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Peripheral Nerve

Novel Technique for Ulnar Nerve Transposition at the Elbow: The Neocubital Tunnel

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Background: Many standard surgical procedures for cubital tunnel syndrome rely on ulnar nerve transposition at the elbow. Placing the ulnar nerve anterior to the axis of motion decreases compression during flexion. Subcutaneous, subfascial, and submuscular positioning of the ulnar nerve may predispose to nerve irritation, instability, and compression in the two first scenarios, and requires invasive dissection in the third one. With no single procedure demonstrating clear advantages and outcomes, this study reports the results of a novel technique using the epitrochleo-olecranon ligament to create a neo-tunnel, anatomically stabilizing the ulnar nerve.
Methods: Nine consecutive patients were enrolled. Patients were evaluated qualitatively for symptomatic improvements using physical examination. The Wilson and Krout, modified McGowan, and PRUNE grading scores were used for quantitative measurement.
Results: Postoperatively, all patients reported subjective improvement in symptoms and functional improvement. There were no intraoperative or postoperative complications. Baseline severity of disease was evaluated using the McGowan scale (modified by Goldberg): eight (89%) grade IIA patients and one (11%) grade III patient. Postoperatively, seven (78%) patients were reduced to grade 0, and two (22%) patients to grade 1 ($P < 0.001$). Using the Wilson and Krout criteria, outcomes were as follows: six (67%) excellent, two (22%) good, and one (11%) fair. The mean postoperative PRUNE survey score was 19.3 (SD ± 24.4).
Conclusions: The neocubital tunnel technique is a relatively noninvasive, safe surgical alternative that may be considered when an anterior transposition of the ulnar nerve is indicated for surgical decompression of the cubital tunnel. *(Plast Reconstr Surg Glob Open 2024; 12:e6109; doi: 10.1097/GOX.0000000000006109; Published online 27 August 2024.)*

INTRODUCTION

Ulnar nerve (UN) compression at the elbow resulting in cubital tunnel syndrome (CuTS) is the second most common peripheral nerve entrapment neuropathy in the upper limb.[1,2] The nerve may be subject to compression at multiple sites along its route medially along the elbow. CuTS is characterized by varying degrees of paresthesia in the small and ulnar half of the ring fingers. In severe cases, symptoms may progress to weakness of grip and difficulty with fine manipulation, which can ultimately lead to wasting and atrophy of the major intrinsic muscles of the hand in advanced cases.[1–4]

Although mild cases may be amenable to conservative treatment with physical and occupational therapy, more severe cases, or those where conservative management has failed, warrant surgical decompression of the cubital tunnel and release of the UN.[5] The most basic element of the procedure consists of in situ, or simple decompression of the UN in the cubital tunnel. When significant tension of the nerve is encountered at the epicondylar groove, or if subluxation is noted on elbow flexion during surgery, anterior transposition of the nerve is performed to shorten its course at the elbow to relieve dynamic tension. A variety of surgical techniques for anterior transposition of the UN are used with no standardization to guide procedure selection.[6–8] Technique selection is determined on a case-by-case basis and is also largely dependent on surgeon preference. Partial medial epicondylectomy is an alternative to anterior transposition and is used by some

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surgeons to remove the epicondylar prominence upon which subluxation of the UN occurs.

When anterior transposition of the UN is used, soft tissue coverage of the UN in one of three planes is considered: below the skin flaps of the medial elbow or subcutaneous (ASCT), under the fascia of the flexor-pronator muscular masses or intramuscular (AIMT), or underneath the thick muscular masses of the flexor-pronator muscles or submuscular (ASMT).[9,10] To date, no studies have yet demonstrated definitive superiority of any one technique.

We present a case series illustrating a novel technique for UN coverage following anterior transposition. It uses the epitrochleo-olecranon ligament (EOL), the main fibro-aponeurotic structure covering the ulnar groove, positioned proximal to what is eponymously referred to in previous studies as the Osborne band.[11] Normally obliterated in the course of UN decompression, our technique preserves and maintains the EOL insertion to the medial epicondyle to provide a soft tissue cover over the transposed UN. This effectively creates a tension-free, "neo-cubital tunnel" with a muscular bed and the transposed EOL as an anatomical roof. Pre- and postoperative outcomes using several patient-reported measures are evaluated to assess the safety and effectiveness of our technique.

Takeaways

Question: Could anterior transposition of the ulnar nerve be reliably and satisfactorily performed in a manner that is relatively less invasive and securely protected?

Findings: We performed nine cases for stabilizing and protecting the transposed ulnar nerve in a "neocubital tunnel" with a muscular bed and the transposed epitrochleo-olecranon ligament as an anatomical roof, within which the ulnar nerve remained tension-free, demonstrating both short-term safety and long-term efficacy.

Meaning: To optimize the successful release of the anteriorly transposed ulnar nerve, it is essential to maintain a well-vascularized soft tissue bed by minimizing over-dissection and avoiding irritation of the ulnar nerve.

METHODS

Ethics Statement

This study was conducted in a tertiary training hospital (American University of Beirut medical center) according to the good clinical practice and the Declaration of Helsinki. The study was approved by the ethics review committee of American University of Beirut (approval number BIO-2023-0096). All participants provided verbal informed consent.

Study Participants and Design

This was a retrospective study performed at the American University of Beirut Medical Center and included patients who were treated between 2012 and 2021. All patients were at least 18 years of age and had presented with severe McGowan stage II or III CuTS (Table 1). Patients with a history of brachial plexus injuries, cervical radiculopathy, oncologic etiologies of UN compression or primary motor neuropathy were not included in the study. Preoperative evaluation for all patients included physical examination demonstrating the presence of a Tinel sign, weakness of grip, and tingling and numbness in the UN distribution. Nerve conduction studies and electromyography had also been performed on all patients to corroborate physical examination findings.

Table 1. McGowan Classification as Modified by Goldberg

Stage	Criteria
I	Purely subjective symptoms
II	Muscle weakness and/or objective sensory signs
II a	No atrophy of intrinsic muscles
II b	Some atrophy of intrinsic muscles
III	Significant sensory and motor defects

Operative Technique

All procedures were performed under loco-regional anesthesia. The skin incision started on the distal aspect of the medial arm 8 cm above the medial epicondyle and continues downward to a point midway between the medial epicondyle and the olecranon process. The incision is continued for approximately 6 cm on the medial aspect of the forearm over the Flexor carpi ulnaris. Upon identification of the UN, the fibro-aponeurotic fascia forming the roof of cubital tunnel in the epicondylar groove is incised to expose the nerve. The portion of the fascia spanning the medial epicondyle and olecranon is released at the olecranon, thus creating the EOL flap which is elevated and turned anteriorly based on its epicondylar insertion. In all cases, it is sufficiently mobile to allow it to be rotated 180 degrees to reach the fascia of the common flexor-pronator muscle mass in the medial elbow.

The decompression of the UN proceeds in a standard fashion. Proximally along the cubital tunnel, the distal portion of the medial intermuscular septum and the Struthers arcade are released. Distally, the Osborne band, which forms the connective tissue bands between the humeral and ulnar heads of the flexor carpi ulnaris, is released as a potential compression site. This proceeds up to the first motor branch for the flexor capri ulnaris.

Upon release of these structures, the UN is gently dissected from its surrounding connective tissue with careful attention to respect its extrinsic blood supply. The elbow is then flexed intraoperatively, and stability of the nerve within the epicondylar groove is verified. If subluxation or excessive tension is present, an anterior transposition is then performed. The flexor-pronator muscle mass fascia is opened anterior to the epicondylar process in a rectangular shaped laterally based flap to allow for a muscular receiving bed for the nerve. This fascia flap is elevated from the underlying muscle fibers forming the lateral roof of the neocubital tunnel. The nerve is then anteriorly transposed and laid between gently separated fibers of the flexor-pronator muscle mass. The EOL is then lifted anteriorly over the transposed UN and secured to the

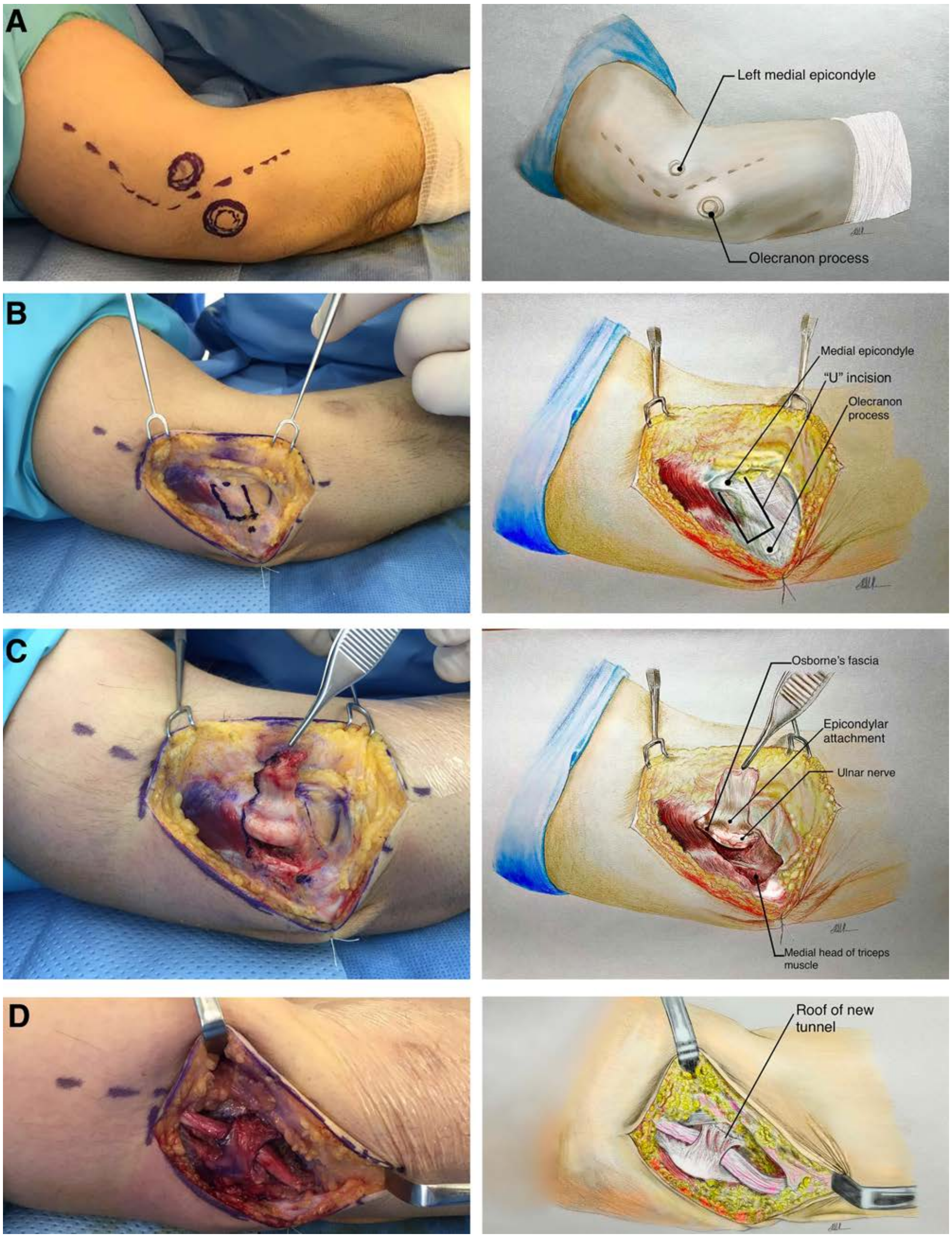

Fig. 1. A 29-year-old male patient underwent anterior UN transposition using the neocubital tunnel technique. Design of skin approach (A), design of the EOL flap of the cubital tunnel (B), elevation of the flap allowing access and decompression of the ulnar nerve (C), anterior transposition of the UN with construction of the neo-tunnel (D).

fascia flap previously dissected and elevated forming the neocubital tunnel. Particular care is taken to ensure this neocubital tunnel remains large enough to allow for normal displacement of the nerve during elbow movement[12] (Figs. 1 and 2). [**See Video (online)**, which demonstrates UN stability while allowing enough room on elbow flexion immediately postoperative.]

The skin flaps are then replaced and sutured over a suction drain. Postoperatively, the patients receive standardized care, and the elbow is immobilized in a splint at 90 degrees of flexion for 3 days.

Postoperative Evaluation

Postoperative evaluation included the following: Wilson and Krout score, modified McGowan grading score, Patient Related Ulnar Nerve Evaluation (PRUNE) survey, and a physical examination. The three quantitative grading systems are all validated for use in adults. The clinical examination assessed postoperative improvement in UN function. The Wilson and Krout score was used to stratify patients based on the presence of motor or sensory symptoms and incision site sensitivity (Table 2).[13] The PRUNE score is a

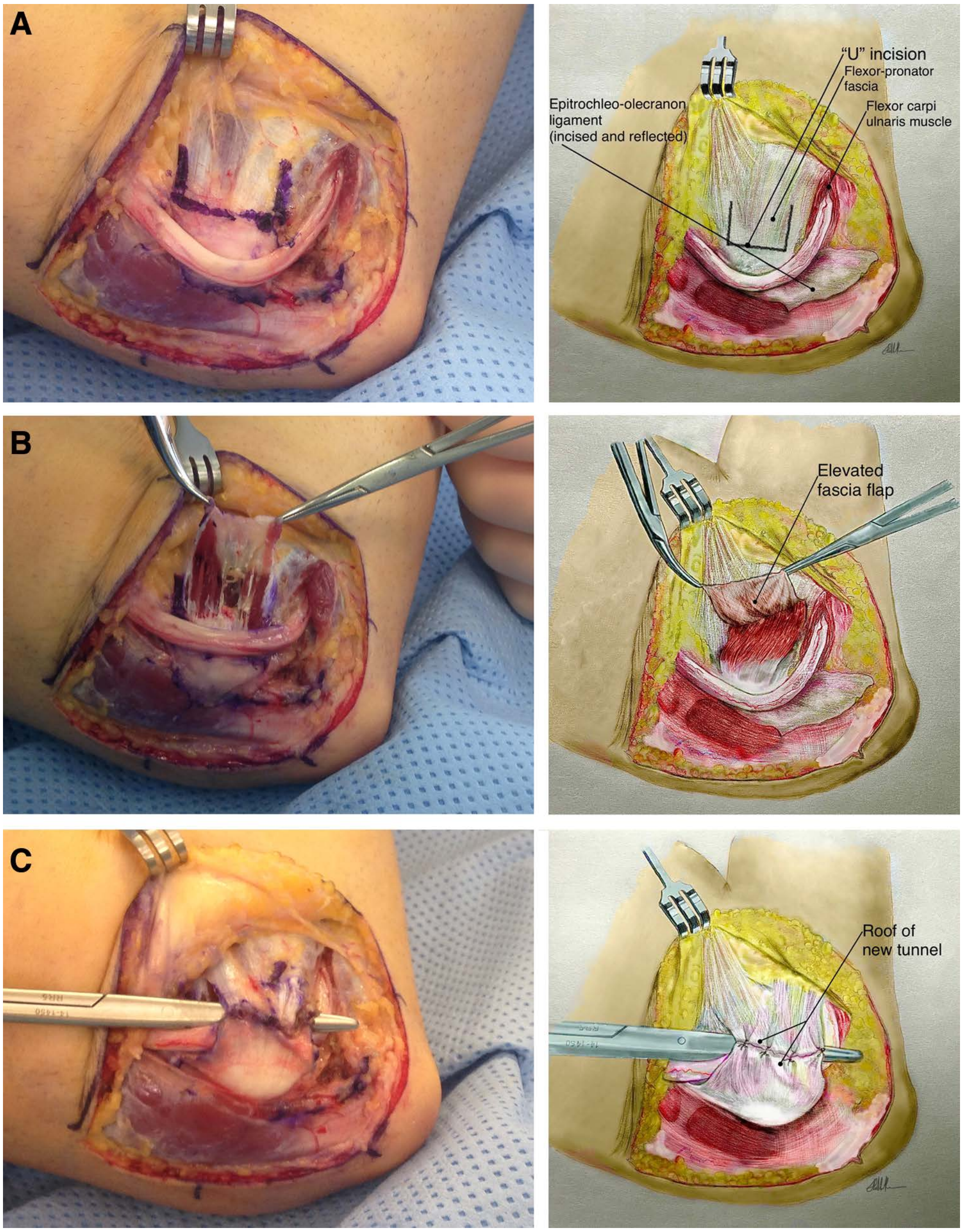

Fig. 2. A 38-year-old male patient underwent anterior UN transposition using the neocubital tunnel technique. Epitrochleo-olecranon ligament incised and reflected (A), Anterior lip of flexors muscle fascia flap was elevated 1 cm to provide enough room (B), Anterior transposition of the nerve and approximation of the flaps creating the neo-tunnel, providing stability for the nerve while remaining tension free (C).

Table 2. Wilson and Krout Classification

Grade	Criteria
Excellent	Minimal motor and sensory changes and no tenderness at the incision site
Good	Loss of symptoms but a regional sensitivity continued at intervals
Fair	Improved but persistent sensory or motor changes that are milder than preoperative status
Poor	No improvement or worsened condition

validated patient-reported outcome score measure of UN function and symptoms, with a score of 0 denoting no symptoms and full functionality, and 100 denoting the worst possible symptoms and function.[14] The modified McGowan grading system used was developed by McGowan and modified by Goldberg (Table 1).[15–17] Eight patients (89%) were classified as having McGowan grade II lesions, and one patient (11%) was classified as having a grade III lesion preoperatively.

Statistical Analysis

IBM SPSS statistics software version 28 was used to conduct statistical analysis for symptomatic resolution by McGowan classification using a paired sample *t* test. *P* values less than 0.05 were considered to indicate statistical significance.

Table 3. Nine Cases of UN Transposition at the Elbow Using the Neocubital Tunnel Technique

Characteristic	Value (%)
Age, y	42.6 ± 16.5
BMI	24.8 ± 2.4
Sex	
Male	6 (67)
Female	3 (33)
Laterality	
Right	2 (22)
Left	7 (78)
PRUNE score	19.3 ± 24.4
Complications	None

The data are shown as mean ± SD or n (%).

RESULTS

Nine patients were enrolled in this study. Their demographic characteristics are presented in Table 3. All study patients reported subjective improvement of ulnar neuropathic symptoms and functional improvement at postoperative follow-up with no reported complications.

The Neocubital Tunnel Technique Achieved Significant Symptomatic and Functional Improvement

Patient outcomes are illustrated by the Wilson and Krout score, modified McGowan grading score and PRUNE survey. Short-term surgical outcomes were evaluated via the McGowen and Wilson and Krout scores, with a median follow-up time of 23 days postoperatively (mean ± SD = 29.6 ± 33.02 days). Long-term surgical outcomes were evaluated with the PRUNE survey, with a mean follow-up of 6.38 years (SD ± 2.96 years). One patient was excluded from the survey due to death.

Wilson and Krout classification demonstrated that six (67%) patients had excellent results, two (22%) patients had good results, and one (11%) patient had fair results. Symptom improvement as measured by the modified McGowan grading system showed a decrease by at least one grading level for all nine patients (Table 4). The most frequently occurring outcome was a reduction from grade IIa (muscle weakness and/or objective sensory signs without muscular atrophy) to grade 0 (symptom-free). The mean postoperative PRUNE survey score was 19.3 (SD ± 24.4).

Our technique uses the flexor mass fascia without deep intramuscular or submuscular dissection providing enough nerve protection via the EOL. Moreover, the neocubital tunnel remained large enough to allow normal displacement of the UN during elbow movement, thereby ensuring UN stability while allowing enough room (Figs. 1 and 2) [**See Video (online)**]. Postoperative clinical examination showed no sensory symptoms on elbow flexion test in all patients.

Table 4. Symptomatic Resolution by Modified McGowan Classification

Grade	Preoperative, n (%)	Postoperative, n (%)	$P < 0.001$
0	0	7 (78%)	
I	0	2 (22%)	
II a	8 (89%)	0	
II b	0	0	
III	1 (11%)	0	

DISCUSSION

In situ decompression of the UN is the accepted treatment for patients with CuTS who fail initial conservative therapy, who exhibit clinical signs of motor nerve dysfunction, or who exhibit abnormality on nerve conduction studies or electromyography.[18] Variations on simple in situ decompression for CuTS include medial epicondylectomy or anterior transposition of the UN with or without muscular coverage utilizing the flexor-pronator muscle mass.[3,18,19] To date, there is no consensus to guide surgeons in choosing a particular surgical technique when surgery is indicated.[20,21] This is especially true when anterior transposition of the UN is involved and the surgeon has to decide on anterior transposition with subcutaneous, intramuscular, or submuscular coverage.[22] Anterior transposition is typically performed in case of significant tension of the nerve, or if subluxation is noted on elbow flexion during the decompression, as it shortens the distance traversed by the UN along the elbow and provides better long-term results than simple in situ decompression. although no strong evidence clearly demonstrates the superiority of any one technique, bypassing anterior transposition following in situ decompression can lead to persistent symptoms that may necessitate secondary procedures.[23,24] This is because it does not sufficiently address the significant tension and traction when the elbow is flexed.[25,26] Medial epicondylectomy obviates the need for UN dissection and transposition while addressing postoperative subluxation. However, tension may still be present due to the longer path the nerve takes through the epicondylar groove. Additionally, medial elbow pain and iatrogenic elbow instability limit its use.[27]

Anterior transposition involves dissection and release of the UN from the epicondylar groove. The nerve is also released proximal and distal to the groove to avoid kinking upon transposition. This approach relieves both compression and tension. The released nerve is then laid anterior to the medial epicondyle, and soft tissue coverage is performed: subcutaneously on the common flexor mass fascia and covered with skin flaps (ASCT), below the fascia intramuscularly within the flexor-pronator muscle mass (AIMT), or submuscularly below the humeral insertion of the flexor-pronator muscle mass (ASMT). Although anterior transposition effectively addresses compression, subluxation, and tension, releasing the nerve from its connective tissue attachments risks segmental ischemia.[28] Therefore, minimizing over-dissection and transposing the released nerve to a relatively vascularized soft tissue bed are crucial.

There are justifications for the various soft tissue coverage techniques following anterior transposition. ASCT allows for UN transposition while providing coverage by advancing relatively thin cutaneous flaps. This technique avoids dissection through the common flexor-pronator muscle mass and results in better postoperative recovery. On the other hand, the nerve is left relatively vulnerable beneath a thin cutaneous flap that may predispose the patient to adhesion formation and incisional hypersensitivity. The patient may also experience a postoperative Tinel sign when pressure is inadvertently placed on the medial elbow.

Providing the UN with more robust soft tissue coverage as in the AIMT or ASMT techniques provides more protection while still yielding promising results.[29,30] Subfacial intramuscular transposition is less commonly performed, however, as studies have found a high risk of nerve secondary irritability due to the tightness of the fascia approximated over the transposed nerve placed traction forces within the muscular bed.[31] This was demonstrated by studies that revealed dense scarring on reoperation after intramuscular transposition, where only 62% of patients had long-term success after AIMT, with many reporting persistent paresthesias and muscle weakness.[31,32]

Submuscular transposition is considered the most invasive of the existing anterior transposition techniques. This approach requires complete release of the flexor-pronator muscle mass from the medial epicondyle.[28] ASMT is a commonly performed procedure for both primary and secondary UN entrapment cases, as safety and efficacy of the technique have been favorable.[33–35] However, ASMT is highly invasive, requiring a longer incision, longer operative times, more postoperative pain, and prolonged immobilization for up to 10 days as the reattached flexor-pronator muscle mass is allowed to heal.[36]

The neocubital tunnel technique described in this study has shown promise in terms of treatment and safety. Our technique performs a standard UN neurolysis followed by anterior transposition and soft tissue coverage. It avoids aggressive maneuvers such as medial epicondylectomy while addressing relief of tension by transposing the nerve anteriorly. Unlike ASCT, it offers more protection to the transposed nerve, as it is placed between gently separated fibers of the flexor-pronator muscle mass—and in contrast to AIMT or ASMT, muscle fibers are neither transected nor detached from their humeral origin. The primary principle in any technique is to avoid introducing new tension or compression on the UN.[20] The tightness of the flexor/pronator fascia poses a challenge for preventing nerve compression with subfascial transposition. To address this, we incorporated an additional structure, the EOL, to the fascia, creating more space for the UN. Goldberg et al[37] utilized the Osborne band to cover the UN by suturing it to the skin or intact flexor/pronator fascia, positioning it subcutaneously and risking irritation. In contrast, our method employs the EOL, a more substantial structure positioned proximal to the Osborne band. After detachment from the olecranon, the EOL can move anteriorly over the medial epicondyle, offering greater length than the Osborne band and transitioning from a posterior to an anterior tunnel. We then incise the flexor/pronator fascia to form an additional rectangular flap, which we suture to the transposed EOL, creating an anatomical roof over the neo-tunnel. This covers the transposed UN with enough space and prevents subluxation, positioning the UN below the fascia on a muscular bed. This approach promotes optimal healing by approximating the EOL flap to a fascial flap. Although its thickness is only 3–4 mm, it is sturdy and provides robust soft tissue protection for the UN. Our technique does not introduce additional risks; the EOL is commonly transected in all cubital tunnel decompressions without resuturing. We observed no complications, such as elbow destabilization or olecranon bursitis, in our cases.

As there are no studies demonstrating definitive superiority of any surgical technique to treat CuTS, we felt that introducing a technique that was easily reproducible, less invasive, and safe was relevant. The neocubital tunnel procedure demonstrated both short-term safety and long-term efficacy. Our study had a majority of excellent results as rated by the Wilson and Krout criteria as well as 100% of patients experiencing a decrease in severity ratings as measured by the modified McGowen's criteria in short-term follow-up. Long-term outcomes of surgery measuring UN symptoms and disability were assessed with a PRUNE survey. At a mean follow-up of more than 6 years, our patient cohort exhibited PRUNE scores superior to those, with patients performing normal activities of daily living, working, or who possessed functional two-point discrimination.[14] These results demonstrate long-term efficacy of the neocubital tunnel technique that is at least comparable to that of existing techniques.

Although we recognize a small sample size as a limitation to our study, we feel that our long-term follow-up compensates for this by giving more validity to our results. Notably, given that complete recovery from muscular atrophy in severe cases may exceed 2 years following surgical treatment, ability to assess long-term outcomes is of great significance to thoroughly assessing the efficacy of the neocubital tunnel, or any other technique.[38,39]

Further studies evaluating this technique with a larger sample size are warranted. To that end, the effect of variable demographics, comorbidities, and preoperative symptom severity should be better elucidated and quantified. Nonetheless, the preliminary results presented in this study are encouraging and illustrate that the technique may be considered in patients with CuTS.

CONCLUSIONS

There is no consensus on a single procedure demonstrating a significant advantage to treat CuTS, particularly when anterior transposition of the UN is indicated, leaving surgeon preference to play a big role. The neo-cubital tunnel technique provides a reliable alternative for patients with cubital tunnel syndrome who are surgical candidates for anterior UN transposition. The present technique provides UN decompression in the cubital tunnel coupled with tension reduction via anterior transposition. Coverage of the nerve with the EOL and the flexor-pronator fascia flaps minimizes invasive dissection and/or detachment of the flexor-pronator muscle mass from the humeral head. It also provides results comparable to those of previously described techniques while minimizing postoperative recovery and complications.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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