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How much does clinical prediagnosis correlate with electrophysiological findings?: a retrospective study

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Background: Electrodiagnostic testing (EDX) is important in the diagnosis and follow-up of neuropathic and myopathic diseases. This study aimed to demonstrate the compatibility between clinical prediagnosis and electrophysiological findings.
Methods: EDX results from 2004 to 2020 at the physical medicine and rehabilitation (PM&R) clinic were screened. Tests with missing data, reevaluation studies, and cases of peripheral facial paralysis were excluded. The clinical prediagnosis and EDX results were recorded, and their compatibility was evaluated.
Results: A total of 2,153 tests were included in this study. The mean age was 49.0±13.9 years and 1,533 of them (71.2%) were female. The most frequently referred clinic was the PM&R clinic (90.0%). Numbness (73.6%) was the most common complaint, followed by pain (15.3%) and weakness (13.9%). The most common prediagnosis was entrapment neuropathy (55.3%), radiculopathy (16.1%), and polyneuropathy (15.7%). Carpal tunnel syndrome was the most frequently identified type of entrapment neuropathy (78.3%). Six hundred and seventy EDX results (31.1%) were within normal limits. While the EDX results were consistent with the prediagnosis in 1,328 patients (61.7%), a pathology different from the prediagnosis was detected in 155 patients (7.2%). In the discrepancy group, the most common pathologies were entrapment neuropathy (51.7%), polyneuropathy (17.3%), and radiculopathy (15.1%). The most common neuropathy type was carpal tunnel syndrome (79.3%).
Conclusion: After adequate anamnesis and physical and neurological examinations, requesting further appropriate tests will increase the prediagnosis accuracy and prevent unnecessary expenditure of time and labor.

Keywords: Correlation study; Diagnosis; Electrodiagnosis; Electromyography; Electrophysiological concepts

Introduction

Electrodiagnostic testing (EDX) is an electrophysiological technique that includes nerve conduction studies (NCS), needle electromyography (EMG), and repetitive nerve stimulation [1]. EDX plays a role in the evaluation of peripheral nerve, muscle, and neuromuscular junction diseases, and is a continuation of the clinical neurological examination [2]. EDX also plays an important role in disease prognosis and follow-up [3,4].

In recent years, the use of detailed clinical examinations in practical applications has gradually decreased, and diagnostic tests, which may be unnecessary, have been requested in large numbers

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[5]. However, this situation can lead to uncomfortable tests for patients, long waiting times, and increased health costs [6]. As with many other diagnostic tests, EDX should not replace careful history taking and physical examination and should be complementary [7]. In addition, ultrasonography is an important tool for assessing nerve entrapment and peripheral nerve injury. This examination can be used to further evaluate the results of clinical examinations and NCS/EMG [8].

This study aimed to compare the compatibility between different clinical prediagnoses and electrophysiological findings. In addition, parameters such as clinic referrals, outpatient or inpatient clinic requests, and patient symptoms will be evaluated.

Methods

Ethical statements: This study was approved by the local ethics committee of Health Health Sciences University, Şişli Hamidiye Etfal Training and Research Hospital (protocol No. 3277/date: May 25, 2021), and the requirement for informed consent was waived. This study was conducted in accordance with the principles of the Declaration of Helsinki.

1. Patients

EDXs performed in the physical medicine and rehabilitation (PM&R) clinic of our hospital between January 2004 and December 2020 were screened retrospectively. A total of 2,415 EDX results were obtained. Age, sex, body mass index (BMI, kg/m^2), hospital admission, referral clinics, presence of trauma, prediagnosis, and electrophysiological diagnosis of the patients were recorded. Patient complaints, clinical examination results, and preliminary diagnoses were obtained from the EDX order notes. A total of 262 patients were excluded from the study, including those with missing control data and tests, and cases of peripheral facial paralysis (PFP). Patients with PFP were excluded because they can usually be diagnosed through anamnesis and physical examination.

2. Assessment of electrodiagnostic test findings

All EDXs were performed by the same physician using the Neuropack device (Nihon Kohden, Tokyo, Japan) at the electrophysiology laboratory of the PM&R clinic. After being grouped as either normal or presenting with pathology, those with pathology were subdivided into entrapment neuropathy, polyneuropathy, radiculopathy, plexopathy, myopathy, motor neuron disease, and peripheral nerve damage groups. The same EDX protocol was applied for similar diseases. Sensory and motor NCS were performed to evaluate entrapment neuropathy and polyneuropathy. Needle EMG was performed along with NCS for radiculopathy, plexopathy, peripheral nerve injury, myopathy, and motor neuron disease. In NCS, the latency, conduction velocity, and amplitude were evaluated, and needle EMG assessed denervation patterns, polyphasia, and recruitment. We determined whether the preliminary diagnosis before EDX and the diagnosis determined after EDX were similar.

3. Statistical analysis

In the descriptive statistics of the data, the mean, standard deviation, median, lowest and highest values, frequency, and ratio were used. The distribution of variables was measured using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used to analyze quantitative independent data. The chi-square test was used to analyze independent qualitative data, and the Fischer test was used when the chi-square test conditions were not met. IBM SPSS ver. 27.0 (IBM Corp., Armonk, NY, USA) was used in the analyses.

Results

1. Patients and demographic characteristics

The study included 2,153 tests. Of the patients evaluated with EDX, 1,533 (71.2%) were female, with a mean age of 49.0 ± 13.9 years. The mean BMI was 28 ± 5.2 kg/m^2. The most frequent referral clinic for EDX was the PM&R clinic (90.0%), followed by other clinics (4.8%), neurosurgery (2%), orthopedics (1.9%), and neurology (1.3%). Of these patients, 91.3% were referred from outpatient clinics. Numbness (73.6%) was the most common complaint, followed by pain (15.3%) and weakness (13.9%). In addition, although they occurred at low rates, complaints such as burning sensation (2.6%), tingling (1.4%), hypoesthesia (0.7%), and electric-shock sensation (0.5%) were reported (Table 1).

2. Comparison of electrodiagnostic findings with prediagnoses

While 55.3% of the prediagnoses were entrapment neuropathies, other common prediagnosis was radiculopathy (16.1%), polyneuropathy (15.7%), and peripheral nerve damage (9.8%). Plexopathy (2.7%), myopathy (0.2%), and motor neuron disease (0.1%) requests occurred less frequently. The most common entrapment neuropathy for which EDX was requested was carpal tunnel syndrome (CTS) (78.3%), followed by cubital tunnel syndrome (15.9%). The most common plexopathy was brachial plexopathy (96.6%). Among peripheral nerve injuries, ulnar nerve injury (21.0%) was the most frequently requested. In addition, 91.8% of the patients had no history of trauma, and 3.8% were not informed about trauma (Table 2).

Table 1. Demographics of the patients

Variable	Data
No. of patients	2,153
Age (yr)	49.0 ± 13.9 (8.0–87.0)
Sex	
Female	1,533 (71.2)
Male	620 (28.8)
Body mass index (kg/m^2)	28.0 ± 5.2 (13.7–49.9)
Referring clinic	
PM&R	1,937 (90.0)
Orthopedics	41 (1.9)
Neurosurgery	43 (2.0)
Neurology	28 (1.3)
Other clinics	104 (4.8)
Hospital admission	
Outpatient	1,966 (91.3)
Inpatient	187 (8.7)
Complaint	
Numbness	1,585 (73.6)
Burning	55 (2.6)
Hypoesthesia	14 (0.7)
Tingling	31 (1.4)
Electric-shock sensations	10 (0.5)
Weakness	300 (13.9)
Pain	329 (15.3)
Prediagnosis	
Entrapment neuropathy	1,190 (55.3)
Polyneuropathy	339 (15.7)
Radiculopathy	347 (16.1)
Plexopathy	59 (2.7)
Myopathy	5 (0.2)
Motor neuron disease	3 (0.1)
Peripheral nerve injury	210 (9.8)
Prediagnosed subtypes (n = 1,459)	
Entrapment neuropathy (n = 1,190)	
Carpal tunnel syndrome	932 (78.3)
Cubital tunnel syndrome	190 (15.9)
Peroneal nerve entrapment	18 (1.6)
Tarsal tunnel syndrome	23 (1.9)
Meralgia paresthetica	25 (2.1)
Others	2 (0.2)
Plexopathy (n = 59)	
Brachial	57 (96.6)
Lumbar	2 (3.4)
Peripheral nerve injury (n = 210)	
Median	39 (18.6)
Ulnar	44 (21.0)
Radial	24 (11.4)
Axillary	11 (5.2)
Long thoracic	5 (2.4)
Sciatic	28 (13.3)
Peroneal	35 (16.7)
Tibial	3 (1.4)
Femoral	13 (6.2)
Others	8 (3.8)

Values are presented as number only, mean ± standard deviation (range), or number (%).
PM&R, physical medicine and rehabilitation.

A total of 31.1% of the EDXs examined were within normal limits. While 61.7% of the patients were found to have a prediagnosis that was consistent with the EDX results, a pathology different from the preliminary diagnosis was detected with EDX in 7.2% of the patients. The most common pathologies were entrapment neuropathy (51.7%), polyneuropathy (17.3%), and radiculopathy (15.1%). The most common entrapment neuropathy was CTS (79.3%), similar to prediagnosis. The age and BMI of the patients were significantly lower in those with discordant prediagnosis and EDX results ($p < 0.05$). Similarly, the proportion of female patients was significantly higher in the discordant group ($p < 0.05$). There was no significant difference between those who had consistent

Table 2. Electrodiagnostic findings

Variable	Data
Trauma	2,153
No	2,053 (95.4)
Yes	100 (4.6)
EDX results	2,153
Normal	670 (31.1)
Pathology	1,483 (68.9)
Resulting pathology subtypes	1,483
Entrapment neuropathy	767 (51.7)
Polyneuropathy	256 (17.3)
Radiculopathy	224 (15.1)
Plexopathy	32 (2.2)
Motor neuron disease	3 (0.2)
Peripheral nerve injury	201 (13.6)
Resulting entrapment neuropathy subtypes	767
Carpal tunnel syndrome	608 (79.3)
Cubital tunnel syndrome	119 (15.5)
Peroneal nerve entrapment	16 (2.1)
Tarsal tunnel syndrome	10 (1.3)
Others	14 (1.8)
Resulting plexopathy subtypes	32
Brachial plexopathy	31 (96.9)
Lumbar plexopathy	1 (3.1)
Resulting peripheral nerve injury subtypes	94
Median	37 (18.4)
Ulnar	45 (22.4)
Radial	25 (12.4)
Axillary	10 (5.0)
Long thoracic	3 (1.5)
Sciatic	23 (11.4)
Peroneal	36 (17.9)
Tibial	3 (1.5)
Femoral	9 (4.5)
Others	10 (5.0)
Additional findings detected in EDX	2,153
No	2,000 (92.9)
Yes	153 (7.1)

Values are presented as number only or number (%).
EDX, electrodiagnostic testing.

prediagnosis-EDX results and those who did not among referrals made by the PM&R, neurosurgery, orthopedics, and neurology clinics ($p > 0.05$). However, the discordance was significantly higher in patients referred from other clinics ($p < 0.05$). In addition, discordance was significantly higher in requests made by the outpatient clinic than in those made by the inpatient clinic ($p < 0.05$). Complaints of numbness, burning, and tingling sensations were significantly higher and the rate of weakness was significantly lower in the discordant group ($p < 0.05$ for both) (Table 3). The rate of entrapment neuropathy was significantly higher ($p < 0.05$) and the rate of peripheral nerve damage was significantly lower ($p < 0.05$) in the discordant group. Similarly, the rates of CTS, peroneal nerve entrapment, meralgia paresthetica, and femoral nerve damage were significantly higher in the discordant group than in the concordant group ($p < 0.05$). There were no significant differences between the concordant and discordant groups in the other prediagnoses and their subgroups ($p > 0.05$). In addition to the preliminary diagnosis, electrophysiological findings consistent with other clinical diagnoses were detected in 7.1% of the EDXs with pathology (Table 4).

Discussion

EDX is often requested in conjunction with radiological imaging to complement patient history and physical examination. However, it has been stated in the literature that an increasing amount of EDX has been requested without detailed anamnesis and physical examination [9]. Therefore, unnecessarily high patient numbers, long waiting times, and financial losses occur in EDX laboratories [10]. Therefore, an EDX request should be made for the appropriate patient at the appropriate time.

Considering the EDX results in our study, no pathology was detected in 31.1% of patients. In the literature, EDX rates without pathology were found to be 16% to 38%, and high normality rates were attributed to inadequate clinical examination and unnecessary EDX requests [6,10-12]. Studies with a high rate of normal EDX results have been performed in patients with peripheral neuropathy [13,14]. Diseases that can cause neuropathic complaints, such as myofascial pain, fibromyalgia, and peripheral neuropathy affecting thin fibers, may have caused this [15]. In addition, the presence of patients with EDX findings inconsistent with the preliminary diagnosis shows that EDX is complementary to the clini-

Table 3. Correlation of demographic variables and electrodiagnostic findings

Variable	Prediagnosis and EDX		*p*-value
	Concordant (n = 1,328)	Discordant (n = 825)	
Age (yr)	50.4 ± 14.4	46.7 ± 12.8	< 0.001[a]
Sex			
Female	920 (69.3)	613 (74.3)	0.012
Male	408 (30.7)	212 (25.7)	
Body mass index (kg/m^2)	28.5 ± 5.4	27.3 ± 4.9	< 0.001[a]
Referring clinic			
PM&R	1,203 (90.6)	734 (89.0)	0.177
Orthopedics	23 (1.7)	18 (2.2)	0.461
Neurosurgery	32 (2.4)	11 (1.3)	0.082
Neurology	18 (1.4)	10 (1.2)	0.772
Other clinics	52 (3.9)	52 (6.3)	0.006
Hospital admission			< 0.001
Outpatient	1,184 (89.2)	782 (94.8)	
Inpatient	144 (10.8)	43 (5.2)	
Complaint			
Numbness	929 (70.0)	656 (79.5)	< 0.001
Burning	26 (2.0)	29 (3.5)	0.026
Hypoesthesia	9 (0.7)	5 (0.6)	0.841
Tingling	12 (0.9)	19 (2.3)	0.008
Electric-shock sensations	5 (0.4)	5 (0.6)	0.383
Weakness	250 (18.8)	50 (6.1)	< 0.001
Pain	188 (14.2)	141 (17.1)	0.066

Values are presented as mean ± standard deviation or number (%).
EDX, electrodiagnostic testing; PM&R, physical medicine and rehabilitation.
[a]Mann-Whitney U test. The others are analyzed using chi-square tests (Fisher exact tests).

Table 4. Correlation of prediagnosis and electrodiagnostic findings

Variable	Prediagnosis and EDX		*p*-value[a]
	Concordant (n = 1,328)	Discordant (n = 825)	
Prediagnosis			
Entrapment neuropathy	702 (52.9)	488 (59.2)	0.004
Polyneuropathy	208 (15.7)	131 (15.9)	0.894
Radiculopathy	204 (15.4)	143 (17.3)	0.226
Plexopathy	33 (2.5)	26 (3.2)	0.357
Myopathy	0 (0)	5 (0.6)	0.008
Motor neuron disease	1 (0.1)	2 (0.2)	0.562
Peripheral nerve injury	180 (13.6)	30 (3.6)	< 0.001
Prediagnosed entrapment neuropathy subtypes			
CTS	569 (81.1)	363 (74.4)	0.006
CuTS	109 (15.5)	81 (16.5)	0.654
Peroneal nerve entrapment	6 (0.9)	12 (2.5)	0.025
TTS	11 (1.5)	12 (2.5)	0.189
Meralgia paresthetica	5 (0.7)	20 (4.0)	< 0.001
Others	2 (0.3)	0 (0)	0.516
Prediagnosed plexopathy subtypes			> 0.999
Brachial	32 (96.9)	25 (96.2)	
Lumbar	1 (3.1)	1 (3.8)	
Prediagnosed peripheral nerve injury subtypes			
Median	35 (19.4)	4 (13.3)	0.426
Ulnar	41 (22.8)	3 (10.0)	0.111
Radial	22 (12.2)	2 (6.7)	0.376
Axillary	9 (5.0)	2 (6.7)	0.660
Long thoracic	3 (1.7)	2 (6.7)	0.150
Sciatic	23 (12.8)	5 (16.7)	0.562
Peroneal	32 (17.8)	3 (10.0)	0.290
Tibial	3 (1.7)	0 (0)	> 0.999
Femoral	7 (3.9)	6 (20.0)	0.004
Others	5 (2.8)	3 (10.0)	0.090
Trauma			< 0.001
No	1,235 (93.1)	818 (99.0)	
Yes	92 (6.9)	8 (1.0)	
EDX results			
Normal		0 (0)	664 (80.5)
Pathology		1,328 (100)	161 (19.5)
Resulting pathology subtypes			
Entrapment neuropathy	704 (53.3)	63 (39.1)	< 0.001
Polyneuropathy	203 (15.4)	53 (32.9)	< 0.001
Radiculopathy	201 (15.2)	23 (14.3)	0.759
Plexopathy	29 (2.2)	3 (1.9)	0.785
Motor neuron disease	1 (0.1)	2 (1.2)	0.033
Peripheral nerve injury	184 (13.9)	17 (10.6)	0.240
Resulting entrapment neuropathy subtypes			
CTS	572 (81.2)	42 (66.1)	0.004
CuTS	107 (15.2)	13 (21.0)	0.230
Peroneal nerve entrapment	9 (1.3)	7 (11.3)	< 0.001
TTS	9 (1.3)	1 (1.6)	0.575
Others	7 (1.0)	0 (0)	> 0.999
Resulting plexopathy subtypes			
Brachial	28 (96.6)	3 (100)	> 0.999
Lumbar	1 (3.4)	0 (0)	

(Continued to the next page)

Table 4. Continued

Variable	Prediagnosis and EDX		*p*-value[a]
	Concordant (n = 1,328)	Discordant (n = 825)	
Resulting peripheral nerve injury subtypes			
Median	32 (17.3)	6 (35.3)	0.070
Ulnar	42 (22.9)	4 (23.5)	0.953
Radial	24 (12.8)	2 (11.8)	0.898
Axillary	10 (5.6)	0 (0)	>0.999
Long thoracic	3 (1.7)	0 (0)	>0.999
Sciatic	24 (12.8)	0 (0)	0.229
Peroneal	32 (17.3)	5 (29.4)	0.218
Tibial	3 (1.7)	0 (0)	>0.999
Femoral	9 (5.0)	0 (0)	>0.999
Others	5 (2.8)	0 (0)	>0.999
Additional findings detected in EDX			
No	1,184 (89.2)	816 (98.9)	<0.001
Yes	144 (10.8)	9 (1.1)	

Values are presented as number (%).
EDX, electrodiagnostic testing; CTS, carpal tunnel syndrome; CuTS, cubital tunnel syndrome; TTS, tarsal tunnel syndrome.
[a]Values were compared using chi-square tests (Fisher exact tests).

cal examination.

When we compared clinical symptoms and EDX results, complaints such as subjective numbness, burning, and tingling sensations were higher in the discordant group, whereas weakness was lower. This can be attributed to the better detection of weakness by physical examination. In a clinical and electrophysiological study of CTS, objective and subjective sensory complaints were consistent with EDX results [16]. Yilmaz and Toluk [17] found a strong correlation between symptom severity and functional status in an EMG study conducted after a preliminary diagnosis of CTS. A recently published study found a positive correlation between CTS severity determined by EDX in patients evaluated using the CTS-6 Evaluation Tool and the Semmes-Weinstein monofilament test. This shows that EDX should be evaluated together with clinical history and examination [18]. However, a study on patients with CTS found that severe electrodiagnostic findings did not correlate with patient-based disability assessments [19]. This shows that there is not always a strong relationship between patient complaints and diagnostic tests.

More than half the EDX requests in our study were for entrapment neuropathy. CTS was the most common prediagnosis of entrapment neuropathy and EDX result, which is consistent with the literature [1,5,20,21]. Polyneuropathy and radiculopathy were also frequent prediagnosis and EDX results in other studies [10,22]. While entrapment neuropathies were more common in the group with discordant prediagnosis-EDX results, peripheral nerve damage was less common. This shows that the presence of objective examination findings, such as a history of trauma or weakness in the anamnesis, increases concordance. Although cases diagnosed as entrapment neuropathy, polyneuropathy, and radiculopathy predominate in the literature and in our study, EDX is also important for other neuromuscular diseases. In the present study, the number of EDXs performed for plexus disorders was relatively low. The use of clinical evaluations and EDX and magnetic resonance neurography is mentioned in the literature [23,24]. Both clinical diagnosis and EDX are required in amyotrophic lateral sclerosis, a motor neuron disease. EDX is particularly important for early diagnosis and prognosis [25]. EDX is also helpful for confirming myopathy and can detect specific pathological changes found in muscle biopsies [26].

There was no significant difference between the referring PM&R, neurosurgery, orthopedics, and neurology clinics in terms of the concordance or discordance between prediagnosis and EDX findings. However, there are publications showing that neurologists provide a higher degree of concordance [14,27]. The concordance between the clinical preliminary diagnosis and electrophysiological diagnosis depends on good clinical evaluation of the patient by relevant specialties and requesting EDX studies for the correct indication. We attribute the higher rate of discordance in patients referred from other clinics to the fact that the abovementioned four clinics deal with neuromuscular symptoms and diseases.

The higher rate of discordance in EDX findings from requests made by the outpatient clinics compared to those made by the inpatient clinics may be due to a more careful and holistic evaluation in the inpatient ward [22]. The limitations of anamnesis and physical examination times in the outpatient clinic, anxiety about making a quick diagnosis and arranging treatment, and sometimes the

inability to observe time may lead to unnecessary EDX requests.

The presence of more than one EDX diagnosis indicates the similarity of neuromuscular diseases upon initial examination. Because of the retrospective nature of our study and the fact that the existing chronic diseases of the patients were unknown, inquiries regarding this situation could not be made.

The most important limitation of our study is that it was a retrospective, single-center study. The fact that the cases were mainly referred from the PM&R outpatient clinic may have caused the concordance in the preliminary and EDX diagnoses to be higher than that in other clinics owing to intra-clinic communication. Additionally, in this study, only the agreement between the preliminary clinical diagnosis and EDX results was evaluated. It should be kept in mind that additional examinations may be required for a definitive diagnosis of diseases such as myopathy, motor neuron disease, and neuromuscular junction diseases. However, the large number of patients, EDX performed by a single person, and the classification of diseases into subgroups were the strengths of our study.

EDX plays an important role in the diagnosis and follow-up of neuromuscular diseases. Because it requires appropriate laboratory conditions, experience, and time, EDX should be requested only for necessary indications and at the right time. EDX complements anamnesis and physical examination, and a sufficient clinical history and preliminary diagnosis should be specified when making a referral. All these factors increase agreement in the prediagnosis and EDX results, which minimizes the workload and time required.

Article information

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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Author contributions

Conceptualization: all authors; Data curation: SÇİ, AA, BK; Formal analysis: SÇİ, AA, FY; Methodology, Supervision: SÇİ, FY; Project administration, Visualization: FY; Investigation: AA; Resources, Software, Validation: BK; Writing-original draft: SÇİ; Writing-review & editing: SÇİ, BK.

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