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Original Research

Electrodiagnostic Testing Predicts Postdecompression Outcomes in Patients With Cubital Tunnel Syndrome

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Purpose: Electrodiagnostic (EDX) testing is commonly used in conjunction with symptoms and physical examination findings to diagnose cubital tunnel syndrome (CuTS). The purpose of this study was to investigate the relationship between preoperative EDX diagnosis and the degree of Disabilities of the Arm, Shoulder, and Hand (*Quick*DASH) improvement after surgery within the CuTS patient population.
Methods: A retrospective review was designed to analyze patients from a single institution who underwent a cubital tunnel release. Patients who had preoperative EDX testing, as well as preoperative and 3-month postoperative *Quick*DASH scores were eligible for inclusion. These patients were divided into two groups, EDX-positive or EDX-negative, based on the findings of their EDX testing for CuTS. Demographics, preoperative *Quick*DASH, postoperative *Quick*DASH, and changes in *Quick*DASH were compared between the two groups.
Results: Fifty-seven patients were included—34 EDX-positive and 23 EDX-negative. The EDX-negative cohort had higher preoperative *Quick*DASH scores, which approached but did not reach significance ($P = .06$). Both groups had significant improvement in *Quick*DASH following cubital tunnel release ($P = .021$, $P < .01$). Patients with EDX-negative testing had a significantly greater improvement in *Quick*DASH from before surgery to 3 months after surgery (25 points vs 11, $P < .01$).
Conclusions: Patients who underwent cubital tunnel release had a significant short-term improvement in their *Quick*DASH scores, regardless of EDX diagnosis. However, negative preoperative EDX studies in the setting of strong clinical suspicion of CuTS do not exclude diagnosis and may in fact be a positive, rather than a negative, predictive factor for short-term postoperative functional improvement.
Type of study/level of evidence: Prognostic IV.

Electrodiagnostic (EDX) testing is one common modality used in the diagnosis of cubital tunnel syndrome (CuTS), the second most common neuropathy of the upper extremity. [1–3] Electrodiagnostic testing uses electric signals to stimulate nerve activity and subsequently records conduction velocity or degree of muscle activation at certain locations to evaluate the functionality of a nerve.[1,4,5]

Currently, there is no established single reference standard in the diagnosis of CuTS.[2] Commonly in practice, EDX is used in conjunction with symptoms and physical examination findings to diagnose CuTS.[1,2,4] Multiple studies have demonstrated variable sensitivity of EDX in the context of CuTS diagnosis, ranging from 11.7% to 87.5%, due to a variety of factors including a variation in the degree of neuronal fibrosis, operator-dependent technical experience, and the lack of a consistent gold standard for CuTS diagnosis.[2,5] Early CuTS may also be characterized by intermittent compression of the nerve, resulting in dynamic ischemia without decreased nerve conduction velocity.[1,5–7] Limitations in EDX testing methodology may fail to elucidate CuTS diagnosis within this population with otherwise characteristic symptoms, physical findings, or positive ultrasonography.

The association of preoperative CuTS EDX diagnosis and degree of improvement in patient-reported outcome measures (PROMs)

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may provide valuable insights concerning the prognosis, treatment, and recovery of CuTS patients. Previous studies have investigated the correlation between EDX testing and CuTS prognosis in patients with abnormal EDX testing demonstrating that a decrease in compound muscle action potential was associated with poorer postoperative symptoms and physical examination findings, and less change in postoperative conduction velocity was related to worse PROM scores.[8,9] Additionally, other studies have explored outcomes after decompression of the ulnar nerve in patients with normal EDX testing showing improvement in symptoms, resolution of proactive testing, and functional outcomes.[10,11] Furthermore, several studies have examined the ability of diagnostic testing to predict outcomes in carpal tunnel syndrome.[12,13] However, there is a paucity of knowledge concerning the prognostic potential of EDX diagnosis for patients who subsequently undergo cubital tunnel release (CuTR). This study aims to investigate the relationship between preoperative EDX diagnosis and the degree of Disabilities of the Arm, Shoulder, and Hand (*Quick*DASH) improvement after surgery within the CuTS patient population. We hypothesize that positive preoperative EDX would be associated with a greater degree of functional improvement, as measured by *Quick*DASH.

Methods

Data collection and patient selection

Institutional review board approval was obtained prior to beginning this study. All patients 18 years or older who had undergone a CuTR at a single tertiary referral institution between September 2016 and May 2023 were eligible for inclusion. Patients who underwent concurrent operations (eg, carpal tunnel release, trigger finger release, etc) at the time of their CuTR were included in the study. These patients were included as it was thought to reflect the variety of presentation of CuTS patients in typical practice. Exclusion criteria included the lack of EDX testing, no preoperative or postoperative *Quick*DASH score, or patients unable to be reached for follow-up. Patients were excluded if they underwent revision CuTR, received anterior interosseous nerve transfers, or were found to have EDX testing indicative of a distal site of compression at Guyon canal or EDX evidence of cervical spine compression (Fig.).

A retrospective review of all clinical information, including basic demographic information, preoperative data, surgery data, and postoperative data, was collected for each patient. Preoperative data included diagnostic testing, physical examination findings, and PROMs. Postoperative data included surgical reports, physical examination findings, complications, and postoperative PROMs. Follow-up data were gathered at the 3-month postoperative routine clinic visits.

Diagnosis of CuTS was determined through clinical evaluation, ultrasound, electrodiagnostic testing, or any combination of the three. Clinical diagnosis was established using one or more of the following criteria: the presence of paresthesias in the ulnar nerve distribution, a loss of 2-point discrimination ($\geq$6 mm), abnormal Semmes-Weinstein testing, weakness or atrophy of the ulnar nerve innervated hand muscles, or positive provocative testing, such as Tinel sign at the medial elbow and the elbow flexion compression test. Clinical evaluations were completed by one of the two senior authors (E.R.W. and M.B.G.). Electrodiagnostic testing was performed by electrodiagnostic medicine board-certified neurologists or physical medicine and rehabilitation physicians at our institution. Ultrasonography was performed by one sports medicine physician.

Electrodiagnostic classification

Patients' CuTS electrodiagnostic diagnosis was determined using the guidelines established by the American Association of Neuromuscular and Electrodiagnostic Medicine.[14] Specifically, a patient was considered positive for CuTS on EDX if the conduction velocity was less than 50 m/s across the elbow or if the above elbow to below elbow segment was >10 m/s slower than the below elbow to wrist segment.[14]

Primary outcomes

The primary outcome variable of this study was the *Quick*DASH, a PROM that is a validated abbreviated version of the disabilities of the arm shoulder and hand questionnaire.[15,16] This instrument uses a set of 11 questions to analyze symptomology and functionality among patients with upper-extremity conditions.[15−17] Patients who underwent preoperative electrodiagnostic testing and completed both a preoperative and a 3-month follow-up *Quick*DASH questionnaire were included in the analysis.

Statistical analysis

Descriptive statistics were generated for the collected data. Continuous data were analyzed using mean and SD while categorical variables were analyzed with counts. The Shapiro-Wilk test was performed to check for normality. None of the samples were considered normal; hence, the nonparametric Mann-Whitney U test was used to compare differences between means. Chi-squared tests were used to compare dichotomous variables. All data analysis was performed using Microsoft Excel and Python with the SciPy Library (Version 1.11.2).[18]

An α of 0.05 and a β of 0.80 were used to determine significance and power. A value of 15.91 was used as the minimal clinically important difference of the *Quick*DASH based on the results of Franchignoni et al.[19] An a priori sample size calculation was performed, which estimated a minimum of 54 patients needed for the difference in change in *Quick*DASH to be sufficiently powered.

Results

Fifty-seven patients who underwent a CuTR and completed both preoperative and 3-month postoperative *Quick*DASH surveys were identified. Upon exclusion of ineligible patients, 34 EDX-positive patients and 23 EDX-negative patients were included. Demographics of the groups are demonstrated in Table 1. The EDX-positive group was significantly older (60 vs 45 years, $P < .05$) and had significantly more male patients (58.8% vs 22.7%, $P < .05$). There were no differences in body mass index or diagnosis of diabetes between the groups. Furthermore, there was no difference in the associated procedures between the two cohorts ($P = .41$). The concurrent procedures and their associated counts can be seen in Table 2. Having a concomitant diagnosis did not affect preoperative *Quick*DASH (41.15 for CuTR only vs 50.57 for CuTR + other, $P = .13$), postoperative *Quick*DASH (28.18 vs 32.80, $P = .48$), or Δ*Quick*DASH (12.97 vs 17.76, $P = .35$). Of the 29 patients included with carpal tunnel syndrome, six were negative for carpal tunnel syndrome on EDX, with three in the CuTS EDX-positive group and three in the CuTS-negative group.

There was a higher preoperative *Quick*DASH among patients with EDX-negative testing (56.10 vs 45.23, $P = .06$) but did not reach significance (Table 3). Among patients with positive EDX studies, *Quick*DASH scores decreased by 11 points (Table 4) from before to 3 months after CuTR ($P = .02$), indicating an improvement, however, not surpassing the minimal clinically important difference. In the

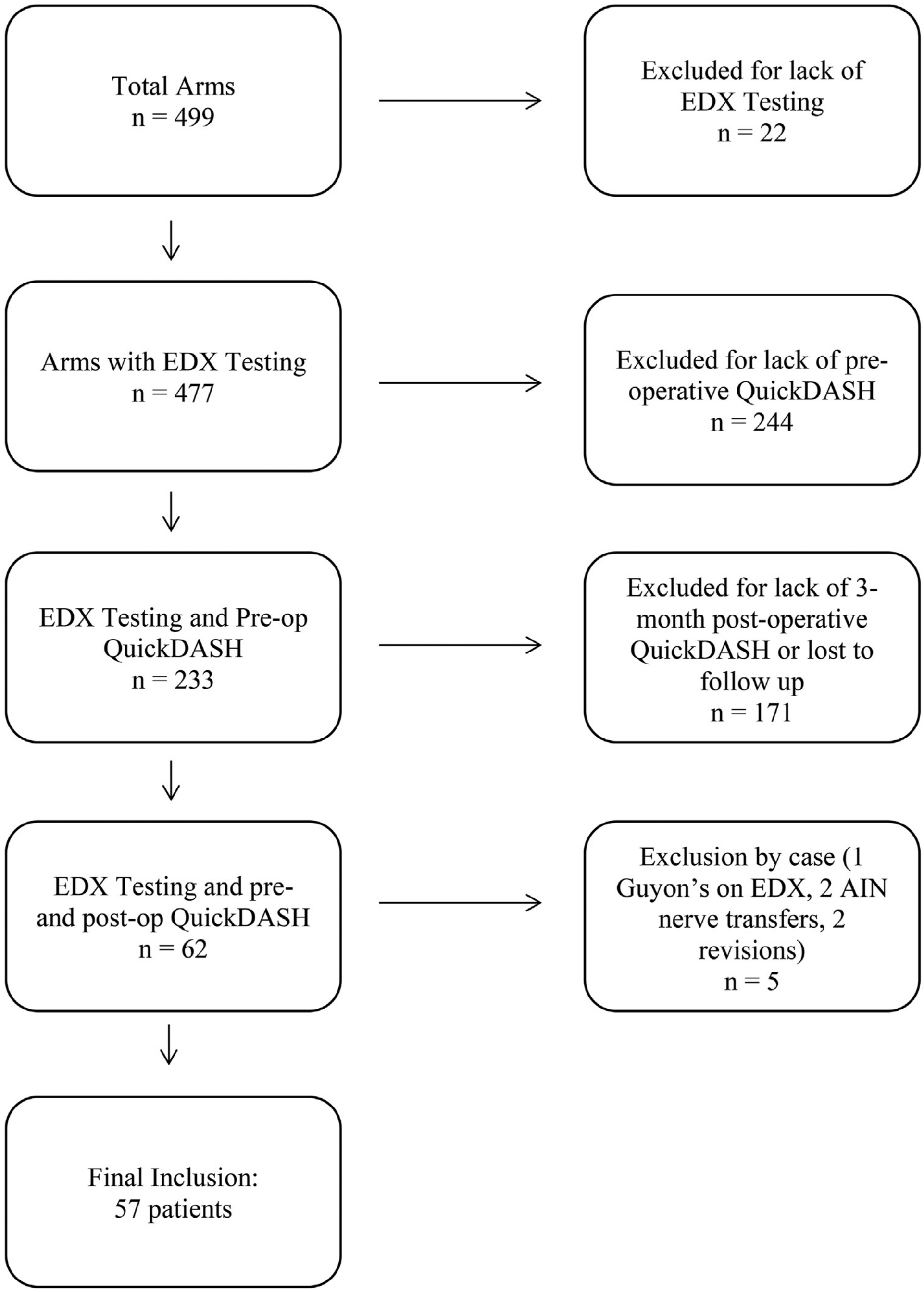

Figure. Patient identification and inclusion schema.

cohort of patients with negative EDX testing, *Quick*DASH scores decreased by 25 points (Table 3), that is, patients had functional improvement, following CuTR ($P < .01$). There was a greater magnitude of functional improvement change among EDX-negative patients ($P < .01$). After CuTR, mean *Quick*DASH scores at 3 months after surgery were the same regardless of if EDX testing was positive or negative ($P = .72$).

Discussion

Given the potentially low specificity of EDX in CuTS, many patients may undergo ulnar nerve release with negative preoperative EDX testing.[2,5] This study sought to answer in a heterogeneous group of patients undergoing CuTR, whether there was a difference in the magnitude of improvement on the *Quick*DASH from before surgery to 3 months after surgery. This study found that both patients with positive and negative EDX testing improved after surgery; there was a greater absolute improvement in *Quick*DASH in those with negative EDX testing (25 vs 11 points). We therefore reject our hypothesis that positive preoperative EDX would be associated with a greater degree of functional improvement, as measured by PROMs.

Prior literature has examined some factors related to poor outcomes after ulnar nerve release. Liu et al[8] previously demonstrated that the decrease in compound muscle action potential on EDX was related to poorer CuTS prognosis as defined by patient concerns,

Table 1
Demographics of EDX+ and EDX− Patients

Demographic	EDX + (n = 34)	EDX− (n = 23)	*P* Value
Age (y)	60.1 ± 12.83	45.47 ± 14.63	< .001
Sex			.006
Male (n)	20	5	
Female (n)	14	18	
BMI	30.87 ± 6.4	30.1 ± 7.58	.474
Diabetes			.859
Present (n)	5	3	
Absent (n)	29	20	
Surgery			.409
CuTR only	14	7	
CuTR + other*	20	16	

BMI, body mass index.
* Patients underwent CuTR with another concurrent operation (carpal tunnel release, trigger finger release, etc).

Table 2
Number of Patients Undergoing Concurrent Procedures

Concurrent Procedure(s)	EDX− Patients (n = 16)	EDX+ Patients (n = 20)
Carpal tunnel release*	10	11
Guyon canal release	1	1
Trigger finger release	1	0
Removal of elbow hardware	0	2
Thumb UCL reconstruction	0	1
Arthroscopic debridement + loose body excision	1	0
CTR + DeQuervain release	1	0
CTR + Dupuytrens excision	0	1
CTR + Guyon canal release	0	2
CTR + flexor tenosynovectomy	0	1
CTR + olecranon bursa resection	0	1
CTR + trigger finger release	2	0

CTR, carpal tunnel release; CTS, carpal tunnel syndrome; UCL, ulnar collateral ligament.
* Of the 29 patients included with CTS, six were negative for CTS on EDX, with three in the CuTS EDX+ and three in the CuTS−group.

Table 3
Comparing Mean *Quick*DASH and Δ*Quick*DASH Between EDX+ and EDX− Patients

Outcome Score	EDX+ (n = 34)	EDX− (n = 23)	*P* Value
Preoperative *Quick*DASH*	45.23 ± 21.42	56.10 ± 19.62	.062
Postoperative *Quick*DASH†	34.41 ± 23.81	30.60 ± 21.11	.720
Δ*Quick*DASH	10.82 ± 20.83	25.49 ± 20.08	.009

* Lower *Quick*DASH reflects a better score, ranging from 0 to 100.
† Postoperative *Quick*DASH recorded at the 3-month follow-up appointment.

Table 4
Comparing Mean Preoperative With Mean Postoperative *Quick*DASH Scores for Both EDX+ and EDX− Patients

EDX Result	Preoperative *Quick*DASH*	Postoperative *Quick*DASH†	*P* Value
EDX+	45.23 ± 21.42	34.41 ± 23.81	.021
EDX−	56.10 ± 19.62	30.60 ± 21.11	< .001

* Lower *Quick*DASH reflects a better score, ranging from 0 to 100.
† Postoperative *Quick*DASH recorded at the 3-month follow-up appointment.

clinical symptoms, and physical examination. However, most of the patients in that study (88 of 91) had a positive EDX diagnosis, and the authors did not include any PROMs as an indication of patient prognosis.[20] Improvement in EDX testing after surgery has been shown to correlate with PROMs in previous studies; Koziej et al[9] demonstrated an association with improvement on the Michigan Hand Outcomes Questionnaire and postoperative improvement in measured conduction velocity at 6 months. Furthermore, other studies have shown that patients with negative EDX may have good outcomes.[10,11] However, there is less evidence of a direct comparison using PROMs in a mixed cohort of EDX-positive and negative patients.

Direct comparison between with EDX-positive and negative groups is difficult in this cohort because of the increased *Quick*DASH scores among patients with EDX-negative testing (56.10 vs 45.23). This value did not reach statistical significance, although this study was not specifically powered to look at preoperative *Quick*DASH as the dependent variable. Furthermore, this difference is unlikely to be clinically relevant as the minimal clinically important difference is 15.91.[19] However, given the fact that the postoperative difference in *Quick*DASH was greater among those with negative EDX (25 vs 11, $P < .05$), this study provides preliminary evidence to refute our hypothesis that positive EDX is more predictive of short-term improvement of PROMs.

Prior literature has reported quicker recovery periods following CuTR in patients with transient ischemia of the nerve without further damage.[1,6,21] This finding is consistent with our EDX cohort, as less severe disease, indicated by negative EDX testing, resulted in greater improvement in *Quick*DASH. Other studies have described that patients who are EDX-positive for CuTS have likely experienced demyelination or axonal loss, which may portend a suboptimal recovery.[1,7,22] Additional studies have shown that more advanced stages of CuTS may be correlated with less nerve recovery as reported on symptoms, physical examination findings, or diagnostic testing.[23−26] Recovery of severe ulnar neuropathy is a prolonged process, as remyelination occurs over several months and nerve regrowth after axonal loss occurs at a rate of 1 mm per day.[1,7] Therefore, the follow-up interval of this study at 3 months may not fully capture the eventual improvement of the EDX-positive patients; however, this finding overall portends earlier recovery among EDX-negative patients.

Other limitations of this study include the age differences of the cohort. Prior studies have shown conduction velocity of peripheral nerves decreases with age, whereas recovery and regeneration of nerves also decline with increasing age.[27−30] The lower average age of the EDX-negative patients may have also contributed to the greater degree of *Quick*DASH improvement observed in this patient population. Other works have demonstrated similar results regarding the efficacy of CuTR in improving symptoms and decreasing disability, regardless of EDX diagnosis.[5,8−11,31] Shubert et al[5] demonstrated symptom relief in 94% of patients following CuTR, whereas EDX testing revealed 11% had clear CuTS, 23% had ulnar neuropathy, and 66% had normal findings. In accordance with these prior findings, although the EDX-negative group improved more than their EDX-positive counterparts, both groups demonstrated significant improvement in *Quick*DASH scores after surgery.

The demonstrated greater improvement in *Quick*DASH scores among EDX-negative patients suggests that negative EDX testing in the setting of clinical suspicion or positive ultrasound findings for CuTS may in fact be a positive predictive factor for improved short-term postoperative outcomes. Ultrasound has been shown to be a useful adjunct in the diagnosis of CuTS, with high sensitivity, specificity, and reliability.[32−34] However, due to cost and user expertise, its use in practice is still limited.[35] Of the 57 patients included in our study, only 18 had preoperative ulnar nerve ultrasonography, with 17 of those being positive for CuTS. Within the EDX-negative cohort, seven of eight patients had positive ultrasound findings of CuTS.

Electrodiagnostic-negative patients may be earlier in their disease progression, and early identification and treatment may prevent demyelination and fibrosis, leading to better outcomes.[1,4,7,10,36] This study further emphasizes the necessity for a standardized diagnostic criterion for CuTS that encompasses diagnosis of EDX-negative patients, since these patients may experience improvement after surgery.

Other limitations include the retrospective nature of this study, in addition to the aforementioned 3-month follow-up interval. Longer follow-up could provide further insights into outcomes, as this would allow for more nerve recovery in patients with demyelination or axonal loss. Large prospective studies would be helpful in enrolling patients and tracking outcomes across the age spectrum. Additionally, there was heterogeneity in terms of the concomitant diagnoses; however, we have documented the degree of overlap of these diagnoses and performed post hoc analysis in attempt to control for confounders. Future investigations could explore alternative diagnostic tools such as ultrasound and other outcome measures to evaluate CuTS patient prognosis.

This study provides evidence that both the EDX-positive and EDX-negative groups had significant short-term improvement in PROMs following CuTR. Negative preoperative EDX studies in the setting of strong clinical suspicion of CuTS do not exclude diagnosis and may in fact be a positive, rather than negative, predictive factor for short-term postoperative functional improvement. Future studies must investigate standardized CuTS diagnostic algorithms that effectively diagnose EDX-negative CuTS patients who may benefit from timely surgical release.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

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