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Managing Ulnar Nerve Subluxation With a Medial Intermuscular Septum Sling

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Abstract

Background: Cubital tunnel syndrome (CuTS) is a lifestyle-altering peripheral neuropathy lacking a consensus for optimal surgical management. We describe creation of a fascial "V-sling" without ulnar nerve transposition, which is associated with increased surgical morbidity compared with decompression. The purpose of this study is to evaluate a novel technique with effective ulnar nerve decompression and subluxation prevention by creating a fascial sling in patients with CuTS and ulnar nerve subluxation. **Methods:** We reviewed records of 39 elbows in 35 patients who underwent in situ ulnar nerve decompression and creation of a fascial sling in a "V" configuration to stabilize the nerve in its native position. We examined patient demographics, Single Assessment Numeric Evaluation (SANE) scores, Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) scores, and patient outcomes. Chi-square and student's *t* test were used for all analysis. **Results:** A total of 37 extremities in 33 patients undergoing nerve decompression had nerve subluxation confirmed intraoperatively. There was a statistically significant change in preoperative and postoperative SANE scores of 64.5 and 82.3, respectively. Mean QuickDASH scores decreased significantly from 49.3 preoperative to 10.8 postoperative. The long-term QuickDASH scores obtained at mean of 564 days were maintained at 10.76. **Conclusions:** This study describes a novel technique for treating CuTS by achieving in situ nerve decompression and addressing ulnar nerve subluxation with creation of an intermuscular septal sling. The technique improved functional outcomes and provided symptomatic relief, while avoiding risks commonly associated with nerve transposition.

Keywords: cubital tunnel syndrome, nerve, diagnosis, nerve compression, ulnar subluxation, V-sling, fascial sling

Background

Cubital tunnel syndrome (CuTS) is a life-limiting peripheral neuropathy with recent cross-sectional analysis estimating it affects 2.7% to 6.8% of the general US population. This makes CuTS the second-most prevalent upper extremity peripheral neuropathy, behind only carpal tunnel syndrome.[1] A lack of consensus for a superior surgical technique for CuTS has been a longstanding issue within the surgical community, and attempts have been made to highlight advantages and complications of specific operative techniques. A meta-analysis evaluating 261 patients in 4 randomized control trials compared simple in situ decompression vs anterior transposition and in all outcome measures, it found similar success rates.[2] Proponents of simple decompression argue areas of focal compression are released without threatening nerve vascularity. Some authors argue decompression with anterior transposition addresses both compression and traction mechanisms of nerve injury.[3] Endoscopic decompression has gained some interest as a newer, effective therapy for CuTS; however, it lacks adequately powered, randomized controlled trials supporting improved outcomes to justify the higher associated operative costs compared with open decompression.[4]

The concept of creating a fascial "V-sling" to prevent subluxation has been around for at least 2 decades; however, previous techniques involve simultaneous ulnar nerve transposition.[5] Nerve transposition has been well documented to be associated with increased surgical morbidity compared with decompression. This is thought to be largely in part to disrupting vascular supply of the nerve during

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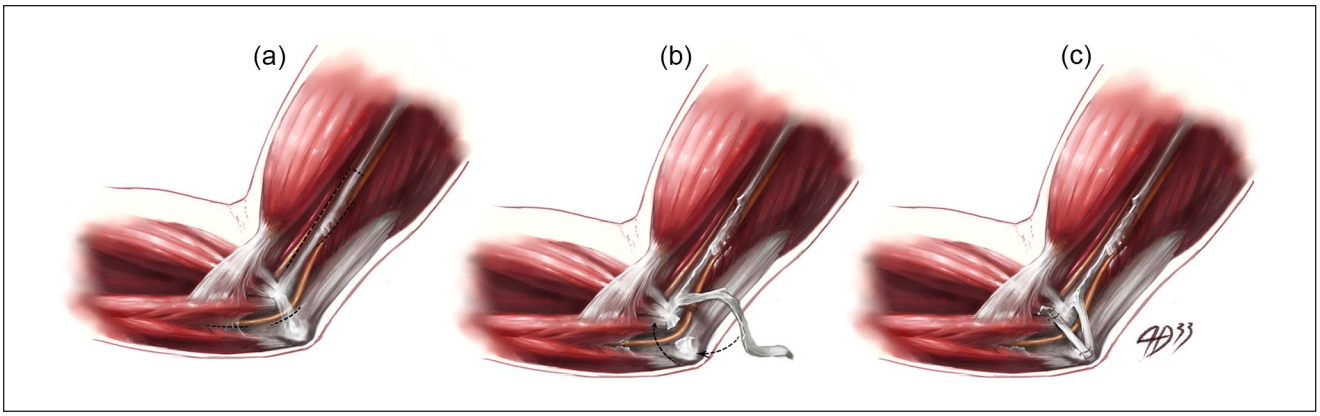

Figure 1. (a) Compression areas released at the arcade of Struthers, the medial intermuscular septum, the arcuate ligament of Osborne, and the deep fascia of the flexor carpi ulnaris. (b) Transposition orientation of the distally based intermuscular septum toward anchoring points at the olecranon process and medial epicondyle. (c) Final location of the ulnar nerve beneath the V-sling in its native position.

dissection resulting in local ischemia.[6] To our knowledge there has yet to be described an effective decompression technique that prevents subluxation, while taking care to protect nerve vascularity and minimize postoperative morbidity.

Given the lack of evidence supporting a single, most efficacious surgical intervention for CuTS, the purpose of this study was to evaluate a novel technique to treat subluxation involving minimal nerve dissection and creation of a stabilizing fascial sling in patients with CuTS and ulnar nerve subluxation.

Material and Methods

A retrospective chart review was conducted examining 39 elbows in 35 patients who underwent in situ decompression and a V-configuration fascial sling. Approval was obtained from the institutional review board. Two patients were excluded due to missing preoperative or postoperative data resulting in 37 elbows in 33 patients included for analysis. Patients were diagnosed preoperatively by physical examination and electromyography (EMG). Treatment consisted of open in situ ulnar nerve decompression and design of a fascial sling using a distally based medial intermuscular septum (MIS) to stabilize the nerve in its native position. We examined patient demographics, Single Assessment Numeric Evaluation (SANE) scores, Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) scores, and patient outcomes. Chi-square and student's *t* test were used for all analysis.

Surgical Technique

All patients received a preoperative supraclavicular regional nerve block on the affected extremity for anesthesia. A nonsterile tourniquet is placed and a 5-cm incision is marked along the cubital tunnel at the medial elbow. The approach and surgical exposure of the ulnar nerve follow the standard technique commonly described. Compression areas at the arcade of Struthers, the MIS, the arcuate ligament of Osborne, and the deep fascia of the flexor carpi ulnaris (FCU) are identified and released (Figure 1a). After addressing these common points of compression, the elbow is examined through flexion and extension while observing for hypermobility of the ulnar nerve. If a hypermobile ulnar nerve is confirmed (Supplemental Video 1), a fascial sling is fashioned using the MIS. The MIS is harvested on a distally based pedicle. This is achieved by first releasing it proximally and carefully mobilizing it to its distal attachment at the medial epicondyle. The MIS is left attached at the medial epicondyle to serve as the first of 3 anchor points to the sling (Figure 1b). In addition, this attachment will provide its vascularity through Sharpey's fibers. The length of the harvested MIS is approximately 6 cm (Figure 2a). With the ulnar nerve in its native position and the elbow flexed approximately 90° to 100°, the second anchor point is created using 3-0 PDS (Ethicon, Somerville, New Jersey) suture between the halfway point of the harvested MIS and the posterior cubital tunnel at the olecranon process. The final anchor point is placed at the medial epicondyle forming a "V" configuration to the sling (Figure 2b). The ulnar nerve remains in its native position beneath the fascial sling (Figure 1c). The anchor points are placed with the elbow flexed as this is the point of maximum tension on the sling. An instrument is then passed under the nerve to ensure there are no new sites of compression as the nerve is flexed. The sling then loosens when the elbow is extended. Again, the elbow is ranged through flexion and extension to confirm the ulnar nerve is no longer hypermobile and excessive tension on the sling is not present (Supplemental Video 2).

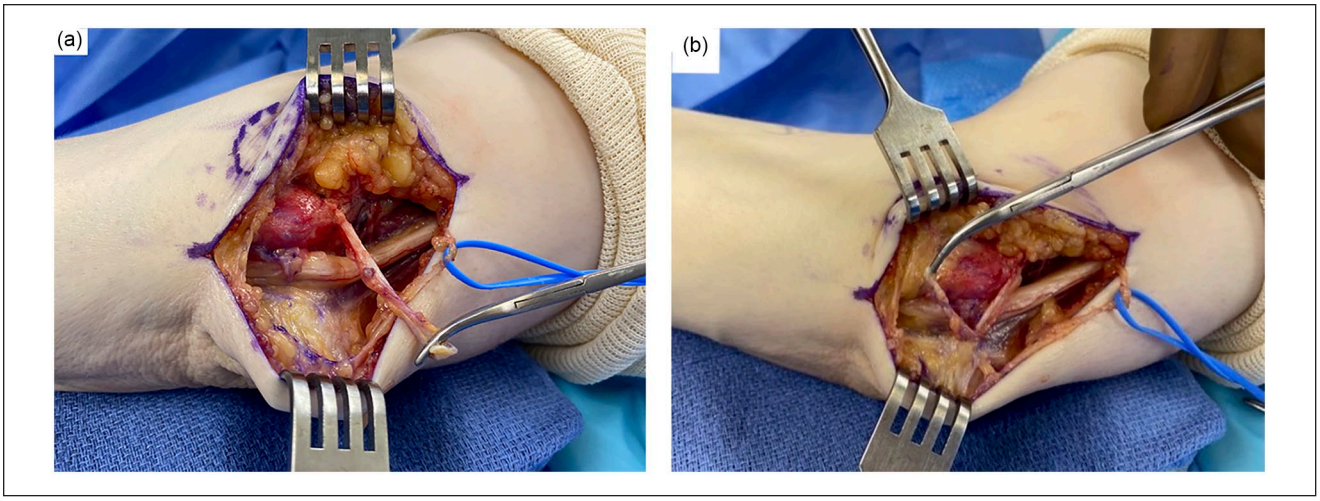

Figure 2. (a) Harvesting of approximately 6 cm of medial intermuscular septum. (b) Anchoring of medial intermuscular septum to medial epicondyle forming a "V" configuration to the sling.

Results

A total of 37 extremities in 33 patients undergoing nerve decompression had nerve subluxation confirmed intraoperatively. Baseline patient demographics are demonstrated in Table 1. Of the 37 operations, 28 patients were male and 9 were female. The right arm was the operative side 17 times, while dominant hand was the operative side (including if ambidextrous) in 18 patients. Fourteen patients were former smokers, and 6 were active smokers. Mean patient body mass index was 33.2 kg/m^2. Patients had a mean age of 60.3 years (range 30-91) and average long-term follow-up of 564 days (median 407 days). There was a statistically significant change in preoperative and postoperative SANE scores of 64.5 and 82.3, respectively (Figure 3). Mean QuickDASH scores decreased significantly from 49.3 preoperative to 10.8 postoperative. The long-term QuickDASH scores obtained at mean of 564 days were maintained at 10.76 (Figure 4). There were 5 postoperative complications. One patient had postoperative loss of flexor digitorum profundus (FDP) of the fourth and fifth digits. One patient developed postoperative ulnar claw hand approximately 6 weeks postoperatively. In this patient, periodic EMG showed improving velocity and latency without active denervation. This result suggests that ulnar nerve recovery transitioned from FDP weakness to FDP recovery with intrinsic hand muscle weakness during the recovery period. One patient developed wound dehiscence necessitating operative closure, and one patient required irrigation and debridement secondary to surgical site infection. One patient developed recurrence of symptoms requiring repeat decompression with submuscular transposition, during which significant scar tissue was noted. Two patients had no

Table 1. Baseline Patient Demographics.

Sex, n (%)	
Male	28 (75.7)
Female	9 (24.3)
Age, y	
Mean (SD)	60.3 (13.6)
BMI, kg/m^2	
Mean (SD)	33.2 (8.24)
Comorbidities, n (%)	
Diabetes	10 (27.0)
Obesity	20 (54.1)
Former smoker	14 (37.8)
Current smoker	6 (16.2)
Osteoarthritis	12 (32.4)
Rheumatoid arthritis	1 (2.70)
Former smoker	16 (43.2)
Hypertension	17 (45.9)
Handedness, n (%)	
Dominant hand right	29 (78.4)
Dominant hand left	2 (5.40)
Ambidextrous	5 (13.5)
Dominant hand surgical side	18 (48.6)
Work status, n (%)	
Currently working	19 (51.4)
Disabled	15 (40.5)
Retired	3 (8.11)
Degree of ulnar neuropathy at elbow on EMG, n (%)	
Mild	9 (24.3)
Moderate	13 (35.1)
Severe	12 (32.4)
NA	3 (8.11)

Note. BMI = body mass index; EMG = electromyography; NA = not applicable.

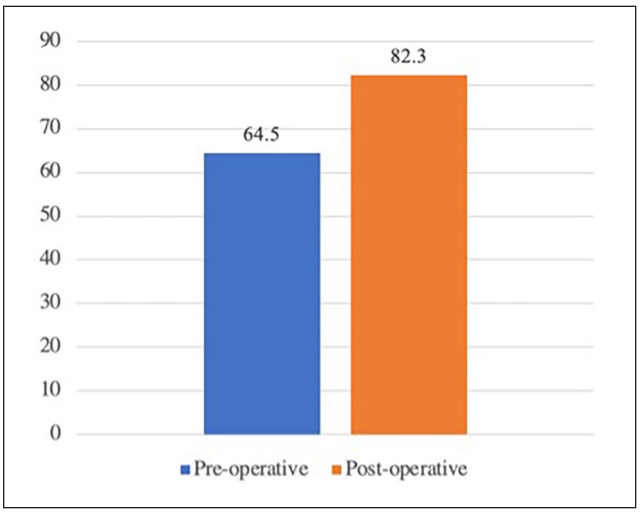

Figure 3. Mean Single Assessment Numeric Evaluation score before and after surgery ($P < .05$).

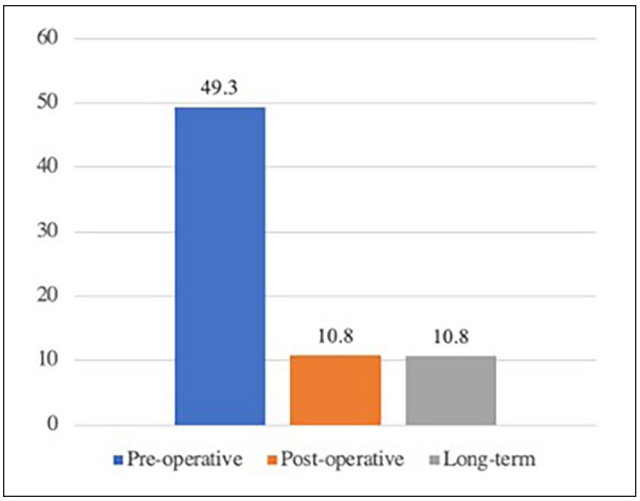

Figure 4. Mean Quick Disabilities of the Arm, Shoulder and Hand score before surgery, after surgery, and long-term ($P < .05$).

improvement of symptoms postoperatively and both carried a diagnosis of cervical stenosis.

Discussion

Despite previously demonstrated equivocal efficacy of simple decompression vs transposition, more recent studies with longer follow-up have recognized concerning failure rates with in situ decompression alone. Several studies have identified ulnar nerve subluxation and associated neuritis as the most frequent factor leading to in situ decompression failure. Given that revision surgery for recurrent CuTS is less efficacious than in primary procedures, it is imperative the index operation is maximally effective.[7] Furthermore, there is growing recognition of ulnar nerve subluxation pathology. While the definition of "subluxation" in the context of CuTS is not universally agreed upon, Richard et al[8] defined it as "the movement of the ulnar nerve out of the postcondylar groove onto or across the tip of the medial humeral condyle when the elbow is flexed and returning to normal location when elbow is extended." It is essential to confirm this clinical finding by intraoperative mobility. The triceps fascia may mimic nerve subluxation as it can occasionally be felt snapping over the medial epicondyle.

Transposition techniques are evolving to address the concerns surrounding subluxation by utilizing stabilization strategies. Tan et al[9] described one such technique that is a modification of the original transposition with V-sling described by Pribyl and Robinson.[5] In this modification the authors created a second fascial sling to prevent not only anterior, but also posterior subluxation. While follow-up indicated neither evidence of subluxation nor any patients requiring revision surgery, 3 of 20 patients had persistent pain and ulnar distribution paresthesia. As previously discussed, the risk of persistent pain and paresthesia is a concern of dissection-induced nerve ischemia in transposition techniques.[9] Patrick et al characterized a triceps muscle tendon sling to prevent ulnar subluxation. In this technique a small, distally based strip of triceps tendon was sutured to the posterior aspect of the Osborne ligament to create a sling between the olecranon and medial epicondyle. The authors noted a significant improvement in DASH scores, pain scores, 2-point discrimination, grip strength, and pinch strength; meanwhile, they noted no recurrences of subluxation.[10]

Techniques of anterior transposition of the ulnar nerve with fascial flap stabilization have existed in the literature for at least 4 decades. Tang detailed a blocking flap technique for preventing ulnar nerve subluxation by raising a rectangular flap off the flexor-pronator fascia and attaching it to the posterior subcutaneous flap. This case series reported 12 of 14 patients had subjective improvement in numbness/tingling or 2-point discrimination. However, the authors note if a large subluxation of the nerve is detected intraoperatively the blocking flap may cause compression of the nerve and continued neuropathy; therefore, the flap is not effective for large subluxations.[11] Acioly et al described a modified decompressive technique utilizing a fragment of loose brachial fascia of the triceps muscle to hold the ulnar nerve in the cubital fossa during forearm flexion, thus preventing subluxation. However, this was conducted in a small sample of 5 patients with leprosy-associated CuTS, and therefore the findings may not translate to the general population with primary CuTS. Further, 3 of 5 patients had no change from their preoperative functional status.[12] Recent studies have described variations of these techniques with small sample sizes of patients such as decompression with a fascial turnover flap to prevent nerve subluxation. In addition, the authors described use of an implanted porcine extracellular matrix to prevent adhesion

formation.[7] However, this technique was noted to have 2 of 13 patients requiring revision surgery. Larger powered trials would be required to determine if the increased cost of implanting a prosthetic, in similar techniques, is associated with improved outcomes.

Some authors have argued that ulnar nerve subluxation pathology is best addressed with anterior transposition to provide stability and place the nerve on its shortest anatomic path, thus preventing worsening traction injury.[3,13] However, more recent studies have found increased perioperative morbidity and narcotic consumption in patients with anterior transposition compared with in situ decompression. As reviewed previously, this is largely attributed to local nerve ischemia from surgical dissection resulting in ischemic pain and increased wound complications.[6] Furthermore, a recent meta-analysis by Wade et al[14] found that simple in situ decompression with or without medial epicondylectomy was found to be the safest operation with the best outcomes.

We identified 5 postoperative complications in our technique including paralysis of ulnar-innervated FDP muscles, ulnar claw hand, wound dehiscence, recurrent CuTS symptoms, and no improvement of symptoms. We postulate that an aberrant takeoff from the ulnar nerve resulted in injury to branches of the fourth and fifth FDP muscles. Postoperative EMG showed denervation with sparing of the FCU muscle. Cadaveric dissections by Marur et al[15] illustrated that the FCU branch was first to take off in 37 specimens just distal to the cubital tunnel. Our dissection is performed under direct visualization; therefore, we do not believe that overly aggressive release was the cause of this complication. The patient was followed with EMG and nerve conduction studies (EMG/NCS), which ultimately showed no recovery. To address the paralysis. A tenodesis to the third FDP was performed. The patient went on to have a satisfactory result with resolution of symptoms. One patient developed postoperative ulnar claw hand. This result is believed to be the natural progression of disease as it presented with a positive Wartenberg sign and severe ulnar neuropathy on EMG/NCS. As the nerve recovered, the weakness transitioned from high ulnar nerve injury involving the FDP muscles to a low ulnar nerve injury with FDP recovery, but with intrinsic muscle weakness. Periodic monitoring with physical exam and electrodiagnostic studies showed improvement of symptoms and eventual resolution of the claw deformity. One patient developed a postoperative infection which was managed with wound irrigation and antibiotics. Finally, two patients had no improvement of symptoms and carried a diagnosis of cervical stenosis observed on EMG and magnetic resonance imaging. This result emphasizes the need for setting postoperative expectations in patients with concurrent pathology that could be contributing to similar symptoms. In certain patients, addressing a neuropathy with a less morbid procedure such as CuTS may provide enough relief to avoid major spine surgery. These complications highlight the importance of optimizing preoperative risk factors, awareness of aberrant anatomy, and setting postoperative expectations.

Our study demonstrates an effective novel technique for treating CuTS by achieving in situ nerve decompression and addressing ulnar nerve subluxation, meanwhile avoiding the risks commonly associated with nerve transposition. Future cadaver-based studies are needed to provide quantitative biochemical data regarding pressure measurements on the ulnar nerve in various reconstructive techniques and positions.

Conclusions

In patients with CuTS and ulnar nerve subluxation, nerve decompression with creation of an intermuscular septal sling is an effective method to improve hand function and prevent subluxation, while preserving the nerve vascularity.

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 individual participants included in this study.

Declaration of Conflicting Interests

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