Improved Surgical Outcomes With Endoscopic Carpal Tunnel Release in Patients With Severe Median Neuropathy

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Abstract

Background: Carpal tunnel syndrome (CTS) can be treated with open carpal tunnel release (OCTR) or endoscopic carpal tunnel release (ECTR). Our goal was to evaluate the safety and efficacy of ECTR versus OCTR in patients with severe CTS. We hypothesized that ECTR would be as safe and effective as OCTR in these patients. **Methods:** This was a retrospective cohort study of patients with severe CTS who underwent ECTR or OCTR by E. G. Deune between 2001 and 2014. Variables were patient age, sex, relevant medical history, alcohol and tobacco use, and preoperative electromyography and physical examination results. The primary outcome was patient-reported resolution of neuropathic symptoms at last follow-up. Secondary outcomes were surgical complications and need for reoperation. We compared the cohorts using Student's *t* tests and chi-square tests. **Results:** We identified 138 cases of severe CTS in 126 patients who met our inclusion criteria. Thirty-nine cases were treated with ECTR and 99 with OCTR. Mean ages were 59 years (ECTR group) and 56 years (OCTR group). The population was 68% women, and 56% of cases involved the dominant hand. The distributions of age, sex, hand dominance, presence of relevant medical history, and alcohol and tobacco use did not differ significantly between groups. Treatment completely resolved CTS symptoms in 82% of ECTR cases and 39% of OCTR cases. Complication rates (all causes) were similar for both procedures. Recurrence was observed in 2.6% of ECTR cases and 10% of OCTR cases. **Conclusions:** ECTR is a safe and effective alternative to OCTR for patients with severe CTS.

Keywords: carpal tunnel syndrome, endoscopic, patient-reported outcomes

Introduction

Median neuropathy, more commonly known as carpal tunnel syndrome (CTS), is the most common peripheral nerve entrapment neuropathy, affecting up to 5% of adults in the United States.³ CTS is graded as mild, moderate, or severe on the basis of electrodiagnostic findings. When nonoperative treatment with postural adjustments, oral anti-inflammatory medications, and corticosteroid injections has failed, surgical division of the transverse carpal ligament is offered. Historically, open carpal tunnel release (OCTR) was the only option. Endoscopic carpal tunnel release (ECTR) was later developed with the advent of the 2-portal Chow technique⁴ in 1989 and the single-portal Agee technique¹ in 1992. Subsequently, several randomized, controlled trials showed that open and endoscopic techniques are similarly effective.^{2,10,14}

Opposition to ECTR stems from concerns about iatrogenic injuries,¹⁷ technical difficulty,⁶ and cost-effectiveness.⁵ However, ECTR has been shown to result in earlier return to work,²⁵ faster return of grip strength,²⁶ and fewer wound

complications.¹¹ Despite this, OCTR is more commonly performed than ECTR.²⁰ When managing severe CTS, OCTR is generally preferred. Support for this surgical approach primarily derives from anatomical investigations that suggest ECTR is more likely to incompletely release the distal fibers of the transverse carpal ligament.^{15,21} However, clinical studies evaluating the safety and effectiveness of ECTR in patients with severe CTS have not been performed.

The purpose of this study was to determine whether ECTR is at least equally safe and effective compared with OCTR in patients with severe CTS by comparing (1) patient-reported symptom relief and (2) postoperative complications and recurrence rates. Our hypothesis was that

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ECTR and OCTR would have equivalent surgical outcomes and complication rates in these patients.

Materials and Methods

Study Design

This was a retrospective study of patients who underwent ECTR or OCTR at 1 institution by E. G. Deune between 2001 and 2014. We included all patients who met the following criteria: (1) age >18 years at surgery, (2) available electrodiagnostic studies performed at our institution, (3) clinical and electrical diagnosis of CTS, and (4) 2 or more postoperative follow-up visits. The following were exclusion criteria: (1) employment by our medical institution at the time of surgery, (2) OCTR or ECTR performed emergently, (3) incomplete medical records, and (4) previous CTS surgery. Our definition of severe CTS was based on the criteria of Sucher; severe CTS was characterized by unobtainable median sensory response, low-amplitude median mixed nerve response, and low-amplitude median compound muscle action potential with prolonged distal latency.²⁴ These criteria were modified and combined with data from nerve conduction studies and electromyography (EMG) at our institution. We used the following guidelines to identify cases of severe CTS: (1) complete block of the median nerve sensory response, and (2) median motor response amplitude below 4 mV with an associated latency greater than 6.45 milliseconds. This study was approved by our institutional review board.

Data Extraction

We collected data in a precise sequence to facilitate blinding of reviewers to severity of CTS. All patient information was extracted from a centralized electronic medical records database. Each record was deidentified and assigned a randomly generated number, which was used for all analytical purposes. Each patient's record was separated into preoperative notes (with nerve conduction study and EMG records) and operative/postoperative notes. Assessment of disease severity and preoperative characteristics was done first, and evaluation of outcome variables was done second. In this way, reviewers were blinded to CTS grading information when assessing patient-reported outcomes.

Study Variables

The primary outcome of interest was patient-reported complete resolution of preoperative CTS pain (yes/no). Secondary outcomes were patient-reported improvement in preoperative CTS symptoms (yes/no), need for reoperation, surgical complications, and recurrence. We defined recurrence as onset of preoperative symptoms after an initial

period of symptom resolution, regardless of time period of presentation. We evaluated the medical records for postoperative patient reports of (1) lack of symptomatic relief at any point during follow-up; (2) any relief of preoperative CTS symptoms, regardless of extent, at any point during follow-up; and (3) explicit indication of total resolution of all preoperative CTS symptoms with no indication of new symptoms at last recorded follow-up. Postoperative pain in the web space was defined as pain between the digits at any point during follow-up.

We collected the following patient data: age; sex; hand dominance; history of diabetes mellitus, sleep apnea, hypertension, coronary artery disease, immunosuppression, or malignant neoplasm; current tobacco use; current alcohol use; preoperative carpal tunnel steroid injections (yes/no); presence of positive physical examination signs (Tinel's sign at the wrist); presence of thenar atrophy; EMG abnormalities (fibrillations, positive sharp waves, or fasciculations); surgical complications; and conversion of ECTR to OCTR (if applicable).

Statistical Analysis

All deidentified data were iteratively entered into a commercially available database program (Excel 2010, Microsoft Corp, Redmond, Washington). A power analysis was conducted using G*Power, version 3.1.9.2 (Universität Dusseldorf, Dusseldorf, Germany). We used the following parameters in calculating our post hoc achieved power: type I error rate of 0.05, effect size ratio of 0.5 (indicating a small expected difference), and our sample sizes for the 2 cohorts. The minimum acceptable power was set at 0.80. Descriptive statistics were computed for the study population to provide an overall assessment of the sample. Student's *t* tests (continuous) and chi-square tests of association (categorical) were used for statistical analysis. Statistical significance was set at $P < .05$.

Results

Patient Characteristics

We identified 138 cases of severe CTS in 126 patients who met the inclusion criteria. Thirty-nine cases were treated with ECTR and 99 cases with OCTR. The mean ages were 59 ± 8.1 years for the ECTR group and 56 ± 10.3 years for the OCTR group ($P = .31$). Of the cases, 73% were in women and 56% involved the dominant hand (Table 1). The distributions of age, sex, hand dominance, presence of relevant medical history, alcohol use, and tobacco use did not differ significantly between patients treated with ECTR versus those treated with OCTR. Patients treated with ECTR were not significantly different from those treated with OCTR in terms of preoperative steroid injections into

Table 1. Characteristics of 126 Patients (138 Cases) Who Underwent ECTR or OCTR for Severe Carpal Tunnel Syndrome.

Characteristic	ECTR group (n = 39 cases)		OCTR group (n = 99 cases)		P value
	No.	%	No.	%	
Mean age, y		59 ± 8.1 ^a		56 ± 10.3 ^a	.31
Female sex	30	77	71	72	.61
Dominant hand affected	22	57	54	55	.59
Relevant medical history	32	83	79	80	.63
Hypertension	31	79	75	76	.60
Diabetes	19	48	53	54	.19
Coronary artery disease	8	21	24	24	.41
Alcohol use	12	30	32	32	.64
Tobacco use	7	18	16	16	.62

Note. ECTR = endoscopic carpal tunnel release; OCTR = open carpal tunnel release.

^aExpressed as means ± SDs.

Table 2. Preoperative Characteristics of 126 Patients (138 Cases) Who Underwent ECTR or OCTR for Severe Carpal Tunnel Syndrome.

Characteristic	ECTR (n = 39 cases)		OCTR (n = 99 cases)		P value
	No.	%	No.	%	
Preoperative steroids	3	8	4	4	.20
Positive physical examination	21	54	41	41	.11
Presence of thenar atrophy	31	79	73	73	.28
Electromyographic abnormalities ^a	19	49	67	68	.07

Note. ECTR = endoscopic carpal tunnel release; OCTR = open carpal tunnel release.

^aFibrillations, positive sharp waves, or fasciculations.

the carpal tunnel, presence of positive physical examination findings, presence of thenar atrophy, or EMG abnormalities (Table 2).

Postoperative Results

Eighty-two percent (32 of 39) of cases treated with ECTR had complete resolution of symptoms compared with 39% (39 of 99) of cases that underwent OCTR ($P < .001$; Figure 1). Symptomatic improvement was noted in 95% (37 of 39) of ECTR cases versus 86% (85 of 99) of OCTR cases ($P = .59$). Patients who underwent ECTR had 6.94 times greater odds (95% confidence interval [CI], 2.77-17.38) of complete resolution compared with patients who underwent OCTR. The mean length of follow-up was 16.6 months (range, 1.0-131 months) for cases treated with ECTR and 9.0 months (range, 1.0-143 months) for cases treated with OCTR. Our post hoc computed achieved power was 0.838.

Complications

There were few complications in both groups (Table 3). Postoperative transient pain in the web space was the most common complication. Wound complications were

Figure 1. Patient-reported outcomes for 126 patients (138 cases) with severe CTS who underwent ECTR or OCTR.

Note. The mean follow-up was 9.0 months for OCTR patients and 16.6 months for ECTR patients. Complete resolution of symptoms as indicated by patient's report of resolution of all preoperative CTS symptoms; improvement of symptoms as indicated by patient's report of any relief of preoperative CTS symptoms. CTS = carpal tunnel syndrome; ECTR = endoscopic carpal tunnel release; OCTR = open carpal tunnel release.

uncommon. There was 1 infection in the OCTR group and no infections in the ECTR group. There was no reported delayed wound healing. Recurrence was noted in 2.6% (1 of 39) of cases that underwent ECTR and 10% (10 of 99) of cases that underwent OCTR. The mean time to recurrence

Table 3. Outcomes of 126 Patients (138 Cases) Who Underwent ECTR or OCTR for Severe Carpal Tunnel Syndrome.

Outcome	ECTR (n = 39 cases)		OCTR (n = 99 cases)		P value
	No.	%	No.	%	
Postoperative pain in the web space	0	0	1	1	.81
Conversion from ECTR to OCTR	0	0		NA	NA
Infection	0	0	1	1	.81
All-cause complication	0	0	2	2	.29
Recurrence	1	2.6	10	10.1	.003
Time to recurrence, mo		112 ^a		17.3 (10.0-91.4) ^a	<.001
Reoperation	0	0	4	4	.015
Follow-up, mo		16.6 (1.0-131) ^a		9.0 (1.0-143) ^a	.14

Note. ECTR = endoscopic carpal tunnel release; OCTR = open carpal tunnel release; NA = not applicable.

^aExpressed as mean (range).

was 112 months for ECTR with no reoperations and 17.3 months (range, 10.0-91.4 months) for OCTR, with 4 cases requiring reoperation.

Discussion

The results of this study confirm our hypothesis that ECTR is at least equally safe and effective at relieving CTS symptoms compared with OCTR in patients with severe CTS. Patients who underwent ECTR reported complete resolution of CTS symptoms in 82% of cases, whereas those who underwent OCTR reported complete symptom resolution in only 39% of cases ($P < .001$). Furthermore, patients treated with ECTR had 6.94 times greater odds (95% CI, 2.77-17.38) of complete resolution compared with patients treated with OCTR. With mean follow-up times of 16.6 months (ECTR) and 9.0 months (OCTR), our study collected data past the point at which ECTR and OCTR are known to produce equivalent outcomes.²⁰ In addition, our post hoc computed achieved power of 0.84 is greater than our predetermined minimum acceptable power of 0.80, indicating our study is sufficiently powered to detect this difference.

There are 2 likely explanations for the observed differences in patient-reported resolution of preoperative CTS symptoms. First, ECTR uses a much smaller incision than OCTR, with less disturbance of the surrounding tissue. Minimizing the invasiveness of the procedure may cause patients to perceive less pain, and therefore to be more likely to report complete resolution of CTS symptoms. Second, ECTR is known to provide faster relief of sensory and motor symptoms than OCTR.²⁰ Thus, it is likely that patients treated with ECTR may have faster symptomatic resolution, which is subsequently reported as more complete symptomatic resolution.

Not only did our analysis show that ECTR was effective in treating severe CTS, but it also showed that ECTR is associated with minimal morbidity. Two percent of patients

treated with OCTR developed postoperative complications, whereas no patients treated with ECTR developed complications. One OCTR patient developed a surgical site infection and another developed postoperative web space pain. Web space pain is a known complication of ECTR because the index and long finger digital nerves are at risk for injury, but it is rare in OCTR procedures. This case did not require reoperation. Also, the overall rates of recurrence were somewhat higher than typically expected in CTS surgery. ECTR patients, however, experienced a lower rate of recurrence than OCTR patients (2.6% vs 10%, respectively). We attribute this overall higher recurrence rate to the severe nature of the CTS affecting our patients. Previous studies have estimated that CTS recurs in 3% to 25% of cases,^{12,13,16,23} and up to 12% of patients require reoperation.¹⁸ In light of these results and the advanced stage of disease in our patients, the recurrence rate is not surprising.

Several studies have shown that ECTR is an effective treatment for CTS.^{10,14,27} In fact, a recent meta-analysis by Sayegh et al²⁰ showed that ECTR and OCTR have equivalent long-term outcomes. Although these studies assessed the efficacy of OCTR and ECTR in various patient populations, only 1 study has explored the role of ECTR in patients with severe CTS.⁸ Hattori et al⁸ showed that ECTR was effective at relieving CTS symptoms and improving activities of daily living in geriatric patients with severe CTS. However, the study included only a specific age group (older than 80 years) and did not compare the effectiveness of ECTR versus OCTR. Our study is the first to assess the role of ECTR in all adults, regardless of age, with severe CTS.

Our study has several limitations. These include retrospective data collection, nonrandomized allocation of ECTR and OCTR, and surgery performed by 1 surgeon. In addition, our study did not use a validated assessment tool as a primary outcome metric. Instead, we used patient-reported outcomes, which may have introduced bias to the outcome assessment. Previous authors have argued that a patient's subjective assessment of symptoms is what truly determines

“effectiveness.”^{19,22} Kanatani et al⁹ also showed that clinical improvement in CTS symptoms correlates with improved objective metrics. Despite this, we acknowledge that this outcome metric may limit the external validity of this study.

Our study did not correct for preoperative severity of disease and, therefore, those treated with OCTR may have had more advanced disease than those treated with ECTR. However, our criteria for defining severe CTS ensured the similarity of the 2 cohorts in terms of CTS severity. In addition, thenar atrophy has been recognized as a sign of late-stage, severe disease,⁷ and both groups had similar rates of thenar atrophy; our ECTR cohort, in fact, had a slightly higher rate of thenar atrophy. Any intercohort differences in CTS severity, therefore, are likely to represent insignificant variation relative to the advanced neuropathy present in all patients in the study.

In conclusion, this retrospective cohort study suggests that ECTR is an effective treatment for patients with severe CTS. Future prospective, randomized, controlled trials are warranted to confirm these findings.

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

Per institutional review board guidelines, individual consent was not needed.

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.

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