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Predictive Values of Preoperative Compound Muscle Action Potential Amplitude for Surgical Outcomes in Idiopathic Ulnar Neuropathy at the Elbow

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ABSTRACT

Introductions/Aims: Despite numerous studies on ulnar neuropathy at the elbow (UNE), the predictive value of preoperative compound muscle action potential (CMAP) amplitude for postoperative intrinsic function remains unclear. This study aimed to evaluate the predictive values of preoperative CMAP amplitude for surgical outcomes in idiopathic UNE.

Methods: A retrospective study was conducted on patients who underwent ulnar nerve transposition for idiopathic UNE with at least 24 months of follow-up. The primary outcome was the Medical Research Council (MRC) muscle strength of the abductor digiti minimi (ADM), and poor ADM function was defined as an MRC grade ≤ 2 at the final follow-up or a grade lower than baseline. Secondary outcomes included the key pinch strength ratio, grip strength ratio, and patient-reported outcomes. Correlation and regression analyses were performed to identify factors associated with clinical outcomes, and a ROC curve was used to determine the cut-off value of preoperative CMAP amplitude for predicting poor ADM function.

Results: A total of 79 patients were included. Preoperative CMAP amplitude showed significant correlations with postoperative ADM MRC grade and key pinch strength ratio. Poor ADM function was observed in 11 patients (14%) and was independently associated with lower CMAP amplitude. The ROC curve analysis revealed a cut-off value of 6.15 mV (AUC 0.83, sensitivity 100%, specificity 71%).

Discussion: This study indicates that preoperative CMAP amplitude could be a key predictor of postoperative ADM function in idiopathic UNE. A cut-off of 6.15 mV may help identify patients at risk of poor recovery and guide surgical decision-making.

1 | Introduction

Ulnar neuropathy at the elbow (UNE) is primarily diagnosed based on clinical findings, including patient history and physical examination, with electrodiagnostic testing used as a confirmatory modality [1]. Surgical treatment options for UNE include in situ decompression, medial epicondylectomy, and anterior transposition of the ulnar nerve (UNT) [2]. Recently, supercharged end-to-side anterior interosseous to ulnar motor nerve transfer (SETS) has emerged as a promising technique for severe cases of UNE, offering the advantages of reducing reinnervation time and improving intrinsic function recovery [3, 4]. However, the limited evidence regarding objective diagnostic tests and reliable treatment algorithms makes it challenging to identify the

Abbreviations: ADM, abductor digiti minimi; AUC, area under the curve; CMAP, compound muscle action potential; DASH, Disabilities of the Arm, Shoulder, and Hand; FDI, first dorsal interossei; MRC, Medical Research Council; ROC, receiver operating characteristic; SETS, supercharged end-to-side anterior interosseous-to-ulnar motor nerve transfer; SNAP, sensory nerve action potential; UNE, ulnar neuropathy at the elbow; UNT, ulnar nerve transposition; VAS, visual analog scale.

optimal surgical procedure for UNE [5, 6] and establish standardized indications for SETS [7].

Electrodiagnostic testing has been extensively assessed for its utility in UNE due to its objectivity and reproducibility [8]. While motor conduction velocity has traditionally been used to diagnose UNE as it reflects demyelinating changes [9], recent studies suggest that it does not accurately reflect the severity of the disease [10, 11]. By contrast, compound muscle action potential (CMAP) amplitude, which is proportional to the functional axon count [9], is considered a more reliable indicator of axonal loss in advanced stages of the disease. Recent studies have demonstrated correlations between CMAP amplitude and preoperative disease severity [12] as well as postoperative subjective outcomes [13]. Consequently, there has been an attempt to utilize CMAP amplitude to classify the severity of UNE [6]. When considering SETS to promote intrinsic recovery, the recipient nerve should be assessed for significant axonal loss and its potential to benefit from additional axons, with CMAP amplitude serving as a key indicator of axonal loss. However, a precise cut-off point has not yet been established [7].

The purposes of this study were (1) to evaluate the association between preoperative CMAP amplitude and both pre- and postoperative clinical measurements in idiopathic UNE and (2) to identify a threshold preoperative CMAP amplitude associated with poor intrinsic function following conventional surgery (UNT), with the cutoff value determined using the Youden index to optimize sensitivity and specificity.

2 | Methods

This study was approved by the Institutional Review Board of Yonsei University Health System, Severance Hospital (No. 4-2024-0870). The requirement for informed consent was waived because of the retrospective nature of the study. The initial diagnosis of UNE was established based on a detailed history and physical examination. For patients with advanced symptoms requiring surgical consideration, electrodiagnostic testing was performed. Surgical treatment decisions were made based on various factors, including disease severity indicated by clinical and electrodiagnostic findings, failure of conservative treatment, medical comorbidities, and etiologies of UNE. The decision to perform concomitant Guyon's canal decompression was made clinically based on whether numbness or tingling worsened during compression-provocative testing. All surgical procedures were performed by the senior author (Y.-R.C.). The ulnar nerve was released at all potential compression sites and, at the elbow, transposed anteriorly to the medial epicondyle, and wrapped in a step-cut fascial flap (with some muscle attached) to create a sling.

Medical records of patients who underwent UNT for UNE between January 2011 and July 2022 were retrospectively reviewed. The exclusion criteria encompassed patients with a follow-up period of less than 24 months, electrodiagnostic studies performed at an outside institution, other compressive nerve diseases except for carpal tunnel syndrome, bilateral involvement, a history of brachial plexopathy, nerve transection, or diabetic neuropathy, previous surgery for ulnar neuropathy at the elbow, simultaneous tendon transfer, tardy ulnar nerve palsy (a delayed ulnar neuropathy secondary to previous elbow trauma or deformity), concomitant surgery for heterotopic ossification or elbow stiffness, a history of elbow fracture surgery, or tumors, rheumatic, or hematologic arthritis affecting the elbow. Additionally, diabetic patients who exhibited abnormalities in nerves other than the symptomatic nerve or showed electrodiagnostic (EDX) abnormalities in the contralateral upper limb were also excluded. The included diabetic patients had positive findings on symptom assessment and physical examination that aligned with their EDX results.

2.1 | Clinical Data

Demographic factors, such as age, sex, body mass index, hand dominance, affected side, duration of symptoms, smoking status, and diabetes mellitus, along with preoperative self-reported symptoms (numbness, weakness, pain, hypoesthesia) and physical examination findings (Tinel's sign, elbow flexion-compression test, Froment's sign, atrophy of intrinsic muscles, subluxation of the ulnar nerve), were collected from electronic medical records. Preoperative electrodiagnostic tests were conducted according to a previously established method [14] by professional rehabilitation physicians at Severance Hospital. Among the electrodiagnostic parameters, conduction velocity across the elbow segment, CMAP amplitude with stimulation at the wrist and recording abductor digiti minimi (ADM), sensory nerve action potential (SNAP) amplitude, measured peak-to-peak with stimulation at the wrist and recording small finger, and presence of abnormal spontaneous activity (fibrillation potentials and/or positive sharp waves) in the ADM were collected. The primary outcome was the Medical Research Council (MRC) muscle strength of the ADM, assessed by the senior author (Y.-R.C.) at each pre- and postoperative visit. The examination was performed with the patient's hand flat on the table to eliminate the effect of gravity [15], and muscle strength was graded from 0 (no contraction) to 5 (normal muscle strength). Poor ADM function was defined as an MRC grade of 2 or lower at the final follow-up [3] or a grade lower than that at baseline. Key pinch strength and grip strength were also measured at each visit using a Jamar hydraulic pinch gauge (PC 5030HPG; Preston Co., Carson City, NV, USA) and a Jamar hydraulic dynamometer (Asimov Engineering, Los Angeles, CA, USA), respectively, and were presented as ratios relative to the contralateral (unaffected) side. Two-point discrimination of the small finger was assessed using a two-point aesthesiometer (10–2128/02; Alphamed Co., Tokyo, Japan). Patient-reported outcomes were evaluated by an independent observer (HNC in the last 10 years, and BRK before that; see Acknowledgments), who was not involved in patient treatment, using paper surveys at each visit. The visual analogue scale (VAS) pain score was used to measure pain severity, ranging from 0 (no pain) to 10 (worst possible pain). The Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) was employed to assess general disabilities related to the upper limb [16] and responsiveness following surgery for UNE [17]. The questionnaire includes 21 questions evaluating specific task difficulties, two questions assessing symptoms, and four questions

gauging social function, work function, sleep, and confidence. The DASH score ranges from 0 to 100, with higher scores indicating greater upper limb disability. The Bishop rating system was used to assess both subjective and objective parameters [18]; the subjective parameters included the severity of residual symptoms, subjective improvement from the preoperative status, and preoperative and postoperative work status, whereas the objective parameters included grip strength relative to the normal side and sensory measurement of static two-point discrimination. Scores were categorized as excellent (8–12), good (5–7), fair (3–4), or poor (0–2). Postoperative complications, including major neurovascular injury and deep wound infection, were evaluated by the surgeon (Y.-R.C.). According to our treatment protocol, all patients enrolled in this study visited the outpatient clinic preoperatively and postoperatively at 2 weeks, 6 months, 1 year, and 2 years, and as needed based on their symptoms. Patients with excellent outcomes did not undergo regular follow-up beyond 2 years but were advised to return if their symptoms worsened. For patients with follow-up exceeding 2 years, the last available assessment was used.

3 | Statistical Analysis

Categorical variables are presented as numbers and percentages, and continuous data are expressed as means and standard deviations. Data normality was assessed using the Kolmogorov–Smirnov test. Differences between preoperative measurements and those at the last follow-up were evaluated using the paired t-test or Wilcoxon signed-rank test. Pearson correlation analysis was used for normally distributed data, while Spearman correlation analysis was used for non-normally distributed data to evaluate the relationships between preoperative electrodiagnostic measures and both pre- and postoperative clinical measurements. The Benjamini-Hochberg correction was applied to control for multiple comparisons. Demographic factors and electrodiagnostic parameters that had a p value less than 0.1 in the bivariate analysis were entered into a multivariable logistic regression analysis to assess their independent association with poor ADM function after UNT. Receiver operating characteristic (ROC) curve analysis was used to assess the optimal cutoff value of preoperative CMAP amplitude for predicting poor ADM function at the final follow-up using the Youden index. Due to their association, the direction of the ROC curve analysis was set to indicate that lower values are associated with a more valid outcome. The area under the curve (AUC) was evaluated to quantify the effectiveness of the model, and the sensitivity, specificity, positive predictive value, and negative predictive value were also assessed. A power analysis was conducted before the ROC curve analysis. We aimed for a predictive AUC of 0.8 [19] with a power of 0.90 and type I error of 0.05. Based on the observation of poor ADM function in 11 of 79 patients, the minimum required sample size was calculated to be 61. Subgroup analysis between groups with and without poor ADM function was performed using appropriate statistical tests based on data distribution, including Student's t-test, the Mann–Whitney U test, and Fisher's exact test. Statistical analyses were conducted using SPSS v. 25 (IBM, Armonk, NY, USA), while the Benjamini-Hochberg correction was performed using R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). The p values less than 0.05 were considered statistically significant.

4 | Results

A total of 322 consecutive patients who underwent UNT for UNE were identified during the study period. Among them, 221 patients were excluded based on the predefined criteria: a follow-up period of less than 24 months ($n = 37$), electrodiagnostic studies performed at an outside institution ($n = 3$), other compressive nerve diseases except for carpal tunnel syndrome ($n = 21$), bilateral involvement ($n = 23$), a history of brachial plexus injury, nerve transection, or diabetic neuropathy ($n = 7$), previous surgery for ulnar neuropathy at the elbow ($n = 25$), simultaneous tendon transfer ($n = 1$), tardy ulnar nerve palsy ($n = 34$), concomitant surgery for heterotopic ossification or elbow stiffness ($n = 65$), a history of elbow fracture surgery ($n = 22$), and tumors, rheumatic, or hematologic arthritis affecting the elbow ($n = 5$). Finally, 79 patients were enrolled in this study, with a mean follow-up period of 33.1 ± 13.5 months. Among them, 72 underwent UNT alone, while seven received concomitant Guyon's canal decompression. The patient demographics, clinical data, and electrodiagnostic parameters are described in Table 1. All patients underwent electrodiagnostic tests prior to surgery, and 11 out of the 79 patients demonstrated normal results. All clinical measurements showed significant improvement at the last follow-up compared to preoperative values, as detailed in Table 2. No major postoperative complications were observed. The primary outcome of this study, poor ADM function, was observed in 11 patients (14%) at the final follow-up.

The correlations between the preoperative electrodiagnostic parameters and both preoperative and postoperative measurements are shown in Table 3. Preoperative CMAP amplitude was weakly to moderately correlated with the ADM MRC grade, key pinch strength ratio, and two-point discrimination both before and after surgery. Scatter plots in Figure S1 show that preoperative CMAP amplitude positively correlated with postoperative ADM MRC grade and key pinch strength ratio.

Demographic factors and electrodiagnostic parameters associated with poor ADM recovery, with a p value of less than 0.1 in the bivariate analysis, are indicated in Table 4. In the multivariable analysis, only preoperative CMAP amplitude showed an independent association with poor ADM function following UNT. Figure 1 presents the ROC curve analysis for preoperative CMAP amplitude in predicting poor postoperative ADM function. The analysis identified a CMAP amplitude threshold that optimally differentiates patients at risk of poor recovery (for detailed statistical values, including sensitivity, specificity, and AUC, refer to Figure 1). Given the relatively low specificity, a subgroup analysis was performed to investigate additional factors associated with poor ADM function (Table S1). In patients with a CMAP amplitude of less than 6.15 mV, age was the only factor significantly higher in the poor ADM function group compared with the good ADM function group.

5 | Discussion

In this study, we identified that preoperative CMAP amplitude was associated with both pre- and postoperative ADM MRC grades and key pinch strength ratios in idiopathic UNE.

TABLE 1 | Basic characteristics of patients.

Characteristics	All ($n = 79$), mean ± SD or n (%)
Age, years	57.2 ± 15.1
Sex	
Male	60 (76%)
Female	19 (24%)
Body mass index, kg/m^2	25.4 ± 3.9
Dominant hand affected	48 (61%)
Duration of symptoms, months	20.2 ± 28.3
Smoking	25 (32%)
Diabetes mellitus	19 (24%)
Self-reported symptoms	
Weakness	54 (68%)
Numbness	75 (95%)
Pain	27 (34%)
Hypoesthesia	37 (47%)
Physical examination	
Positive Tinel sign	73 (92%)
Positive elbow flexion test	70 (89%)
Positive Froment sign	37 (47%)
Atrophy of intrinsic muscles	55 (70%)
Subluxation of ulnar nerve	15 (19%)
Nerve conduction studies	
Compound muscle action potential amplitude, mV	8.7 ± 5.7
Conduction velocity, m/s	40.8 ± 18.0
Sensory nerve action potential amplitude, μV	12.7 ± 16.6
Electromyography, abductor digiti minimi muscle	
Abnormal spontaneous activity (fibrillation potentials, positive sharp waves)	51 (65%)

A threshold of 6.15 mV, determined using the Youden index to optimize sensitivity and specificity, was found to be associated with poor postoperative ADM function. Additionally, among those with a CMAP amplitude below the cut-off value, age was significantly higher in the ADM intrinsic function group compared with the good ADM function group.

Several electrodiagnostic parameters have been demonstrated to correlate with postoperative outcomes in UNE [8]. In 2012, Shi et al. reported that the above-elbow CMAP amplitude and the proportional CMAP amplitude decrease from above-elbow to below-elbow stimulation were correlated with postoperative patient-rated ulnar elbow evaluations in 73 patients [11]. In 2015, Huang et al. demonstrated significant differences in preoperative conduction velocity, CMAP amplitude, and SNAP amplitude between those with excellent/good and fair/poor postoperative outcomes [20]. In 2017, Tong et al. retrospectively analyzed 146 patients with severe UNE (McGowan grade III) and reported that absent SNAP was associated with higher postoperative McGowan grades [21]. However, several other studies reported no correlation between these parameters and outcomes [10, 22, 23].

CMAP amplitude, assessed prior to significant reinnervation by collateral sprouting, is known to be proportional to the functional axon count and, along with electromyography, provides information about the severity of nerve injury [12]. Due to its validity, it is considered a potential objective measure for determining the appropriateness of SETS [7, 24]. A CMAP amplitude of less than 6 mV has typically been considered an abnormal reference point, also suggesting the need for additional SETS [6, 12]. In 2019, Power et al. conducted a retrospective cohort study of 83 patients and found through multivariable regression analysis that only the CMAP amplitude of the first dorsal interosseous (FDI) muscle was a significant independent predictor of both preoperative key pinch strength ratio and grip strength ratio ($p < 0.001$), whereas ulnar nerve conduction velocity when recording from FDI was not [12]. In 2023, Florczynski et al. demonstrated that CMAP amplitude recorded from the ADM was the only parameter predictive of postoperative functional outcomes in a prospective multicenter study of 78 patients [13]. While the threshold value of 6.15 mV was statistically optimized using the Youden index, this cut-off should not be interpreted as a definitive predictor of poor outcome. As shown in Figure S1A, all patients with a preoperative CMAP amplitude above this cut-off exhibited favorable postoperative ADM function, consistent with the understanding that motor function is preserved until motor neuron denervation exceeds 70%–80% [25]. However, among those with preoperative CMAP amplitudes below 6.15 mV, only 11 out of 31 patients (35%) exhibited poor outcomes, suggesting that a low CMAP amplitude alone does not necessarily predict poor results. This heterogeneity indicates that various potential factors may influence postoperative outcomes in UNE, highlighting the need for further research. The CMAP amplitude was also related to the pre- and postoperative key pinch strength ratios; however, the grip strength ratio, associated with both intrinsic and extrinsic muscles, showed no correlation either preoperatively or postoperatively, as it also derives significantly from median innervation, which is not expected to be affected in UNE. Although SNAP amplitude has often been used as a prognostic indicator, it should be used with caution due to its relatively small values and uncertainty, which have been previously reported to limit its efficacy in UNE [6, 8, 14].

Patients with severe UNE, characterized by intrinsic hand muscle atrophy and weakness [3, 21], are less likely to achieve complete recovery following conventional surgical treatments, with unsatisfactory outcomes reported in 20% to 33% of cases [26–28]. SETS has been studied over the past decades for its potential to improve intrinsic function and reduce reinnervation time using expandable nerve. Although Power et al. suggested appropriate treatment indications for SETS in 2020 [12], there remains a lack of evidence for specific CMAP amplitude cut-off points to determine significant axonal loss

TABLE 2 | Preoperative and postoperative clinical measurements.

Variable	Preoperative	Last follow-up	*p*
ADM MRC grade	3.1 ± 1.4	4.2 ± 1.3	**< 0.001**[b]
Key pinch strength ratio, %	65.9 ± 26.2	87.5 ± 30.1	**< 0.001**[a]
Grip strength ratio, %	80.6 ± 21.8	94.8 ± 21.1	**< 0.001**[a]
Two-point discrimination, mm	8.0 ± 4.6	5.8 ± 3.9	**< 0.001**[b]
VAS pain score	4.7 ± 2.3	1.6 ± 1.7	**< 0.001**[b]
Mean DASH score	37.4 ± 20.6	18.8 ± 15.9	**< 0.001**[b]
Bishop score	—	9.0 ± 2.4	—

Note: Significant values are shown in bold.
Abbreviations: ADM, adductor digiti minimi; DASH, Disabilities of the Arm, Shoulder, and Hand questionnaire; MRC, Medical Research Council; VAS, visual analogue scale.
[a]Paired *t*-test.
[b]Wilcoxon signed-rank test.

TABLE 3 | Correlation analyses between electrodiagnostic parameters and preoperative and postoperative measurements.

Variable		CMAP amplitude at wrist (mV)	Conduction velocity across elbow (m/s)	SNAP amplitude (μV)
ADM MRC grade	Preoperative	**0.643 (0.491 to 0.756)**[a]	**0.385 (0.179 to 0.558)**[a]	**0.364 (0.161 to 0.554)**[b]
	Postoperative	**0.431 (0.232 to 0.595)**[a]	**0.296 (0.081 to 0.486)**[a]	0.158 (−0.055 to 0.362)[b]
Key pinch strength ratio	Preoperative	**0.434 (0.235 to 0.598)**[a]	**0.341 (0.130 to 0.523)**[a]	0.212 (−0.009 to 0.414)[a]
	Postoperative	**0.336 (0.124 to 0.519)**[a]	0.177 (−0.046 to 0.383)[a]	0.201 (−0.021 to 0.404)[a]
Grip strength ratio	Preoperative	0.128 (−0.095 to 0.340)[a]	0.153 (−0.071 to 0.362)[a]	0.056 (−0.167 to 0.274)[a]
	Postoperative	−0.043 (−0.261 to 0.180)[a]	−0.112 (−0.325 to 0.112)[a]	0.070 (−0.153 to 0.287)[a]
Two-point discrimination, mm	Preoperative	**−0.423 (−0.589 to −0.223)**[a]	−0.242 (−0.440 to −0.022)[a]	**−0.366 (−0.540 to −0.153)**[b]
	Postoperative	−0.259 (−0.454 to −0.040)[a]	−0.160 (−0.368 to 0.063)[a]	**−0.308 (−0.501 to −0.082)**[b]
VAS pain score	Preoperative	−0.047 (−0.266 to 0.176)[a]	0.120 (−0.104 to 0.333)[a]	0.038 (−0.188 to 0.258)[b]
	Postoperative	−0.081 (−0.297 to 0.143)[a]	0.032 (−0.191 to 0.251)[a]	0.014 (−0.205 to 0.239)[b]
DASH score	Preoperative	−0.168 (−0.375 to 0.055)[a]	−0.074 (−0.291 to 0.149)[a]	−0.063 (−0.293 to 0.181)[b]
	Postoperative	−0.209 (−0.411 to 0.013)[a]	−0.005 (−0.226 to 0.216)[a]	−0.131 (−0.350 to 0.120)[b]
Bishop score	Postoperative	0.188 (−0.035 to 0.392)[a]	0.008 (−0.213 to 0.229)[a]	−0.009 (−0.230 to 0.210)[b]

Note: The correlations are presented as *r* values with 95% confidence intervals. Significant values, determined based on Benjamini-Hochberg adjusted *p* values, are shown in bold.
Abbreviations: ADM, abductor digiti minimi; CMAP, compound muscle action potential; DASH, Disabilities of the Arm, Shoulder, and Hand questionnaire; MRC, Medical Research Council; SNAP, sensory nerve action potential; VAS, visual analogue scale.
[a]Pearson correlation analysis.
[b]Spearman correlation analysis.

in the recipient nerve. CMAP amplitude is considered an important parameter for assessing axonal loss; however, its impact on surgical outcomes has shown inconsistent results. In 2020, Dengler et al. found that among 42 patients with severe UNE, three showed poor recovery after SETS, and there was no significant difference in preoperative CMAP amplitude between these patients and those with adequate recovery [3]. In our study, even when the CMAP amplitude was below 6.15 mV, many patients demonstrated favorable postoperative ADM function. Therefore, the results of this study should be considered cautiously. The suggested cut-off should not be interpreted as an absolute indication for SETS but rather as one of the factors that should be considered in decision-making.

The limitations of this study primarily originate from its retrospective nature. Patients who underwent other procedures, including in situ decompression, were excluded, and most patients lost to follow-up had favorable outcomes, which could potentially affect the study's results. Second, a potential limitation of this study is that preoperative and postoperative assessments of ADM MRC grade were performed by the surgeon who conducted the operation rather than by an independent, unbiased examiner. This could introduce a degree of observer bias, highlighting the need for future studies incorporating blinded assessments to enhance objectivity. Third, this study did not assess conduction block, which could cause significant weakness despite preserved distal CMAP amplitude and is generally associated with

TABLE 4 | Bivariate and multivariable analysis of factors associated with poor intrinsic function after ulnar nerve transposition.

Explanatory variable	β coefficient	Standard error	Odds ratio	95% CI		*p*
				Lower	Upper	
Bivariate analysis						
Age	0.119	0.046	1.127	1.029	1.234	0.010
Duration of symptom	0.015	0.009	1.015	0.997	1.033	0.095
CMAP amplitude	−0.283	0.095	0.754	0.626	0.908	0.003
Conduction velocity	−0.042	0.020	0.959	0.921	0.998	0.038
Abnormal spontaneous activity (fibrillation potentials, positive sharp waves)	1.885	1.078	6.585	0.797	54.440	0.080
Multivariable analysis						
Age	0.089	0.046	1.093	0.999	1.196	0.051
CMAP amplitude	−0.241	0.099	0.786	0.647	0.955	**0.016**

Note: Significant values after multivariable analysis are shown in bold.
Abbreviations: CI, confidence interval; CMAP, compound muscle action potential.

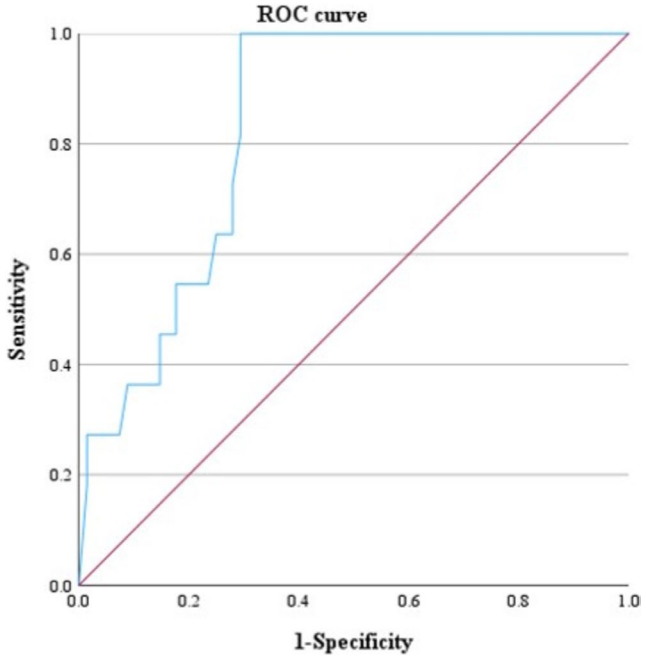

FIGURE 1 | Receiver operating characteristic (ROC) curve analysis for preoperative compound muscle action potential amplitude in predicting poor intrinsic function following ulnar nerve transposition. The Youden index and AUC were highest (0.71 and 0.83 [95% confidence interval, 0.74–0.93], respectively) at a CMAP amplitude cut-off of 6.15 mV. At this threshold, the sensitivity was 100%, specificity was 71%, positive predictive value was 78%, and negative predictive value was 100%.

better recovery. While these cases represent a small subset, their exclusion may have impacted outcome interpretation. Fourth, concomitant Guyon's canal release was performed in seven patients to ensure there were no compressive structures along the ulnar nerve pathway. Although patients with proximal lesions, such as thoracic outlet syndrome, were excluded, this may still have influenced the study results. Lastly, similar to other studies on UNE, this study was limited by the lack of consensus on diagnosis and outcome measurements. CMAP amplitude is typically measured in the ADM and/or FDI muscles; ADM is the most frequently used parameter [29], but some authors argue that FDI is more appropriate for assessing UNE. Moreover, although patient-reported outcomes are commonly used for outcome measurements in UNE, they are limited by their subjective nature. Consequently, the utility of objective measurements, such as adduction–abduction spread [24], has been explored. Future research in this area is necessary to improve the methodology of studies on UNE.

In conclusion, preoperative CMAP amplitude was significantly associated with pre and postoperative ADM muscle strength and key pinch strength ratio in idiopathic UNE. Although a CMAP amplitude threshold of 6.15 mV was identified using the Youden index to differentiate poor ADM function, this cut-off should be interpreted with caution due to its limited clinical specificity and should not serve as the sole basis for surgical decision-making.

Author Contributions

Jae-Yong Cho: project administration, writing – original draft, funding acquisition. **Hyeong-Jun Rhyu:** investigation. **Hyun-Kyo Kim:** investigation. **Hee-Soo Kim:** investigation. **Won-Taek Oh:** supervision, formal analysis. **Il-Hyun Koh:** supervision, formal analysis. **Yun-Rak Choi:** writing – review and editing, conceptualization.

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Ethics Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Research data are not shared.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** Correlation of the preoperative abductor digiti minimi (ADM) compound muscle action potential (CMAP) amplitude at the wrist with (A) the postoperative ADM Medical Research Council (MRC) grade and (B) key pinch strength ratio after ulnar nerve transposition. **Table S1:** Comparison of the characteristics between the groups with and without poor intrinsic function when CMAP amplitude is less than 6.15 mV.