Pain and Function Following Revision Cubital Tunnel Surgery

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Kristen M. Davidge¹, Gregory C. Ebersole², and Susan E. Mackinnon²

Abstract

Background: The purpose of this study was to determine pain and functional outcomes following revision cubital tunnel surgery and to identify predictors of poor postoperative outcome. **Methods:** A retrospective cohort study was conducted of all patients undergoing revision cubital tunnel surgery over a 5-year period at a high-volume peripheral nerve center. Intraoperative findings, demographic and injury factors, and outcomes were reviewed. Average pain, worst pain, and impact of pain on self-perceived quality of life were each measured using a 10-cm visual analog scale (VAS). Function was evaluated using pinch and grip strength, as well as the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. Differences in preoperative and postoperative pain, strength, and DASH were analyzed using nonparametric tests. Predictors of postoperative average pain were evaluated using odds ratios and linear regression analyses. **Results:** The final cohort consisted of 50 patients (mean age: 46.3 ± 12.5 years; 29 [68%] male) undergoing 52 revision ulnar nerve transpositions (UNTs). Pain VAS scores decreased significantly following revision UNT. Strength and DASH scores demonstrated nonsignificant improvements postoperatively. Worse preoperative pain and greater than 1 prior cubital tunnel procedure were significant predictors of worse postoperative average pain VAS scores. **Conclusions:** Patients can and do improve following revision cubital tunnel surgery, particularly as it relates to pain. Intraoperative findings during the revision procedure suggest that adherence to specific principles in the primary operation is key to prevention of secondary cubital tunnel syndrome.

Keywords: cubital tunnel, revision, outcomes, secondary, pain, function

Introduction

Cubital tunnel syndrome is the second most common entrapment neuropathy of the upper extremity.²² When surgery is indicated, there is no consensus on the superiority of outcomes for different operative techniques.^{5,7,13,18} Recurrence rates following cubital tunnel surgery have ranged from 7% to 25%.^{13,17,18} The differential diagnosis for recurrent cubital tunnel symptoms is extensive. In addition to recurrent ulnar nerve compression at the elbow, potential diagnoses include multilevel ulnar nerve compression, cervical radiculopathy, brachial plexopathy, systemic polyneuropathy, amyotrophic lateral sclerosis, and nonneurological diseases such as rotator cuff syndrome, localized tendonitis, and a subluxating triceps muscle.¹⁷ Careful history and physical examination are necessary to direct further investigations and establish the diagnosis.⁶

Indications for revision cubital tunnel surgery can be classified using the persistent, recurrent, or new criteria described for revision carpal tunnel surgery.²⁶ In our experience, failure of simple decompression procedures is

often associated with recurrent symptoms, whereas failure of transposition procedures is usually associated with new symptoms owing to new sites of kinking or compression of the ulnar nerve.¹⁷ The causes of these failed procedures have been explored and include technical failure (inadequate decompression, distal or proximal kinking, iatrogenic injury), nerve traction, secondary compression by scar tissue, and misdiagnosis.^{9,17,21,24} There has been debate over the proper surgical treatment for failed cubital tunnel procedures with similar results shown for simple decompression, and subcutaneous and submuscular transpositions.^{3,4,11,15–17,23,27}

¹SickKids Hospital, Toronto, Ontario, Canada

²Washington University in St. Louis, MO, USA

Corresponding Author:

Kristen M. Davidge, Division of Plastic and Reconstructive Surgery, SickKids Hospital, 5th Floor Black Wing, 555 University Avenue, Toronto, Ontario, Canada M5G 1X8.

Email: kristen.davidge@sickkids.ca

Recently, it was shown that outcomes after revision cubital tunnel surgery are generally worse than after primary surgery.¹ However, this study did not evaluate demographic or intraoperative predictors of outcomes following revision surgery, and did not differentiate function from pain outcomes. The objectives of the current study were thus 4-fold: (1) to better delineate the clinical presentation of patients referred for secondary cubital tunnel surgery; (2) to review the intraoperative findings in revision cubital tunnel surgery; (3) to evaluate both pain and functional outcomes following revision cubital tunnel surgery; and (4) to determine potential predictors of postoperative pain.

Materials and Methods

A retrospective cohort study was performed of consecutive adult patients undergoing revision cubital tunnel surgery for secondary cubital tunnel syndrome between January 2008 and December 2012. The senior author performed all definitive revision cubital tunnel procedures in this cohort, whereas all primary and previous revision ulnar nerve procedures were performed at outside institutions. The decision to reoperate was based on the history and physical examination, including persistent, recurrent, or new sensorimotor dysfunction and pain in the ulnar nerve distribution, and new pain in the medial antebrachial cutaneous (MABC) nerve distribution.¹⁷ The severity of the patient's symptomatology and its impact on their quality of life (QoL) were also factors in the decision-making process. Once the decision to reoperate was made, electrodiagnostic studies were performed for preoperative documentation of the presence and extent of axonal injury. Patients whose final diagnosis was not cubital tunnel syndrome and those patients who had no follow-up postrevision surgery were subsequently excluded. All clinical, intraoperative, and outcome data were collected from patient charts.

Surgical Technique and Intraoperative Findings

Intraoperative findings at the time of revision ulnar nerve transposition (UNT) were identified from the operative record. The surgical technique for revision surgery by the senior author included a transmuscular transposition of the ulnar nerve in all cases. This technique has been described in detail elsewhere,^{17,20} but here we highlight the additional considerations for a revision case. First, we avoid paralytics with induction to allow intraoperative stimulation of the ulnar nerve during dissection in a scarred bed. Second, we have a low threshold to concurrently decompress multiple sites of ulnar nerve compression, including the arcade of Struthers and Guyon canal, if there is clinical evidence of nerve compression at these sites.^{17,20} Guyon canal release is additionally performed if the patient demonstrates any clinical or electrodiagnostic signs of intrinsic muscle denervation. Third, the

original cubital tunnel incision is generously extended proximally and distally, so that the ulnar nerve is first identified outside of the previous operative zone. Fourth, careful attention is paid to the cause of ongoing symptoms; commonly, this is related to distal kinking of the nerve following a prior transposition procedure. Proximal transposition of an injured MABC is performed as indicated. Fifth, perioperative pain control is an important aspect of the management of many patients undergoing revision surgery, and multidisciplinary pain management is initiated as needed. Finally, unrestricted range of movement is encouraged 2 to 3 days postoperatively, and hand therapy, including desensitization and graded motor imagery, is initiated 2 weeks postoperatively.

Clinical and Outcome Data

The following clinical data were extracted from patient charts: demographics, comorbidities, workers' compensation status, presenting symptoms, use of pain medications (opioids, gabapentin/pregabalin, or tricyclic antidepressants), technique of primary ulnar nerve procedure (decompression, subcutaneous or submuscular transposition), number of previous cubital tunnel releases, and electrodiagnostic studies.

Physical examination (2-point discrimination, pinch and grip strength), self-report pain, and self-report function data were prospectively collected as part of routine clinical care before surgery and at each postoperative visit. Static and dynamic 2-point discrimination in the ulnar and median distributions were performed in the small and index fingers, respectively. Pinch and grip strength were measured using a Jamar dynamometer (Sammons Preston, Bolingbrook, Illinois). Average pain, worst pain, and impact of pain on self-perceived QoL were each measured using a 10-cm visual analog scale (VAS). Higher values on the VAS indicate more pain or greater pain impact. Upper extremity function was evaluated using the 30-item Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.^{2,14} Item responses are transformed into a total score from 0 to 100, with higher DASH scores signifying greater disability.

Statistical Analysis

Descriptive statistics (mean, standard deviation, frequency) were calculated for all demographic and outcome variables. Differences in preoperative and postoperative pinch strength, grip strength, DASH, and pain VAS scores were analyzed using the Wilcoxon rank-sum test. When postoperative data were available for multiple time points, the most recent values were used for analysis. Outcomes for the revision cubital tunnel cohort were then compared with a previously published cohort ($n = 89$, 52% female, mean age: 48.4 years) undergoing primary transmuscular UNT by the senior author¹⁰ using Student t test.

Predictors of worsened average pain outcomes were analyzed in 2 ways. First, univariable logistic regression was performed to determine the odds of worsened or no change in average pain VAS scores. Worsened pain was defined as greater than 1 cm increase in VAS score postoperatively and no change was defined as a postoperative VAS score within 1 cm of baseline VAS pain scores. Second, a backward, stepwise linear regression was completed to identify predictors of postoperative average pain VAS scores. Using the rule of thumb of 10 patients per predictor variable, we were able to include 5 variables for our sample size of 52 upper extremities. These predictor variables were selected a priori and included age, use of pain medications, number of prior releases (1 vs >1), workers' compensation status, and preoperative average pain VAS scores. *P* values < .05 were considered statistically significant.

Results

Patients

Sixty patients underwent revision transmuscular UNT during the study period. Ten patients were excluded for the following reasons: presence of direct ulnar nerve injury from prior surgery (*n* = 6) or gunshot (*n* = 2), and fracture of operative limb within the follow-up period of revision surgery (*n* = 2). The final cohort consisted of 50 patients (mean age: 46.3 ± 12.5 years; 29 [68%] male) undergoing 52 revision transmuscular UNT. These patients had previously undergone 1 (*n* = 34) or more (*n* = 16) cubital tunnel procedures using the simple decompression, subcutaneous transposition, or submuscular transposition techniques (Table 1). Of the 16 patients with a prior revision operation at the cubital tunnel, 14 had a single prior revision (including 1 patient who underwent bilateral revisions) and 2 patients each had 2 and 3 prior revisions. The most common presenting symptom in this cohort was pain (*n* = 44, 85%). The pain was typically located at the elbow and ring and small finger, or in the entire distribution of the ulnar nerve from the elbow to the ulnar digits. Further demographic and descriptive characteristics are shown in Table 1.

Intraoperative Findings

A summary of the intraoperative findings and additional procedures performed at the time of revision UNT is displayed in Table 2. The most common intraoperative findings were severe scarring of the ulnar nerve, followed by distal ulnar nerve kinking, compression by a residual medial intermuscular septum, and neuroma of the MABC nerve. Decompression of Guyon canal was performed at the time of revision UNT in the majority of patients.

Table 1. Baseline Characteristics of 50 Patients Undergoing Revision Cubital Tunnel Surgery, by Operative Extremity (*N* = 52).

Characteristics	<i>N</i> = 52
Age (SD)	46.3 (13)
Male sex	30 (58%)
Dominant hand	27 (52%)
BMI (SD)	28.6 (6.3)
Comorbidities	
Smoking	26 (50%)
Diabetes	7 (13%)
Hypothyroid	5 (10%)
Arthritis	14 (27%)
Back pain	26 (50%)
Neck pain	19 (37%)
Complex regional pain syndrome	1 (2%)
Using pain medication	26 (50%)
Workers' compensation	16 (31%)
Number of prior releases	
1	35 (67%)
>1	17 (33%)
Primary cubital tunnel surgery technique ^a	
Decompression	19 (37%)
Subcutaneous transposition	24 (46%)
Submuscular transposition	9 (17%)
Mean interval since primary cubital tunnel surgery (mo)	31 (29)
Prior revision cubital tunnel surgery technique ^a	
Subcutaneous transposition	7 (13%)
Submuscular transposition	6 (12%)
Neurolysis	4 (8%)
Mean interval since most recent cubital tunnel surgery (mo)	24 (25)
Presenting symptoms	
Pain	44 (85%)
Numbness	26 (50%)
Weakness	16 (31%)
Paresthesia	14 (27%)
Mean 2-point discrimination	
Ulnar >6 mm	20 (38%)
Median >6 mm	8 (15%)
Normal EMG	14 (27%)

Note. BMI = body mass index; EMG = electromyography.

^aAll primary and prior revision cubital tunnel surgery procedures were performed at an outside institution.

Outcomes of Revision Cubital Tunnel Surgery

Preoperative and postoperative strength, pain VAS, and DASH scores for the revision UNT cohort are shown in Figure 1. Mean follow-up was 5.4 ± 3.6 months. Worst pain, average pain, and impact of pain on QoL VAS scores decreased by 1.7 ± 3.0 cm, 1.4 ± 2.8 cm, and 2.4 ± 3.1 cm following revision UNT (*P* < .01), respectively. These

Table 2. Intraoperative Findings and Additional Surgical Procedures in 52 Revision UNTs.

Intraoperative findings	N (%)
Severe scarring of ulnar nerve	35 (67)
Compression of ulnar nerve	
Residual medial intermuscular septum	30 (58)
At medial epicondyle	21 (40)
At arcade of Struthers	9 (17)
Kinked ulnar nerve	
Proximal	4 (8)
Distal	30 (58)
Subluxing ulnar nerve	2 (4)
MABC injury	
Neuroma	30 (58)
Pseudoneuroma	23 (44)
Crushed/compressed	12 (23)
Additional surgical procedures at the time of revision UNT	
Decompression of Guyon canal	30 (58)
Carpal tunnel release	14 (27)
SETS procedure	6 (12)

Note. MABC = medial antebrachial cutaneous; UNT = ulnar nerve transposition; SETS = supercharge end-to-side transfer of anterior interosseous nerve to ulnar motor nerve.

improvements in pain scores were statistically significant ($P < .01$). There were slight, nonsignificant improvements in pinch strength, grip strength, and DASH scores postoperatively.

Outcomes of Revision Versus Primary UNT

Compared with the previously published primary UNT cohort, patients undergoing revision UNT had significantly higher worst pain ($P < .05$) and impact of pain on QoL at baseline ($P < .01$) (Figure 1). Preoperative strength and DASH scores were not significantly different. The revision UNT cohort demonstrated greater mean improvements in grip strength than the primary UNT group ($P < .05$), but less improvement in DASH scores ($P < .05$). Mean changes in pinch strength and pain VAS scores did not significantly differ between groups. Mean follow-up for the primary UNT group was significantly shorter (3.6 ± 3.0 months vs 5.4 ± 3.6 months, $P < .01$).

Predictors of Postoperative Pain in Revision UNT

Average pain VAS scores did not change or worsened following 14 of the 52 revision UNT procedures. A primary simple decompression procedure was associated with significantly lower odds of worsened or unchanged postoperative average pain—odds ratio (95% confidence interval), OR (95% CI), 0.02 (0.00-0.51). Primary incomplete resection of the medial intermuscular septum was associated

with significantly increased odds of worsened or unchanged postoperative average pain: OR (95% CI), 15.86 (1.06-237.39).

In multivariable regression analyses, higher preoperative average pain VAS score and greater than 1 prior cubital tunnel procedure were significant predictors of worse postoperative average pain VAS scores (Table 3).

Discussion

Pain is a major concern in patients undergoing revision cubital tunnel surgery and may play an important role in determining postoperative outcomes. Indeed, 85% of patients in this cohort reported pain preoperatively, which was often severe in nature and associated with poor self-reported QoL. Possible reasons for the high prevalence of pain in this cohort include new kinking or compression of the ulnar nerve following a transposition procedure, causing acute nerve ischemia; MABC injury resulting in a painful neuroma; heavy scarring around the ulnar nerve resulting in acute compression; as well as patient referral and selection bias for revision surgery. This high prevalence of pain after failed primary cubital tunnel surgery has been similarly reported by others^{1,23,27} and can render preoperative examination difficult. Diagnostic complexity may be further compounded by other factors like multiple prior releases or normal electrodiagnostic studies, seen in almost one-third of patients in this study. Ulnar nerve pain may occur in the setting of normal electrodiagnostics, because pain fibers (C fibers) are not detected by nerve conduction studies. In these situations, we have found clinical provocative maneuvers, including the Tinel sign, scratch collapse test (SCT),⁶ and hierarchical SCT,⁸ to be highly useful in localizing specific sites of ongoing ulnar nerve compression and identifying pain related to MABC injury preoperatively.

The demographics of our cohort also highlight that recurrent and persistent symptoms following primary cubital tunnel surgery can occur irrespective of operative technique. This emphasizes the importance of other intraoperative factors on surgical outcome, such as release of all possible points of compression in the region of the cubital tunnel and avoiding iatrogenic compression of the ulnar nerve during transposition^{19,21} (Table 4). Consistent with prior literature,^{11,20,23,27} ongoing compression of the ulnar nerve was a common intraoperative finding in this study. Specifically, MABC injury, and distal ulnar nerve kinking or incomplete resection of the medial intermuscular septum following transposition procedures were frequent findings. Heavy scarring of the ulnar nerve was also commonly seen in revision cases, more than one might intuitively expect. Identifying the ulnar nerve outside of the zone of prior dissection and scarring is thus a key first step in revision surgery to avoid iatrogenic injury. It also emphasizes the need for early postoperative mobilization. In cases

Figure 1. Differences in preoperative and postoperative physical exam, pain VAS, and DASH scores for the revision UNT cohort ($n = 52$ extremities, shown in solid line) and the previously published primary UNT cohort ($n = 89$ extremities, shown in dashed line). Error bars signify standard deviation. Asterisks indicate statistically significant changes in preoperative versus postoperative values. Average follow-up times were 5.4 ± 3.6 and 3.6 ± 3.0 months for the revision and primary UNT cohorts, respectively. VAS = visual analog scale; QoL = quality of life; DASH = Disabilities of the Arm, Shoulder and Hand; UNT = ulnar nerve transposition.
* $p < .05$.

Table 3. Predictors of Postoperative Average Pain in Multivariable Regression Analyses.^a

Outcome = "average pain" $R^2 = 0.198$ ($df = 2$)	β	Standard error (β)	t	P value
Constant	0.13	0.14	0.96	
Preoperative "average pain"	0.41	0.21	1.97	.05
Number of prior releases	0.20	0.09	2.30	.03

^aSequence of elimination from the regression model: 1. use of pain medication; 2. workers' compensation; 3. patient age.

where the primary operation was a simple decompression procedure, other reasons for revision included ongoing strain on the nerve during elbow flexion, subluxation of the ulnar nerve anterior to the medial epicondyle, and incomplete release of the ulnar nerve within the cubital tunnel.

Outcomes of revision cubital tunnel surgery are thought to be less predictable and generally worse than primary surgery.^{1,23,24,27} Vogel et al²⁷ and Rogers et al²³ reported substantial, albeit incomplete, improvements in pain following revision cubital tunnel surgery, but less satisfactory

Table 4. Key Surgical Principles for Prevention of Ongoing Symptoms Following Primary Cubital Tunnel Surgery.

1. Meticulous identification of the MABC nerve under high-power loupe magnification
The surgeon should be aware that 1 MABC branch runs with the intermuscular septum and crosses the incision approximately 1.5 cm proximal to the medial epicondyle, and 1 branch crosses the incision approximately 3.5 cm distal to the medial epicondyle.
2. Meticulous mobilization of the MABC nerve to avoid injury during the operation
If an MABC nerve branch is injured, it should be transposed well away from the incision.
3. Ensure there is no kinking of the ulnar nerve proximally and distally following decompression/transposition, especially distally
Sufficient incision length is important to adequately assess kinking.
4. Routine excision of the distal medial intermuscular septum, particularly during a transposition procedure
5. Use of a sterile tourniquet
Therefore, it can be removed intraoperatively, and compression of the ulnar nerve at the arcade of Struthers can be evaluated and treated as necessary.
6. Initiation of early range of motion at the elbow at 2-3 days postoperatively

Note. MABC = medial antebrachial cutaneous.

motor outcomes. Aleem et al¹ demonstrated symptomatic improvements in most patients following revision surgery, but a higher likelihood of persistent and worse symptoms versus primary surgery. In this study, postoperative pain VAS and DASH scores were also worse in our revision versus primary cohorts, but this was not true of pinch and grip strength. Importantly, *preoperative* pain scores were also worse in revision cases, and therefore the magnitude of improvement in pain was in fact similar in the revision and primary groups. In both revision and primary cohorts, the mean change in pain VAS scores exceeded the minimal important difference of 1.0 to 1.3 cm.^{12,25} The improvements in patient-reported pain seen in this study are thus both statistically significant and clinically meaningful.

These comparisons shed some positive light on the short-term outcomes following revision cubital tunnel surgery, but the true rate and maximal improvement in symptomatology over the long term remain unknown. Disabilities of the Arm, Shoulder and Hand scores also did not improve as readily following revision surgery in this study. There are multiple possible explanations for this finding, including the longer symptom duration and greater pain and dysfunction seen in patients presenting for revision surgery. Furthermore, the DASH measure is not very sensitive to change in cubital tunnel syndrome¹⁰ and longer term follow-up is needed to better compare DASH outcomes.

Important predictors of worse postoperative pain outcomes in this study included greater preoperative pain and greater number of prior procedures at the cubital tunnel. This finding is consistent with prior literature in revision cubital tunnel surgery,^{4,23} as well as in revision carpal tunnel surgery.²⁸ We also found that simple decompression was associated with a higher likelihood of improved pain outcomes in univariable analyses. One can hypothesize that because simple decompression entails less dissection of the ulnar nerve and less potential for creating new compression points, less scarring is encountered at the revision procedure and the nerve location is more predictable. However, as the type of primary procedure did not remain significant

in our multivariable analyses, future studies are required to confirm the predictive value of primary surgical procedure on outcomes following revision surgery. Other factors previously reported to predict a negative outcome include increased age,^{4,11} prior submuscular transposition,¹¹ and denervation on electromyography.¹¹

Given that revision cubital tunnel surgery is uncommon, the strengths of the current study lie in the relative size and heterogeneity of the sample. Being able to compare preoperative and postoperative pain and function in revision and primary UNT treated by a single surgeon also sheds new light on the absolute and relative improvements between groups. However, our study is limited by its retrospective nature and lack of long-term follow-up. A prospective longitudinal study is needed to better understand the rate and maximal degree of improvement in pain symptomatology in patients undergoing revision surgery, as well as predictors of outcome. This information would help further guide management of preoperative patient expectations and utilization of ancillary pain-reduction strategies. Future studies should also document the pain therapies utilized by patients, as this may represent an unmeasured determinant of the response to surgical intervention and may explain some variability between published studies. Patient selection for revision cubital tunnel surgery is also a potentially important determinant of outcome that has not yet been evaluated.

Ultimately, the key to improving outcomes is to avoid the need for revision surgery in the first place through careful surgical technique and thorough understanding of ulnar nerve and MABC anatomy. When symptoms do persist, recur, or worsen following the primary operation, the complexity in diagnosis and management increases substantially and a strong adherence to surgical principles is required to avoid ulnar nerve injury and potentially worsen patient outcomes. This study highlights the substantial pain experienced by these patients and emphasizes the need for multimodal pain management. This study also adds to the body of literature suggesting that these patients can and do improve postoperatively from a pain and motor function

perspective. The completeness and time frame of this recovery are still unknown. Future studies that further define predictors of outcome will assist us in refining our patient selection criteria and improving our nonoperative and operative management strategies to optimize outcomes in this challenging patient population.

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.

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