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ORIGINAL ARTICLE

Diagnostic Role of EEG in Parkinson's Disease Patients with Cognitive Impairment

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Abstract

Introduction: The most common finding in comparative electroencephalography (EEG) exams in patients with Parkinson's disease and healthy individuals in similar age groups is the increased generalized or localized slow-wave activity. The present study aims to investigate the EEG findings in patients with Parkinson's disease and to determine their possible contribution to diagnosis.

Methods: The study included patients followed up by the Movement Disorders Outpatient Clinic for diagnosed Parkinson's disease. The Unified Parkinson's Disease Rating Scale (UPDRS) was used to rate the clinical disability in patients with Parkinson's disease with and without dementia based on DSM-V criteria. Patients were also evaluated using the Standardised Mini-Mental State Examination (SMME), the Geriatric Depression Scale (GDS), and the Neuropsychiatric Inventory (NPI). EEG recordings were performed according to the 10-20 system in both the patient group and healthy individuals in similar age groups with no metabolic/organic diseases.

Results: 60 patients (16F, 44M, mean age: 69.23±11.56 years) diagnosed with Parkinson's disease were compared with a control group of 25 individuals (17F, 8M, mean age: 70.12±8.18 years). In the patient group, 19 patients (31.7%) showed EEG pathology in the form of 4-8 Hz theta wave activity interpreted as mild disorganization, while 2 patients (3.33%) showed nonspecific slow-wave activity on both hemispheres. In the control group, only 1 patient (4%) had pathological EEG findings. 47.6% of the patients with Parkinson's disease dementia showed EEG pathology. 2 patients with nonspecific slow-wave activity on both hemispheres were found to be from the Parkinson's disease dementia group. Patients with EEG pathology had higher UPDRS scores (p=0.011), lower SMME scores (p=0.002), and higher NPI scores (p=0.004).

Discussion and Conclusion: The present study points out that there is a parallel between the development of dementia and EEG pathology in Parkinson's disease and thus EEG may be important in the diagnosis and follow-up of cognitive decline.

Keywords: Electroencephalography; Parkinson's disease; Parkinson's disease dementia.

Parkinson's disease is the most common neurodegenerative movement disorder resulting from the loss of dopaminergic neurons in the substantia nigra pars compacta. In addition to motor symptoms such as tremor, rigidity, postural instability, and bradykinesia/akinesia, it also presents non-motor symptoms[1]. The prevalence of cognitive dysfunction and dementia, two non-motor symptoms, is approximately 30%, and they are collectively observed in about 75% of patients who have had Parkinson's disease for 10 years[2,3]. Age, disease duration, low level of education, male gender, and axial extrapyramidal system involvement have been reported as risk factors for dementia[4].

Considering its neuropathology, while studies suggest

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that the distribution of Lewy bodies and Lewy neurites over the cortical and limbic regions is the best correlation indicator for Parkinson's disease dementia, other studies have not found any relationship between the distribution of Lewy bodies in the brain and cognitive function[2]. Cholinesterase inhibitors are used for symptomatic effects in dementia treatment; however, no disease-modifying treatments have been found yet[5]. The SMME test and the relatively more sensitive Montreal Cognitive Assessment (MoCA) test are used for diagnosis[6].

Resting-state EEG has been considered a complement to these neuropathological tests aimed at examining cognitive decline in patients with Parkinson's disease. It is suggested to be an ideal biomarker, particularly in patients with Parkinson's disease, because it is free of verbal or motor responses, which may affect the results, requires minimal patient cooperation, and is easy to obtain[7]. A literature review on EEG findings in patients with Parkinson's disease included 36 studies and found that EEG slowing was correlated with cognitive decline[8].

Starting from these studies, the present study aims to show whether EEG plays a role in the diagnosis and follow-up of cognitive impairment in Parkinson's disease.

Materials and Methods

The present study included patients who were followed up by the Movement Disorders Outpatient Clinic of the Neurology Department of Haydarpaşa Numune Training and Research Hospital for diagnosed idiopathic Parkinson's disease (IPH). Patients with diagnosed epilepsy and parenchymal or metabolic diseases, which may result in EEG pathology, were excluded from the study. The study population comprised a total of 60 patients, 15 of whom had accompanying Parkinson's disease dementia, and 25 healthy volunteers suitable for the age group of the patient population. Informed consents were obtained from the participants. This study was conducted in accordance with the Declaration of Helsinki and approved by the Haydarpaşa Numune Training and Research Hospital Ethics Committee with the decision no. 230632214 of February 23, 2021.

Twenty-minute EEGs were recorded in both the patient and control groups during wakefulness. EEGs were routinely recorded for 20 minutes with the Nicolet EEG machine using at least 21 silver electrodes placed on the scalp, first cleaning the site where the paste and electrodes would be placed, according to the international 10-20 system. Waves ranging from 0.5 Hz to 70 Hz were recorded as the frequency filter. Waves outside this frequency range were considered artifacts. EEGs were evaluated by a single neurologist who was experienced in EEG evaluation and was unaware of the clinical features of the participants.

The IBM SPSS Statistics 22 software was used for data analysis. One sample t test was used to compare age, gender and EEG findings of the patient and control groups. In the patient group, the mean difference of binary categorical variables was measured by independent t test. The value $p<0.05$ was taken as the threshold for statistical significance.

Results

The present study included 60 patients (16 females and 44 males) with diagnosed Parkinson's disease, and 25 volunteers (17 females and 8 males). The mean age of the patient group was 69.23±11.56 years, while it was 70.12±8.18 years for the control group, which were not significantly different from each other.

While 39 of the EEGs recorded in the patient group were reported to be normal, 19 EEGs showed 4-8 Hz theta wave activity, which was interpreted as mild disorganization. The remaining 2 patients showed nonspecific slow-wave activity on both hemispheres. In the control group, however, only 1 individual showed EEG pathology, which was detected to be mild disorganization (Table 1).

Examination of the subgroups of the patient group, namely the Parkinson's disease group and the Parkinson's disease dementia group, revealed that only 5 of the 15 patients diagnosed with Parkinson's disease dementia had normal EEG findings, 53.3% had mild disorganization, while 13.3% had nonspecific slow-wave activity. On the other hand, in the Parkinson's disease group, 75.5% of the patients had normal EEG findings, with the remaining 24.5% having mild disorganization. In the patient group; there was no difference in disease duration between individuals with normal and pathological EEG (Table 3).

In the patient group, the average UPDRS score of the

Table 1. EEG Findings in the Patient and Control Groups

	Normal (Number/%)	4-8 Hz Theta Wave (Number/%)	Nonspecific Slow-Wave (Number/%)
Patient Group	39 (65)	19 (31.7)	2 (3.3)
Control Group	24 (96)	1 (4)	

Table 2. Relationship of the Clinical Tests on Patients with the EEG Findings

Test	EEG Condition	Number of Patients	Mean	Standard Deviation	p
UPDRS	Normal	39	34.13	18.20	0.011
	Pathological	21	48.33	20.49	
SMME	Normal	39	24.10	3.34	0.002
	Pathological	21	20.52	5.17	
MoCA	Normal	39	16.13	5.49	0.005
	Pathological	21	11.19	6.44	
GDS	Normal	39	11.05	7.02	0.076
	Pathological	21	13.90	5.08	
NPI	Normal	39	12.44	10.06	0.004
	Pathological	21	24.19	20.11	

Table 3. Disease duration between patients with normal and pathological EEG

	EEG condition	N	Mean	Standart deviation	p
Disease duration					
	Normal	39	5.5385	4.31549	0.821
	Pathologic	21	5.7619	3.19225	

patients with normal EEG findings was 34.12±18.2 compared to 48.33±20.49 for those with EEG pathologies, and this showed a significant difference between the scores (p=0.011). Similarly, average NPI scores of the patients with EEG pathologies were significantly higher than those of the patients with normal EEG findings (p=0.004).

SMME and MoCA tests were performed on patients for cognitive assessment, and the average scores were 24.1±3.33 and 16.12±5.49, respectively, for the subgroup with normal EEG findings, while they were 20.52±5.17 and 11.19±6.43, respectively, for the subgroup with EEG pathologies. Both tests showed significant differences.

In the GDS test for the patient group, the subgroup with normal EEG findings scored 11.05±7.02 on average, while the subgroup with EEG pathologies scored 13.9±5.07 on average, which suggested no significant difference (p=0.076) (Table 2).

Discussion

Parkinson's disease dementia is clinically characterized by an insidious onset and slowly progressive cognitive decline accompanied by a variety of behavioral symptoms such as hallucinations, depression, anxiety, and excessive daytime sleepiness[9]. The risk of dementia in patients with Parkinson's disease is 1.7 to 5.9 times higher than in the normal population. Dementia is associated with a greater burden of healthcare, as well as a lower quality of life for both the patient and the caregiver. Therefore, understanding the risk of dementia is crucial for patients, caregivers, and healthcare planners[10].

Although tests such as the SMME and MoCA are often used for the diagnosis of dementia, other supplementary diagnostic techniques are also employed, such as nano-imaging via computed tomography or magnetic resonance imaging, functional neuroimaging via positron emission tomography, cerebrospinal fluid analyses, and EEG[11].

A 1958 study with 17 Alzheimer's disease patients investigating the diagnostic role of EEG in dementia found all the EEGs to be abnormal with 4 to 7-Hz slow activities, which were mostly generalized and often irregular, though sometimes rhythmic[12]. Another study stated that since EEGs were found to be normal in psychiatric conditions such as depression, confusion, and agitation in early-stage dementia patients, they could be used to distinguish organic dementia from pseudodementia. The same study found that EEG abnormalities had the highest specificity in Alzheimer's disease and Parkinson's disease dementia, and detected a correlation between the level of these abnormalities and the disease severity[13]. Our study, which performed UPDRS, SMME, and MoCA tests aimed at evaluating mental and motor states, revealed a significant difference in the group with abnormal EEG findings compared to the one with normal EEG findings, meaning the patients with abnormal EEG findings showed lower cognitive performance.

Small-scale studies showed that patients with Parkinson's disease dementia had EEG slowing more frequently than those without PDD[14,15]. In addition to the slowing, there have been reports of other EEG findings as well, such as

increased amplitude, low-amplitude frequency, rapid activity, and the loss of occipital dominance of the alpha wave[16]. A study with 100 patients by Morita et al.[17] found that EEG slowing increased with severe cognitive impairment. Yet another study reported that delta waves were prevalent in patients with Parkinson's disease dementia while PD patients without dementia had more theta wave activity, and both groups showed slower EEG activities compared to the control group[18]. Classifying cognitive impairment in patients with Parkinson's disease into two categories, namely mild cognitive impairment and dementia, Fonseca et al.[19] found no significant differences between the EEGs of the patients without cognitive impairment and the control group, but detected increases in the posterior theta amplitude in the group with mild cognitive impairment or dementia and in the posterior delta amplitude in the group with dementia. Similarly, the present study found slower EEG activity in the patient group compared to the control group, with theta waves being the predominant waves, and detected a higher number of EEG pathologies in patients with Parkinson's disease dementia compared to patients with Parkinson's disease.

A study examining the localizations of pathological EEG findings in PD patients with executive dysfunction reported significantly slower EEGs for the patient group compared to controls in frontal and frontopolar locations than in other locations, indicating frontal dysfunction[20]. Our study detected widespread slowing down; however, it found no significantly different localizations.

Conclusion

The importance of EEG tests is underscored by the fact that EEG can be used for diagnosis in patients with Parkinson's disease with suspected dementia. It may present a diagnostic advantage, particularly because it does not require patient cooperation and is easy to use.

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