preoperative grading (Grade III) was reported in the OCTuR group (57.2% vs 35.6%), which may mitigate the higher complication rate observed with this technique, only 57.2% of patients (243/425) had the severity of their symptoms graded compared with 98.4% of patients (547/556) in the endoscopic group.

Nevertheless, we were able to combine the only 3 comparative studies in a meta-analysis, which showed no difference in clinical improvement outcome among both groups (RR 1.10 [95% CI, 0.97-1.25]), but demonstrated a significant reduction in the overall complication rate (RR 0.44 [95% CI, 0.23-0.85]), particularly in scar tenderness and elbow pain (RR 0.08 [95% CI, 0.02-0.40]) in favor of ECTuR. However, given the small sample size and scarcity of comparative studies included, a meta-analysis on this subject does not provide sufficient evidence to draw con-

crete conclusions and does not show superiority of one procedure versus another.

Advantages of OCTuR over other types of surgical releases (transposition, epicondylectomy) have been well documented in the literature as evidenced by its comparable outcomes with lower complication profile.^{15,19,32} Yet, no comparisons were made to endoscopic release, which in theory achieves the same goals of simple in situ decompression but using a minimally invasive approach. Reported advantages of ECTuR include smaller incision, minimal soft tissue dissection with reduced injury of MABC nerve, and complete release of distant potential compression sites. Furthermore, it requires no special instrumentation apart from the endoscope and has a relatively short learning curve.¹¹ Hoffmann and Siemionow demonstrated multiple compression sites of the ulnar nerve up to 9 cm distal to the midpoint of the retrocondylar groove.¹¹ He believes that the release of those bands would otherwise require a radical in situ decompression or a complex transposition, and hence an endoscopic release would offer a greater advantage of releasing those bands without complex soft tissue dissection. Drawbacks of ECTuR include higher risk of hematoma, resulting ulnar nerve subluxation, and theoretical risk of iatrogenic ulnar nerve injury with blind introduction of the endoscope.

Our systematic review showed an overall complication rate of 9% and 12% in ECTuR and OCTuR, respectively. The slightly lower trend in complication rate in the ECTuR group is supported by the meta-analysis that showed RR of 0.44 in favor of ECTuR. Hematoma was the most common complication in the ECTuR group (34% of overall complications) compared with 4% in the OCTuR; however, less than 25% of those required surgical evacuation. Despite the fact that almost all studies in the ECTuR group (9 out of 12) have reported some form of preventive steps to reduce hematoma formation (tourniquet release, bipolar cauterization, closed suction drains, compressive dressing), the incidence of hematoma persisted to be higher in this group. The only explanation of such a finding is the inherent narrow surgical field in ECTuR with resulting limited hemostasis. On the contrary, numbness around elbow and medial forearm likely related to MABC nerve injury was the most common complication in the OCTuR group (39%) compared

with 20% in the ECTuR (only 4% were permanent). MABC nerve injury is undoubtedly more common in OCTuR, as demonstrated in our meta-analysis and in the rest of literature.^{7,14} Furthermore, better postoperative scar tenderness was noticed in the ECTuR group that goes along with similar findings in endoscopic carpal tunnel release.²⁷

For purposes of this review, we defined recurrence as worsening symptoms following an initial period of improvement after original cubital tunnel release that necessitated a reoperation whereas failure was defined as the persistence of original symptoms despite surgical intervention. Reasons for reoperation were either recurrence of symptoms, failure of treatment, or resulting ulnar nerve subluxation following decompression. The reoperation rate was slightly higher in OCTuR (2.8% vs 1.6%). Generally, reoperated cases among the ECTuR group were done using OCTuR for failures, endoscopic subcutaneous transposition for subluxation, or open submuscular transposition for recurrences. In contrast, reoperations in the OCTuR group were mostly done using subcutaneous transposition for failures/subluxation or epicondylectomy for subluxation (Table 4). The intraoperative conversion from ECTuR to OCTuR was needed due either to a ganglion compressing ulnar nerve, an intraoperative ulnar nerve subluxation necessitating a transposition, or ulnar nerve adhesions necessitating a safe open neurolysis. However, conversion rate is probably underestimated as many studies had excluded converted cases in their exclusion criteria. Similarly, studies in OCTuR did not include any cases that were converted to transposition due to ulnar nerve subluxation. Hence, careful interpretation of the conversion rate should not overlook an inherent selection bias in those studies.

Limitations of our study include the absence of randomized controlled trials, inclusion of predominantly observational studies (Level IV evidence), paucity of articles directly comparing OCTuR and ECTuR included in the meta-analysis, and inconsistency in outcome measures reporting, making an objective conclusion more difficult to make. Diversity in postoperative outcome scales makes data pooling and subgroup analysis a statistically impossible task to perform and therefore calls for a more unified classification system to be used in all future studies. Attempt at combining those systems was done for purposes of combining crude results using weighted averages but not to contemplate statistical analysis. In addition, data on return to work and grip strength were insufficient to draw any useful inferences if any difference exists. One should be cautious in interpreting the results of unified postoperative scale, as it does not address those objective outcomes (grip strength, postoperative nerve conduction studies, etc). Another limitation is selection bias in those studies inherent to their nonrandomized, uncontrolled designs. Majority of studies excluded patients who had an intraoperative subluxation and therefore needed epicondylectomy or an anterior transposition. Furthermore, patients who were expected to have subluxation (on preoperative evaluation) were not

included at first intention. We tried to include those patients in data pooling in an intention to treat analysis; however, this was not possible in most studies in systematic review due to unreported data. Such a bias could have a significant impact on overall conversion rates, and hence it should be interpreted cautiously. With regard to surgical techniques, several ones have been used by different studies, but conducting a subgroup analysis was not feasible due to lack of standardized outcome measures as previously discussed. Techniques can be broadly categorized as those involving passing endoscope below the cubital tunnel roof: Agee system,^{25,30} Universal Subcutaneous Endoscope,³¹ cannula or glass tube-assisted,^{6,28} or in a plane between the cubital tunnel roof^{1,8,9,11} and subcutaneous tissue.^{3,13,22}

The current study demonstrates similar effectiveness between the endoscopic (ECTuR) and open (OCTuR) techniques for treatment of idiopathic cubital tunnel syndrome with similar outcomes, complication profiles, and reoperation rates. However, it should be applied in selected patients who do not have preoperative evidence of nerve subluxation, previous traumatic injuries to elbow, or obvious anatomical pathology. Current evidence lacks data to draw rigorous conclusion on objective outcome measures, return to work, and cost-benefit analyses. Further randomized controlled studies implementing standardized classification systems and objective outcome measures are required.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all patients for being included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Ahcan U, Zorman P. Endoscopic decompression of the ulnar nerve at the elbow. *J Hand Surg Am.* 2007;32:1171-1176.
2. Bartels RH, Verhagen WI, van der Wilt GJ, Meulstee J, van Rossum LG, Grotenhuis JA. Prospective randomized controlled study

- comparing simple decompression versus anterior subcutaneous transposition for idiopathic neuropathy of the ulnar nerve at the elbow: Part 1. *Neurosurgery*. 2005;56:522-530.
3. Bolster MA, Zöphel OT, van den Heuvel ER, Ruettermann M. Cubital tunnel syndrome: a comparison of an endoscopic technique with a minimal invasive open technique. *J Hand Surg Eur Vol*. 2014;39:621-625. doi:10.1177/1753193413498547.
 4. Caliendo P, La Torre G, Padua R, Giannini F, Padua L. Treatment for ulnar neuropathy at the elbow. *Cochrane Database Syst Rev*. 2012;7:CD006839.
 5. Cho YJ, Cho SM, Sheen SH, Choi J-H, Huh D-H, Song J-H. Simple decompression of the ulnar nerve for cubital tunnel syndrome. *J Korean Neurosurg Soc*. 2007;42:382-387.
 6. Cobb TK, Sterbank PT, Lemke JH. Endoscopic cubital tunnel recurrence rates. *Hand*. 2010;5:179-183.
 7. Dellon AL, MacKinnon SE. Injury to the medial antebrachial cutaneous nerve during cubital tunnel surgery. *J Hand Surg Br*. 1985;10:33-36.
 8. Dutzmann S, Martin KD, Sobottka S, et al. Open vs retractor-endoscopic in situ decompression of the ulnar nerve in cubital tunnel syndrome: a retrospective cohort study. *Neurosurgery*. 2013;72:605-616.
 9. Flores LP. Endoscopically assisted release of the ulnar nerve for cubital tunnel syndrome. *Acta Neurochir*. 2010;152:619-625.
 10. Gervasio O, Gambardella G, Zacccone C, Branca D. Simple decompression versus anterior submuscular transposition of the ulnar nerve in severe cubital tunnel syndrome: a prospective randomized study. *Neurosurgery*. 2005;56:108-117.
 11. Hoffmann R, Siemionow M. The endoscopic management of cubital tunnel syndrome. *J Hand Surg Br*. 2006;31:23-29.
 12. Karthik K, Nanda R, Storey S, Stothard J. Severe ulnar nerve entrapment at the elbow: functional outcome after minimally invasive in situ decompression. *J Hand Surg Eur Vol*. 2012;37:115-122.
 13. Leclerc FM, Manz S, Unglaub F, Cardenas E, Hahn P. Endoscopic decompression of the ulnar nerve in the cubital tunnel syndrome: about 55 patients. *Neurochirurgie*. 2011;57:73-77.
 14. Lowe JB, Maggi SP, Mackinnon SE. The position of crossing branches of the medial antebrachial cutaneous nerve during cubital tunnel surgery in humans. *Plast Reconstr Surg*. 2004;114:692-696.
 15. Macadam SA, Gandhi R, Bezuhly M, Lefaivre KA. Simple decompression versus anterior subcutaneous and submuscular transposition of the ulnar nerve for cubital tunnel syndrome: a meta-analysis. *J Hand Surg Am*. 2008;33:1314-1324.
 16. Miller RG, Hummel EE. The cubital tunnel syndrome: treatment with simple decompression. *Ann Neurol*. 1980;7:567-569.
 17. Mondelli M, Giannini F, Ballerini M, Ginanneschi F, Martorelli E. Incidence of ulnar neuropathy at the elbow in the province of Siena (Italy). *J Neurol Sci*. 2005;234:5-10.
 18. Mondelli M, Giannini F, Morana P, Rossi S. Ulnar neuropathy at the elbow: predictive value of clinical and electrophysiological measurements for surgical outcome. *Electromyogr Clin Neurophysiol*. 2004;44:349-356.
 19. Mowlavi A, Andrews K, Lille S, Verhulst S, Zook EG, Milner S. The management of cubital tunnel syndrome: a meta-analysis of clinical studies. *Plast Reconstr Surg*. 2000;106:327-334.
 20. Nagle DJ, Patel RM, Paisley S. Endoscopic detection of compressing fascial bands around the ulnar nerve within the FCU. *Hand*. 2012;7:103-107.
 21. Nathan PA, Keniston RC, Meadows KD. Outcome study of ulnar nerve compression at the elbow treated with simple decompression and an early programme of physical therapy. *J Hand Surg Br*. 1995;20:628-637.
 22. Oertel J, Keiner D, Gaab MR. Endoscopic decompression of the ulnar nerve at the elbow. *Neurosurgery*. 2010;66:817-824.
 23. Oxford Centre for Evidence-Based Medicine—Levels of Evidence (March 2009). Produced by Bob Phillips, Chris Ball, Dave Sackett, Doug Badenoch, Sharon Straus, Brian Haynes, Martin Dawes since November 1998. Updated by Jeremy Howick March 2009.
 24. Pavelka M, Rhomberg M, Estermann D, Löscher WN, Piza-Katzer H. Decompression without anterior transposition: an effective minimally invasive technique for cubital tunnel syndrome. *Minim Invasive Neurosurg*. 2004;47:119-123.
 25. Stadie AT, Keiner D, Fischer G, Conrad J, Welschehold S, Oertel J. Simple endoscopic decompression of cubital tunnel syndrome with the Agee system: anatomic study and first clinical results. *Neurosurgery*. 2010;66:325-331.
 26. Taniguchi Y, Takami M, Takami T, Yoshida M. Simple decompression with small skin incision for cubital tunnel syndrome. *J Hand Surg Br*. 2002;27:559-562.
 27. Thoma A, Veltri K, Haines T, Duku E. A meta-analysis of randomized controlled trials comparing endoscopic and open carpal tunnel decompression. *Plast Reconstr Surg*. 2004;114:1137-1146.
 28. Tsai TM, Bonczar M, Tsuruta T, Syed SA. A new operative technique: cubital tunnel decompression with endoscopic assistance. *Hand Clin*. 1995;11:71-80.
 29. Tsai TM, Chen IC, Majd ME, Lim BH. Cubital tunnel release with endoscopic assistance: results of a new technique. *J Hand Surg Am*. 1999;24:21-29.
 30. Watts AC, Bain GI. Patient-rated outcome of ulnar nerve decompression: a comparison of endoscopic and open in situ decompression. *J Hand Surg Am*. 2009;34:1492-1498.
 31. Yoshida A, Okutsu I, Hamanaka I. Endoscopic anatomical nerve observation and minimally invasive management of cubital tunnel syndrome. *J Hand Surg Eur Vol*. 2009;34:115-120.
 32. Zlowodzki M, Chan S, Bhandari M, Kalliaainen L, Schubert W. Anterior transposition compared with simple decompression for treatment of cubital tunnel syndrome. A meta-analysis of randomized, controlled trials. *J Bone Joint Surg Am*. 2007;89:2591-2598.