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Original Research

Surgical Decision Making for Mild-to-Moderate Cubital Tunnel Syndrome

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Purpose: The management of ulnar neuropathy remains unclear as there are neither consensus guidelines nor compelling data available to inform optimal treatment. Identifying patients in the mild-to-moderate group that would benefit most from surgery is challenging as their symptoms can be subtle and less debilitating. This study investigated predictors of surgical intervention among patients presenting with McGowan mild or moderate cubital tunnel syndrome (CuTS).

Methods: This is an institutional review board–approved study. Patients evaluated from March 2016 to July 2022 were included if they were diagnosed with McGowan mild or moderate CuTS and underwent concurrent electrodiagnostic and ultrasound evaluations. Patient demographics, symptom presentation, and clinical and diagnostic test findings were analyzed. Variables were analyzed using Student *t* test, Mann-Whitney U test, or Pearson's chi-square test. Multivariable logistic regression was used to assess the association of covariates and surgery.

Results: Seventy-three patients and 103 elbows were identified. The mean age and body mass index were 51 years and 26.9, respectively. Most patients were men, right-handed, and unilaterally symptomatic in the dominant hand. Twenty-six elbows were surgically treated. Bivariable analyses by surgical treatment showed that patients who underwent surgery more often had positive electrodiagnostic findings including motor nerve conduction velocity $<$50 m/s and a $>$10 m/s conduction velocity difference across the forearm compared with elbow. Fifty-nine cases were categorized as electrodiagnostically normal. Of the electrodiagnostically normal cases, 29 had positive findings of CuTS on ultrasound. Logistic regression model showed that electrodiagnostically severe cases had 3.7 times higher odds of being surgically treated than normal counterparts (adjusted odds ratio, 3.7; 95% CI, 1.11–12.6; $P = .03$).

Conclusions: Not many differences in objective findings identify patients who should receive operative treatment. In addition to test results, more subjective findings from patients such as patient-reported level of impairment may be able to bridge this gap in surgical decision making.

Clinical relevance: This study contributes to treatment decision making for mild and moderate CuTS.

Cubital tunnel syndrome (CuTS) is a common compressive neuropathy that causes pain, altered sensation, weakness, and atrophy in the ulnar nerve (UN) distribution of the arm. Cubital tunnel syndrome is often classified into three discrete categories originally described by McGowan: mild if only paresthesias are present, moderate if weakness or clumsiness of the hand is observed, or severe if atrophy of the first dorsal interosseous muscles is noted.[1] Most affected patients present in the mild or moderate stages with subtle signs or symptoms, which make the diagnosis and treatment challenging.[2]

Optimizing treatment of CuTS is challenging, particularly for patients with mild-to-moderate disease. Surgical indications for CuTS remain unclear as there are neither consensus guidelines nor compelling data currently available to inform when to offer operative interventions. Initial treatment focuses on ameliorating symptoms related to compression and traction on the UN about the elbow with a combination of postural adjustments and activity modification. However, when nonsurgical management is offered for these patients, symptom resolution is as low as 44% over a

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Table 1
McGowan Categorization[1]

McGowan Grade	Clinical Features
Mild	Paresthesias, no muscle weakness
Moderate	Muscle weakness, but no atrophy
Severe	Atrophy

Table 2
Electrodiagnostic Severity Categorization[10]

Category	Conduction Velocity	Sensory Nerve Action Potential
Normal	Normal (50+ m/s)	Normal (10+ μV)
Mild	Normal	Reduced (<10 μV)
	Reduced (<50 m/s)	Normal
Moderate	Reduced	Reduced
Severe	Absent	Absent

period of 1 year.[3] For patients who fail nonsurgical management, surgery is an option. Although early recommendation for surgical intervention is relatively straightforward for patients who present with severe CuTS, the recommendation of surgical management of patients with a mild-to-moderate presentation is more complicated because the degree of patient symptomatology can vary widely within each individual McGowan classification.

Surgery is not without its own challenges, including recovery time and possibility of complications, impacting health care outcomes and patient economics. Ideally, surgery should be reserved for cases where nonsurgical treatment is not going to achieve a positive outcome. Although we struggle to predict which of these patients will do well after surgery, we continue to see a rise in surgeries performed for this condition. From 1996 to 2006, the total number of surgical procedures on the UN increased by 47%, and more recently, a study focusing on Medicare population in the United States showed a 55% increase from 2005 to 2021.[4,5] In 2015, Krogue et al[6] noted that patients presenting with mild symptoms were 3.2 times more likely to require revision surgeries than those with moderate and severe symptoms. This is of particular concern as most patients (40%) presenting with symptoms of CuTS fall into the mild to moderate categories.[2,7]

The purpose of the study was to investigate predictors of surgical intervention among patients presenting with McGowan mild and moderate CuTS.

Materials and Methods

Study design/participants

This institutional review board−approved retrospective review was performed on patients with CuTS from March 2016 to July 2022. A single surgeon's cohort was investigated to eliminate practice variance due to surgeon preferences. All patients with mild or moderate CuTS on the McGowan scale who underwent concurrent electrodiagnostic and ultrasound (US) evaluations on initial evaluation were included. We excluded patients with severe disease and patients with disease-exacerbating comorbidities, such as diabetes, hypothyroidism, brachial plexopathy, or C7-T1 cervical radiculopathy. We also excluded patients with a history of elbow trauma or UN surgery. Patients were not excluded if they requested surgery of their own will or chose to forgo surgery.

Variables/data sources

Demographic and clinical data were collected. Clinical data included patient-reported symptoms, Medical Research Council muscle grading of the first dorsal interosseous muscle, two-point discrimination test of the ring and small fingers, and provocative maneuvers (flexion-compression test or Tinel's sign at the elbow). These were used to assign case severity based on the McGowan grading system (mild [I]: paresthesias in ulnar area of hand; moderate [II]: weakness of interossei and no atrophy; severe [III]: atrophy of the first dorsal interosseous) (Table 1).[1]

Sonographic evaluations of the UN at the elbow included assessments of hypoechogenicity and hypermobility, as well as measurement of cross-sectional area (CSA) at the cubital tunnel inlet. Ulnar nerve CSA was divided into the following terciles: 4.9−9.7 mm^2, 10−14 mm^2, and 14.4−34 mm^2 based on a prior meta-analysis of control and symptomatic patients.[8]

Electrodiagnostic study data were collected, including motor nerve conduction velocity (CVm) and compound muscle action potential across the forearm, elbow, and upper arm as well as sensory nerve action potential from the wrist to digit five. These were used to create binary variables based on American Association of Neuromuscular & Electrodiagnostic Medicine diagnostic criteria including CVm <50 m/s, CVm difference across the forearm compared with elbow >10 m/s (CVm difference), and compound muscle action potential across the upper arm compared with elbow >20% (compound muscle action potential difference).[9] Electrodiagnostic severity was adapted from the neurological classification by Padua et al and based on normative values from our testing facility (Table 2).[10]

Our primary outcome measure was surgical treatment for CuTS.

Statistical analysis

Mean and SD were reported for demographic characteristics. Student *t* test or Mann-Whitney U test were used to compare differences in continuous variables between surgical and nonsurgical cases. Differences in continuous variables between electrodiagnostic severity groups were tested with one-way analysis of variance or Kruskal-Wallis test. Pairwise comparisons were adjusted using Tukey's honestly significant difference or Dunn's test. Pearson's chi-square test or Fisher exact test was used to assess differences among categorical variables. Multivariable analyses were conducted using logistic regression models that were adjusted for cluster-correlated data, presenting as multiple cases per patient, using a robust between-cluster variance estimator.[11] The association with covariates of interest and surgery was tested using simple models. Covariates with an alpha of ≤0.1 were included in the fully adjusted model. Variables were then removed in a step-wise fashion. Hosmer-Lemeshow goodness of fit tests were conducted after any modifications to the models; these were kept if the $P > .05$. The final model only included significant covariates that fit the data well.

Results

We identified 73 patients and 103 cases. Most patients were men, right-handed, and reported unilateral symptoms in the dominant hand. The mean age was 51 years, and the mean body mass index was 26.9 (Table 3).

Twenty-six of 103 cases were surgically treated for CuTS. Bivariable analyses by surgical treatment showed that patients who underwent surgical treatment for CuTS more often had positive electrodiagnostic findings including CVm <50 m/s and CVm difference >10 m/s. Surgical patients were also found to have a higher body weight than nonsurgical patients (Table 4).

Fifty-nine cases were categorized as electrodiagnostically normal, 31 as mild-moderate, and 13 as severe. Of the electrodiagnostically normal cases, 29 had positive findings of CuTS on US.

Table 3
Demographic Characteristics of 73 Patients Presenting With CuTS (2016−2022)

Characteristic	Total
Sex, n (%)	
Female	35 (48)
Male	38 (52.1)
Side dominant, n (%)	
Left	10 (13.7)
Right	63 (86.3)
Dominant affected, n (%)	
No	28 (38.4)
Yes	45 (61.6)
Bilateral, n (%)	
No	41 (56.2)
Yes	32 (43.8)
Cervical, n (%)	
No	66 (90.4)
Yes	7 (9.6)
Age (y), mean (SD)	50.6 (14.3)
Height (cm), mean (SD)	78.2 (16.2)
Weight (kg), mean (SD)	170.4 (9.9)
Body mass index (kg/m^2), mean (SD)	26.9 (4.7)

Bivariable analyses by electrodiagnostic severity revealed that men more commonly presented as mild-moderate or severe, whereas females were more commonly categorized as normal. Cases involving the dominant hand were more often electrodiagnostically normal or mild-moderate, whereas those involving the nondominant hand were more often severe. Abnormalities on US were more often noted among mild-moderate and severe cases and equally in normal cases. Most mild-moderate and severe cases had slowing of CVm across the elbow. Motor nerve conduction velocity difference was apparent in 87% of severe, 52% of mild-moderate, and 17% of normal cases. Normal cases were mostly found with UN CSA of 4.9−9.7 mm^2, whereas severe cases were mostly found with UN CSA of 14−34 mm^2. Patients with severe cases were older and taller than patients than those who were electrodiagnostically normal and only taller than those with mild-moderate cases (Table 5).

The final logistic regression model to identify variables that influenced the decision for surgery only included electrodiagnostic severity. Electrodiagnostically severe cases had 3.7 times higher odds of being surgically treated than those with who were electrodiagnostically normal (adjusted odds ratio, 3.7; 95% CI, 1.11−12.6; $P = .03$).

Table 4
Clinical Characteristics of Cases With Mild-to-Moderate CuTS by Surgical Treatment

Characteristic	Surgical Treatment, n (%)			*P* Value
	No	Yes	Total	
Sex				.126
Female	40 (51.9)	9 (34.6)	49 (47.6)	
Male	37 (48.1)	17 (65.4)	54 (52.4)	
Dominant affected				.177
No	27 (35.1)	13 (50)	40 (38.8)	
Yes	50 (64.9)	13 (50)	63 (61.2)	
Bilateral symptoms				.598
No	31 (40.3)	12 (46.2)	43 (41.7)	
Yes	46 (59.7)	14 (53.8)	60 (58.3)	
McGowan grade				1
Mild	68 (88.3)	23 (88.5)	91 (88.3)	
Moderate	9 (11.7)	3 (11.5)	12 (11.7)	
Provocative maneuvers				.71
No	16 (20.8)	1 (3.8)	17 (16.5)	
Yes	55 (71.4)	24 (92.3)	79 (76.7)	
Not tested	6 (7.8)	1 (3.8)	7 (6.8)	
Two-point discrimination				.068
≤5 mm	42 (54.5)	12 (46.2)	54 (52.4)	
5+ mm	11 (14.3)	9 (34.6)	20 (19.4)	
Not tested	24 (31.2)	5 (19.2)	29 (28.2)	
UN hypermobility				.216
No	32 (42.1)	5 (19.2)	37 (36.3)	
Yes	44 (57.9)	21 (80.8)	65 (63.7)	
US abnormality				.036
No	32 (42.1)	5 (19.2)	37 (36.3)	
Yes	44 (57.9)	21 (80.8)	65 (63.7)	
Positive electrodiagnostic findings				.011
No	54 (70.1)	11 (42.3)	65 (63.1)	
Yes	23 (29.9)	15 (57.7)	38 (36.9)	
Other electrodiagnostic findings				.84
No	52 (67.5)	17 (65.4)	69 (67)	
Yes	25 (32.5)	9 (34.6)	34 (33)	
CVm <50 m/s				.011
No	56 (76.7)	12 (48)	68 (69.4)	
Yes	17 (23.3)	13 (52)	30 (30.6)	
CVm difference forearm-Elb >10 m/s				.03
No	53 (72.6)	12 (48)	65 (66.3)	
Yes	20 (27.4)	13 (52)	33 (33.7)	
Percent difference CMAP >20%				.227
No	68 (93.2)	21 (84)	89 (90.8)	
Yes	5 (6.8)	4 (16)	9 (9.2)	
CSA at CuT inlet				.335
4.9−9.7	28 (46.7)	7 (31.8)	35 (42.7)	
10−14	19 (31.7)	7 (31.8)	26 (31.7)	
14.4−34	13 (21.7)	8 (36.4)	21 (25.6)	
Electrodiagnostic severity				.1
Normal	48 (62.3)	11 (42.3)	59 (57.3)	
Mild-moderate	22 (28.6)	9 (34.6)	31 (30.1)	
Severe	7 (9.1)	6 (23.1)	13 (12.6)	
Age (y), mean (SD)	51.1 (13.6)	51.7 (17.5)	6.7 (1.8)	.71
Height (cm), mean (SD)	169 (10.4)	172.8 (7)	10 (3.6)	.089
Weight (kg), mean (SD)	76.4 (16.4)	83.3 (15.2)	13.1 (6.2)	.043
Body mass index (kg/m^2), mean (SD)	26.6 (4.7)	27.9 (4.5)	7.3 (2.9)	.181

CMAP, compound muscle action potential; CuT, cubital tunnel; CVm, motor nerve conduction velocity; Elb, elbow.

Discussion

In this study of a single institution, single orthopedic practice, we initially aimed to identify predictors of surgical intervention for patients with clinically mild-to-moderate CuTS. This condition is mainly diagnosed by patient-reported symptoms and confirmed by physical examination using provocative maneuvers including the flexion-compression test (elbow flexion with direct nerve compression) or an elbow Tinel test. However, the sensitivities of these two tests are low at 46% and 54%, respectively.[12] In addition to this, US and electrodiagnostic studies of the UN are commonly but not always used to support the diagnosis. These additional tests also perform poorly with sensitivities as low as 14% and 67% for short-segment nerve conduction studies and 29% and 44% for US in patients with very mild and mild ulnar neuropathy at the elbow.[7] In our study, we failed to identify many objective findings that differed in patients successfully managed nonsurgically when compared with those who went on to operative intervention. More subjective findings, such as pain tolerance, symptom severity, and perceived impairment, may potentially offer greater insight into between-group differences.

Key results

Analysis of patient diagnostic test results appears to support the concept that the diagnosis of CuTS is complicated, especially in relation to similar conditions such as carpal tunnel syndrome. In our cohort, some patients who were electrodiagnostically normal had positive findings of CuTS on US (50%) and positive provocative maneuvers (83.3%). Electrodiagnostic studies have been known to have false

Table 5
Clinical Characteristics of Cases With Mild-to-Moderate CuTS by Electrodiagnostic Severity

Characteristic	Electrodiagnostic Severity, n (%)				*P* Value
	Normal	Mild-Moderate	Severe	Total	
Surgery					.09
No	48 (81.4)	22 (71)	7 (53.8)	77 (74.8)	
Yes	11 (18.6)	9 (29)	6 (46.2)	26 (25.2)	
Sex					.008
Female	35 (59.3)	12 (38.7)	2 (15.4)	49 (47.6)	
Male	24 (40.7)	19 (61.3)	11 (84.6)	54 (52.4)	
Dominant affected					.006
No	17 (28.8)	13 (41.9)	10 (76.9)	40 (38.8)	
Yes	42 (71.2)	18 (58.1)	3 (23.1)	63 (61.2)	
Bilateral symptoms					.63
No	24 (40.7)	12 (38.7)	7 (53.8)	43 (41.7)	
Yes	35 (59.3)	19 (61.3)	6 (46.2)	60 (58.3)	
McGowan grade					.77
Mild	51 (86.4)	28 (90.3)	12 (92.3)	91 (88.3)	
Moderate	8 (13.6)	3 (9.7)	1 (7.7)	12 (11.7)	
Provocative maneuvers					.07
No	9 (16.7)	8 (27.6)	0 (0)	17 (17.7)	
Yes	45 (83.3)	21 (72.4)	13 (100)	79 (82.3)	
Two-point discrimination					.18
≤5 mm	32 (54.2)	19 (61.3)	3 (23.1)	54 (52.4)	
5+ mm	10 (16.9)	5 (16.1)	5 (38.5)	20 (19.4)	
Not tested	17 (28.8)	7 (22.6)	5 (38.5)	29 (28.2)	
UN hypermobility					.796
No	45 (76.3)	21 (70)	10 (76.9)	76 (74.5)	
Yes	14 (23.7)	9 (30)	3 (23.1)	26 (25.5)	
US abnormality					.002
No	29 (50)	7 (22.6)	1 (7.7)	37 (36.3)	
Yes	29 (50)	24 (77.4)	12 (92.3)	65 (63.7)	
Other electrodiagnostic findings					.23
No	41 (69.5)	22 (71)	6 (46.2)	69 (67)	
Yes	18 (30.5)	9 (29)	7 (53.8)	34 (33)	
CVm <50 m/s					<.001
No	59 (100)	8 (25.8)	1 (12.5)	68 (69.4)	
Yes	0 (0)	23 (74.2)	7 (87.5)	30 (30.6)	
CVm difference forearm-Elb >10 m/s					<.001
No	49 (83.1)	15 (48.4)	1 (12.5)	65 (66.3)	
Yes	10 (16.9)	16 (51.6)	7 (87.5)	33 (33.7)	
Percent difference CMAP >20%					.13
No	56 (94.9)	27 (87.1)	6 (75)	89 (90.8)	
Yes	3 (5.1)	4 (12.9)	2 (25)	9 (9.2)	
CSA cubital tunnel >10 mm					.016
No	26 (57.8)	8 (30.8)	2 (18.2)	36 (43.9)	
Yes	19 (42.2)	18 (69.2)	9 (81.8)	46 (56.1)	
CSA at CuT inlet					
4.9–9.7	26 (57.8)	7 (26.9)	2 (18.2)	35 (42.7)	.03
10–14	12 (26.7)	10 (38.5)	4 (36.4)	26 (31.7)	
14.4–34	7 (15.6)	9 (34.6)	5 (45.5)	21 (25.6)	
Age (y), mean (SD)	49.1 (14.8)	51.2 (12.8)	61.2 (14.9)	51.3 (14.6)	Normal vs mild: .786 Normal vs severe: .019 Mild vs severe: .092
Height (cm), mean (SD)	169.9 (9)	168.2 (10.9)	174.5 (9.4)	170 (9.7)	Normal vs mild : .666 Normal vs severe: .002 Mild vs severe: .016
Weight (kg), mean (SD)	76 (17.1)	79.6 (15.8)	84.3 (12.5)	78.1 (16.3)	
Body mass index (kg/m^2), mean (SD)	26.2 (4.7)	28.1 (4.8)	27.7 (3.9)	26.9 (4.7)	

CMAP, compound muscle action potential; CuT, cubital tunnel; CVm, motor nerve conduction velocity; Elb, elbow.

negative results in the literature possibly due to improper elbow positioning or early UN involvement.[13] This suggested that the diagnosis of this condition should not rely solely on electrodiagnostic findings.

When focusing on US, we found that electrodiagnostically normal cases were mostly found with UN CSA of 4.9–9.7 mm^2 (58%), whereas severe cases were mostly found with UN CSA of 14–34 mm^2 (45.5%). This aligns with prior normative and symptomatic measurements calculated in a meta-analysis of 14 studies, which observed that the mean CSA in patients with CuTS was significantly larger than participants without CuTS at all levels except at the forearm level.[8] Abnormalities on US were prevalent among mild-moderate (77%) and severe cases (92%). For electrodiagnostically normal cases, abnormalities were only detected 50% of the time. This suggests that it is possible that some patients can present with CuTS symptoms but have normal findings on US and or EMG.

Surgical patients were found to have a higher body weight than nonsurgical patients. Although weight has not been shown to be a predictor for surgical treatment or even diagnosis of CuTS, lower body mass index has been found to be associated with slower CVm across the elbow and an increased risk of developing CuTS.[14] Additionally, higher weight is associated with an increased risk of diabetes. This could warrant preoperative hemoglobin A1c testing of patients with higher body mass index.

McGowan grade offered no predictive value in surgical decision making for patients in the mild or moderate category. Additionally, McGowan grading did not correlate with electrodiagnostic severity. It may have predictive value in more severe cases; however, decision for surgical intervention may be more obvious in those cases.

Our logistic regression model only identified electrodiagnostic severity as a significant predictor of surgical treatment, with electrodiagnostically severe patients having 3.7 greater odds of having surgery than electrodiagnostically normal patients. However, currently, there has not been a randomized control trial comparing surgical treatment with conservative management.[15] Further research is needed to investigate functional outcomes to determine which patients benefit most from surgery.

Limitations

This study had a few notable limitations. First, the study was conducted on patients from a single surgeon with over a decade in practice. It is possible that the surgeon's biases during the diagnosis of patients with suspected CuTS may have affected this study's results. However, this limitation is mitigated by the fact that (1) all patients underwent standardized electrodiagnostic and US evaluations irrespective of clinical suspicion and (2) the decision for surgery was based on symptom severity and failure to respond to nonsurgical treatment.

The diagnosis of CuTS in this cohort was performed in a systematic manner using a combination of clinical, US, and electrodiagnostic test findings. Ultrasound parameters were provided by an independent fellowship-trained radiologist. Electrodiagnostic evaluations were also provided by a fellowship-trained physiatrist. McGowan grading was used as a research tool to identify patient severity. The standardization of diagnostic procedures minimizes systematic and random error as well as selection bias because all patients underwent electrodiagnostic and US evaluations for CuTS as routine standard of care.

Bias and generalizability may be of concern as patients who are being evaluated by a surgeon are more often willing to have surgery, and this study was based on a single practice. Additionally, treatment may have also been affected by the single surgeon's bias. However, there are no clear guidelines on the treatment of patients with CuTS, much less patients with mild or moderate symptoms. However, using a single practice may be more reliable as it decreases the heterogeneity of criteria for surgery by different surgeons. The retrospective nature of this study also allows for the use of a single surgeon in that treatment decisions for the patients were not made with this study in mind.

Regarding the association of surgery in patients who had a higher body weight, it is possible that there are some patients with diabetes, which is associated with peripheral neuropathy, who have not been diagnosed, and these were misclassified as nondiabetic. Other patient-specific factors that were not considered were field of occupation or perceived level of risk, which could influence the shared decision for surgery. Another limitation was sample size. Due to the small sample size, patients with mild or moderate electrodiagnostic signs of CuTS were grouped, inhibiting our ability to analyze differences within these groups. Due to the retrospective nature of this study, the number of patients that could be used for the logistic model was decreased since several patients were missing data in their charts. Future studies should be prospective to further reduce selection bias and allow for blinded US and electrodiagnostic evaluations.

In conclusion, McGowan grading is based on subjective findings, whereas US and electrodiagnostic studies provide more objective data. This difference can lead to discrepancy in patient severity when using the McGowan grade compared with electrodiagnostic studies. We retrospectively reviewed 103 cases of CuTS and determined from logistic regression that patients who are electrodiagnostically severe have 3.7 greater odds of having surgery than their electrodiagnostically normal counterparts. In terms of clinical practice, this emphasizes that surgeons should not solely rely on a singular test result to move forward with surgery. The decision for surgery is a shared decision that considers the patient's subjective feeling on how the condition impacts them as well as the diagnostic test findings. It also opens the conversation of how a more holistic review of patients with CuTS that includes more subjective findings such as self-reported level of impairment may be able to bridge this gap in surgical decision making.

Conflicts of Interest

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

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