Analysis of surgical options for patients with bilateral carpal tunnel syndrome

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ABSTRACT

Background: Bilateral endoscopic carpal tunnel release is a modality offered for the treatment of the median nerve compression neuropathy. This retrospective study compares outcomes for patients undergoing open carpal tunnel release versus bilateral endoscopic carpal tunnel release. We hypothesized that there is no significant difference in postoperative complication rates between unilateral open and bilateral endoscopic carpal tunnel release surgery.

Methods: The authors identified all patients who underwent open carpal tunnel release, unilateral endoscopic carpal tunnel release and bilateral endoscopic carpal tunnel release at a university hospital from 2012 to 2014. Cases were identified using CPT billing codes and the data was assessed using an analysis of variance (ANOVA). All endoscopic carpal tunnel releases were done by the same surgeon (AP), and greater than 90% of open procedures were done by a different same surgeon (DF).

Results: The total combined complication rate was 24.7% with no significant difference ($p > .05$) between techniques. There were no major complications necessitating a return to the operating room. Variables that had a statistically significant difference between groups ($p < .05$) included mean tourniquet time, mean total procedure time, and return to work as determined from the number of follow-up appointments.

Conclusions: The study demonstrates equivocal complication profiles and decreased cost associated with bilateral endoscopic tunnel release as compared to sequential open carpal tunnel release. Endoscopic bilateral carpal tunnel release for patients with bilateral carpal tunnel syndrome offers a safe and effective alternative to open carpal tunnel release.

1. Introduction

As defined by The American Academy of Orthopedic Surgeons (AAOS), carpal tunnel syndrome (CTS) is a symptomatic compression neuropathy of the median nerve at the level of the wrist.¹ Anterior interosseous nerve syndrome and pronator syndrome are two additional forms of median nerve compression neuropathies.² CTS is estimated to be present in 3.8% of the general population making it the most prevalent entrapment neuropathy.³ Evidence has demonstrated that decreased median nerve function can be attributed to mechanical trauma, ischemic injury, synovial inflammation of the flexor tendons, or increased pressure within the carpal tunnel. Often times, the cause of CTS

is multifactorial and can result in median nerve demyelination.^{4,5} Clinically, CTS is characterized by numbness or pain, paresthesias, weakness, and decreased function distributed along the sensory digital nerves in the affected hand. Thenar atrophy may be observed in severe cases of chronic CTS.^{6,7} 1 out of every 5 patients who complains of these symptoms will be diagnosed with CTS following clinical exam and electrophysiological testing.^{2,8}

Current treatment options include non-surgical modalities such as splinting, physical therapy, oral steroids and steroid injections. When such methods fail to alleviate symptoms within 2–7 weeks, surgical decompression of the median nerve is a well-documented procedure that is recommended by the American Academy of Orthopaedic

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Surgeons.^{1,9} Multiple randomized controlled trials have shown that surgical decompression provides superior symptomatic relief as well as better-long term outcomes as compared to non-invasive treatment options.^{10–13} Carpal tunnel release (CTR) is a procedure in which the transverse carpal ligament is divided longitudinally, which reduces interstitial pressure and relieves median nerve compression and symptoms.^{2,8} The current gold standard for treatment of bilateral CTS is sequential open carpal tunnel release.

The purpose of this retrospective chart review is to compare outcome measures between bilateral endoscopic (BECTR), unilateral endoscopic (ECTR) and sequential open carpal tunnel release (OCTR). We hypothesized that there is no significant difference in operative variables and postoperative complication rates between unilateral open, unilateral endoscopic and bilateral endoscopic carpal tunnel release surgery. Furthermore, our hypothesis states that endoscopic carpal tunnel release (unilateral or bilateral) affords patients and physicians a shorter time of discharge from office care. Lastly, we compared cost among these different procedures and hypothesized that bilateral endoscopic carpal tunnel release is a more cost effective option in the treatment of bilateral CTS as compared to sequential unilateral releases.

2. Methods

This was a retrospective study of patient outcomes following open and endoscopic carpal tunnel release, and was approved by our institutional review board. All included patient charts were those that underwent carpal tunnel release between 2012 and 2014. 230 charts were pulled, and 140 patients met the inclusion criteria. Patients who were eligible for the study were patients who underwent bilateral endoscopic carpal tunnel release, patients who underwent unilateral endoscopic carpal tunnel release, and patients who underwent unilateral open carpal tunnel release at Cooper University Hospital (CUH) from January 2012–2014 without undergoing additional procedures. Patients undergoing bilateral open carpal tunnel release were not available as this procedure was not offered by the two surgeons at this institution. Patients who underwent open carpal tunnel release were operated on by a fellowship-trained orthopedic upper-extremity surgeon from the Bone and Joint Institute at CUH. Those patients who underwent either bilateral or unilateral endoscopic carpal tunnel release were operated on by a fellowship-trained plastic surgeon from the CUH Department of Plastic and Reconstructive Surgery. All subjects were identified based on Current Procedural Terminology (CPT) billing codes (64721 and 29848). The patients' records were reviewed for various outcomes. Only medical record numbers were used on data sheets and electronic files, maintaining the anonymity of the subjects.

The operative variables recorded were (1) tourniquet time and (2) incision to close time. Clinical outcomes recorded were (3) motor branch nerve injury, defined by weakness of the thenar muscles assessed on physical exam in the clinic by the surgeon, (4) post-operative hand numbness that did not improve with surgery, (5) wound infection, (6) hematoma assessed on physical exam in the clinic, (7) post-operative pillar pain, (8) number of follow-up appointments during a 3 month post-operative period, (9) recurrence of CTS, and (10) need for hand therapy. Post-operative hematoma causing compression of the median nerve was returned to the operating room for irrigation and debridement. Hand therapy was defined as a post-operative complication because the majority of carpal tunnel patients do not need therapy after this common procedure. A cost analysis was performed separately using available cost information from the Cooper University Hospital Billing Department.

In order to examine surgical cost data, patients were identified using CPT billing codes.

Because of the large variability that exists in determining total procedure cost, we analyzed the average physician fee reimbursement for three different procedure types. This analysis included all open carpal tunnel release, endoscopic carpal tunnel release, and bilateral

endoscopic carpal tunnel release done by the two physicians between January 2012 and January 2014.

The data was analyzed using descriptive statistics and graphs. Specifically, the data was assessed using an Analysis of Variance (ANOVA). The level of significance was set at $p < 0.05$. The results were then used to offer a statistical comparison of the outcome variables of both surgical procedures.

3. Results

3.1. Intraoperative and follow-up appointment data

A retrospective analysis looked at 140 patients who underwent carpal tunnel release surgery from 2012 to 2014. 62 patients (44%) underwent open carpal tunnel release, 40 patients (29%) underwent unilateral endoscopic carpal tunnel release, and 38 patients (27%) underwent bilateral endoscopic carpal tunnel release. For those patients who underwent bilateral endoscopic release, the data for each wrist was collected separately except for total procedure time. The total combined complication rate observed was 24.7% (Table 4).

Mean total procedure time (95% CI), which was defined as the time from initial incision to final suture placement, is provided in Tables 1–3. No significant difference in total procedure time was detected between open and unilateral endoscopic carpal tunnel release groups ($p = .58$). However, there was a significant difference in total procedure time between unilateral and bilateral procedures ($p < .001$). Mean tourniquet time (95% CI) was defined as the total time of tourniquet inflation. No statistically significant difference in mean tourniquet time was observed between the unilateral endoscopic and bilateral endoscopic carpal tunnel release groups ($p > .05$). Both unilateral and bilateral endoscopic procedures were associated with statistically significant longer tourniquet times when compared to open releases ($p < .05$).

In order to evaluate discharge from office care time we analyzed the mean number of follow-up appointments (95% CI) for the different procedures. Patients who underwent endoscopic procedures, both unilateral and bilateral, had statistically significant fewer follow-up appointments than did patients who underwent OCTR. No significant difference was detected for number of follow-up appointments between the unilateral and bilateral endoscopic carpal tunnel release groups (Table 3).

3.2. Postoperative complication rates and need for postoperative hand therapy

Postoperative complications included hematoma (2.25%), hand numbness (16.85%), wound infection (0.56%), pillar pain (0.56%), and recurrence of carpal tunnel syndrome (0.56%). Motor branch injury was not observed as a complication of CTR surgery. Rates of post-operative hand numbness, wound infection, recurrence of carpal tunnel

Table 1
Comparison of OCTR and ECTR Intraoperative and Follow-up Appointment Data.

Method			
Variable (95% CI)	OCTR	ECTR	P value
Mean Total Procedure Time (minutes)	13.26 ± 4.49	14.13 ± 5.46	.58
Mean Tourniquet Time (minutes)	8.60 ± 4.84	9.98 ± 4.05	.05
Mean Number of Follow-Up Appointments	1.65 ± 0.77	1.15 ± 0.36	< .001

Abbreviation: CI, confidence interval.

OCTR, open carpal tunnel release.

ECTR, unilateral endoscopic carpal tunnel release.

Table 2
Comparison of OCTR and BECTR Intraoperative and Follow-up Appointment Data.

Method			
Variable (95% CI)	OCTR	BECTR	P value
Mean Total Procedure Time (minutes)	13.26 ± 4.49	31.92 ± 9.05	< .001
Mean Tourniquet Time (minutes)	8.60 ± 4.84	10.47 ± 4.48	.01
Mean Number of Follow-Up Appointments	1.65 ± 0.77	1.24 ± 0.46	< .001

Abbreviation: CI, confidence interval.

BECTR – bilateral endoscopic carpal tunnel release.

Table 3
Comparison of ECTR and BECTR Intraoperative and Follow-up Appointment Data.

Method			
Variable (95% CI)	ECTR	BECTR	P value
Mean Total Procedure Time (minutes)	14.13 ± 5.46	31.92 ± 9.05	< .001
Mean Tourniquet Time (minutes)	9.98 ± 4.05	10.47 ± 4.48	> .05
Mean Number of Follow-Up Appointments	1.15 ± 0.36	1.24 ± 0.46	> .05

Abbreviation: CI, confidence interval.

Table 4
Occurrence of postoperative complications.

Method				
Variable	OCTR (n = 62)	ECTR (n = 40)	BECTR (n = 76)	Total (n = 178)
Hematoma ^a	0	1	3	4 (2.25%)
Hand Numbness ^a	14	6	10	30 (16.85%)
Wound Infection ^a	1	0	0	1 (0.56%)
Pillar Pain ^a	1	0	0	1 (0.56%)
Recurrence of CTS ^a	1	0	0	1 (0.56%)
Postoperative Physical Therapy ^b	3	1	3	7 (3.93%)
Combined Complication Occurrences ^a	20	8	16	44 (24.7%)

OCTR, open carpal tunnel release.

ECTR, unilateral endoscopic carpal tunnel release.

BECTR, bilateral endoscopic carpal tunnel release.

^a Rate of complications had no statistical significance between surgical methods ($p > .05$).

^b Rate of postoperative physical therapy had no statistical significance between surgical methods ($p > .05$).

Table 5
Direct Cost Analysis.

Method			
Variable	OCTR	ECTR	BECTR
Number of Encounters	295	109	37
Physician Fee Billed	\$1998.00	\$2140.00	\$4280.00
Average Physician Fee Reimbursement	\$454.82	\$507.62	\$900.69

syndrome, hematoma formation, and pillar pain were not statistically significant between groups ($p > .05$). Additionally, 7 patients (3.93%) underwent postoperative physical therapy. Again no significant difference was recorded among surgical groups ($p > .05$). This information is summarized in Table 4. Table 5 presents physician fee and reimbursement data for all carpal tunnel release procedures done by the

two physicians between January 2012 and January 2014.

4. Discussion

Surgical release of the transverse carpal ligament is a common procedure used to treat CTS after conservative treatment options have failed. Before 1989, open carpal tunnel release was the only procedure described in the literature for median nerve decompression.^{14–16} That year, Drs. Chow and Okutsu published two separate articles that detailed an endoscopic approach to the release of the transverse carpal ligament. Originally, its intention was to decrease morbidity associated with open carpal tunnel release.¹⁵ Today, OCTR is still recognized as the gold standard for carpal tunnel decompression, which has sparked much debate between those who argue in favor of and against endoscopic carpal tunnel release.^{17,18}

While the literature has shown equivalent efficacies between endoscopic and open releases, this study focuses on how those diagnosed with bilateral carpal tunnel surgery can benefit from endoscopic carpal tunnel release surgery. Open releases, while effective, leave patients without adequate utility of their affected hand postoperatively as their incision heals. They must rely on the use of their contralateral hand for normal activities of daily living including but not limited to eating and personal hygiene. This then raises the question, if the morbidity of open carpal tunnel release prevents surgeons from performing bilateral open procedures, are we doing our patients a disservice by not offering the option of bilateral endoscopic carpal tunnel release surgery?

Analysis of our data demonstrates equivalent safety profiles between all open and endoscopic procedures. In addition, patients who underwent these procedures showed no difference in the need for postoperative hand therapy. Although the literature contains many studies that have compared complication rates between open and endoscopic release, the safety variables used to compare these procedures vary from study to study.^{14,19–24} Therefore, the conclusions drawn from each analysis must be viewed individually rather than as an attempt to replicate prior results.

Total procedure time was not significantly different between unilateral procedures, although tourniquet time was found to be greater for endoscopic releases. Ferdinand and MacLean found that open carpal tunnel release took less time when compared to endoscopic release. While statistically significant, they concluded that the magnitude of difference had no clinical significance.²⁵ Our study came to a similar conclusion. Currently, there is no evidence to suggest that the longer tourniquet time seen with endoscopic surgery affects patient's functional outcome or relief of symptoms. Comparable complication profiles and intraoperative times support endoscopic carpal tunnel release as an equivalent treatment option for median nerve decompression.

Return to work time is measured in much of the existing literature.^{17,24,26–28} Because this study was retrospective, we were unable to assess this outcome measure. While future prospective studies could be conducted in order to compare return to work time, comparing speed of return for specific preoperative activities of daily living would eliminate many confounding variables associated with measuring return to work time. These variables include the disparity in stress that different jobs place on the postoperative wrist, the duration of a typical workday, and many patient specific factors, such as patient demographics, personal motivation to work, and other psychosocial factors.

As an alternative, we compared the mean number of follow-up appointments between surgical groups in order to examine how different surgical modalities affected length of postoperative care. Both unilateral and bilateral endoscopic procedures had statistically significant shorter durations of postoperative care compared to open procedures, thereby reducing the burden of postoperative care for both the patient and physician (Tables 1 and 2). However, this significant difference in mean follow-up appointments is probably not clinically significant. As with many studies, losing patients to follow-up is a limitation of this variable.

Limitations of this study include evaluation of the effectiveness of either surgical modality at treating CTS. In order to evaluate the effectiveness of either surgical method, further prospective studies would need to be done that compare patient outcomes following surgery. Such outcomes include patient satisfaction, return to work time, return to daily activity time, pain scores, and recurrence rate. The statistically significant difference in intraoperative and tourniquet time have not been shown to be clinically significant and future studies would need to be conducted in order to determine how these variables affect surgical outcomes. Additionally, the incidence of post-operative hand numbness were likely higher due to the fact that many patients may have had long-standing median nerve neuropathy and needed more than three months to achieve resolution in paresthesia symptoms.

Patients with bilateral CTS have a unique set of variables that must be considered when determining a treatment plan. Currently, three options exist for surgical decompression in this patient population: bilateral endoscopic release, sequential unilateral open release, and sequential unilateral endoscopic release. Unless a patient presenting with bilateral CTS has a strong support network that would assist with ADL's such as personal hygiene and feeding, physicians are unable to offer bilateral open carpal tunnel release. Sequential open and endoscopic release procedures require patients to undergo two separate surgical events, which includes preoperative assessment, intraoperative anesthesia or regional block, and postoperative recovery. Many still choose to perform sequential unilateral releases, but by refusing to offer endoscopic procedures, surgeons are committing their patients to two separate surgeries and the perioperative management that comes with it. Since our data shows no clinically significant difference between open and endoscopic CTR, we believe that bilateral endoscopic CTR should be offered to our patients with bilateral carpal tunnel syndrome. Additionally, our cost analysis indicates that BECTR is less expensive compared to sequential unilateral releases. Therefore we, support BECTR as a valid treatment modality for patients with bilateral CTS.

Our study demonstrates equivocal complication profiles and decreased cost associated with bilateral endoscopic tunnel release as compared to sequential open carpal tunnel release. We believe that the option of endoscopic bilateral CTR for patients with bilateral CTS offers a safe and effective alternative to open carpal tunnel release. Additionally, this option may reduce the stresses and costs of multiple surgeries without compromising patient care or safety. Therefore, orthopaedic and plastic hand surgeons should strongly consider offering the option of bilateral endoscopic carpal tunnel release to patients with bilateral CTS.

Declaration of competing interest

We, the authors, have no conflicts of interest to disclose with regards to this study.

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