Original Research

Sensitivity of Clock Drawing Test Alone to Screen for Cognitive Impairment in Patients with Parkinson's Disease

 Nazli Durmaz Celik,[1] Aydan Topal,[2] Muge Kuzu Kumcu,[3] Serhat Ozkan,[1] Sabiha Tezcan Aydemir[4]

[1]Department of Neurology, Osmangazi University Faculty of Medicine, Eskisehir, Türkiye
[2]Department of Neurology, Samsun Training and Research Hospital, Samsun, Türkiye
[3]Department of Neurology, Lokman Hekim University Faculty of Medicine, Ankara, Türkiye
[4]Aysel Sabuncu Brain Research Center, Ankara, Türkiye

Abstract

Objectives: Cognitive impairment is a prevalent non-motor symptom of Parkinson's disease (PD), significantly impacting patient quality of life. The Clock Drawing Test (CDT) evaluates cognitive abilities, including planning, organization, and executive functions such as attention, memory, and visuospatial skills. This study aimed to determine the sensitivity of the CDT in diagnosing cognitive impairment in PD.

Methods: We reviewed the records of 44 PD patients (16 female, 28 male) diagnosed with dementia (30 patients) or mild cognitive impairment (14 patients) between 2018 and 2022. These patients were compared to 106 visitors to the neurological outpatient clinic, serving as a control group. A separate researcher assessed the patients' CDT scores, maintaining confidentiality of all other patient data except age and education level.

Results: Among the 44 PD patients, two with mild cognitive impairment were rated as normal, while all PD dementia cases were identified solely through the CDT. In the healthy control group, 72 out of 106 individuals reported no cognitive complaints, whereas 34 individuals (32.1%) reported cognitive complaints as assessed by a blind investigator. The CDT demonstrated a positive predictive value of 55.3% and a negative predictive value of 97.3%. Sensitivity was calculated at 95.5%, and specificity was 67.9%.

Conclusion: The findings suggest that the CDT is sensitive in detecting cognitive impairment in PD patients with cognitive deficits. While the CDT serves as an effective rapid screening tool, high scores indicate the absence of cognitive impairment, but low scores alone are insufficient for a definitive diagnosis of dementia. Comprehensive neurological evaluation and detailed cognitive assessment remain essential for confirming dementia diagnoses.

Keywords: Clock Drawing Test, dementia, Parkinson's disease

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Parkinson's disease (PD) is the second most common neurodegenerative disease after Alzheimer's disease (AD) worldwide in the elderly and affects approximately 1% of the population over the age of 65. PD causes both motor and non-motor symptoms in affected individuals, ultimately leading to morbidity. Tremor, postural instability, rigidity, and bradykinesia are the primary motor symptoms. Additionally, non-motor symptoms such as dysphagia, decreased gastrointestinal motility, monotonous speech, fatigue, depression, and particularly cognitive impairment may also develop.[1,2]

Mild cognitive impairment (MCI) progressing to dementia represents a significant challenge for individuals with PD.[3]

The prevalence of cognitive impairment in PD varies widely, with reports suggesting that nearly one in three PD affects 80–90% of individuals with the condition.[4,5] Besides, nearly one in three PD patients eventually develop dementia, studies show.[6,7]

AD dementia manifests primarily through deficits in memory and language.[8–10] On the contrary, cognitive decline associated with PD often starts with frontal deficits and executive function deterioration, especially in selective attention, reasoning, cognitive flexibility, and planning.[10,11]

Given the distinct clinical presentations of cognitive impairment in PD, it has become imperative to employ separate diagnostic techniques and screening measures to monitor clinical progression effectively.[12]

In light of the growing attention to the cognitive aspects of PD, particularly in its advanced stages, there is a pressing demand for a standardized method of neuropsychological evaluation within this population.[13] The detrimental impact of cognitive impairment underscores the necessity for such standardized approaches. This standardized evaluation is crucial for advancing our understanding of the severity of cognitive impairment in individuals with PD. Moreover, it plays a pivotal role in identifying early-stage therapeutic and supportive interventions tailored to address the cognitive challenges faced by these patients.[13]

The Mini-Mental State Assessment Test (MMSE) and the Montreal Cognitive Assessment (MoCA) stand out as the most commonly used psychometric cognitive screening tests globally.[14] While the MMSE is recognized for its efficacy in detecting dementia, its focus primarily on memory limits its utility in identifying early-stage cognitive impairments.[15] On the other hand, the Montreal Cognitive Assessment is deemed more sensitive to MCI at this stage.[16] Some studies suggest that MoCA may be a superior cognitive screening test for PD compared to MMSE.[8]

However, MoCA's efficacy remains a topic of debate. Challenges in its administration, particularly among individuals with lower levels of education, pose significant concerns. Furthermore, its diagnostic value is lower than that of MMSE in older age groups with limited education.[17] This discrepancy is noteworthy, especially considering that lower education levels are associated with a higher risk of PD-related dementia. Unfortunately, individuals with lower education levels have yet to benefit from a reliably practical dementia screening test.[15]

The Clock Drawing Test (CDT) emerges as a valuable screening tool for PD, offering a quick and straightforward assessment that typically takes less than two minutes to complete, even among elderly individuals.[18] Notably, the CDT appears unaffected by racial or ethnic differences, up-

bringing, or level of education, enhancing its applicability across diverse populations.[10]

What makes the CDT particularly noteworthy is its ability to assess multiple cognitive domains, including visuospatial ability, executive function, motor programming, and visual memory.[19–21] When combined with the Mini-Mental State Examination (MMSE), the CDT can complement the MMSE's low specificity in PD patients with lower educational backgrounds, thereby serving as an effective screening tool, particularly in the early stages of the disease.[22] This combined approach proves beneficial before the onset of moderate or severe symptoms, including dementia.

The primary aim of this study was to determine the sensitivity of the CDT as a standalone measure in diagnosing cognitive impairment among individuals with PD.

Methods

Patients diagnosed with PD and cognitive impairment who were under follow-up at the movement disorder outpatient clinic were enrolled in the study. The study protocol received approval from the Lokman Hekim University Non-interventional Clinical Research Ethics Ccommittee (number: 25/2022 2021/026, date: 10.03.2021). The study was in accordance with the 1964 Helsinki Declaration. All PD patients in the study met the diagnostic criteria outlined by the UK Parkinson's Disease Brain Bank for idiopathic PD.

A total of 44 participants, comprising 16 women and 28 men, were diagnosed with either dementia (n=30) or MCI (n=14). Additionally, cognitive issues of 106 age- and sex-matched individuals without PD were included in the study as a comparative group.

Patient Evaluation

Patients diagnosed with Parkinson's disease dementia (PD-D) or Parkinson's disease mild cognitive impairment (PD-MCI) underwent a comprehensive assessment involving detailed medical history, laboratory examinations, imaging studies, and neuropsychological tests.

The cognitive state of the patients was evaluated using the Mini-Mental State Examination (MMSE) test. It has been a very well-validated and widely used tool for almost five decades.[23] It's designed to provide a quick and reliable measure of cognitive impairment, or monitoring cognitive changes covering orientation, registration, attention and calculation, recall, and language. The total score of the MMSE ranges from 0 to 30, with higher scores indicating better cognitive performance. Normal range is considered if the patient gets a score of 24 or above, suggesting no significant cognitive impairment.[23] Scores below 24 can indicate various degrees of cognitive impairment. Mild cog-

nitive impairment scores of 19-23, moderate cognitive impairment scores of 10-18, and severe cognitive impairment scores below 10.[24,25] The test's brevity and comprehensive coverage of essential cognitive domains make it a valuable tool for assessing cognitive function in patients with PD, where cognitive impairment can significantly impact quality of life.[26]

Clock Drawing Test Evaluation

A CDT was applied to all patients. The CDT assesses cognitive function, particularly visuospatial and executive abilities. Various scoring systems exist for the CDT; one of the most popular methods is the Sunderland method.[3] This method scores the clock drawing based on the correct placement of numbers, accuracy, and clock hands. Scoring ranges from 0 to 10, with higher scores indicating better cognitive performance. The correct presence and placement of the clock circle, numbers, and hands, with particular attention to the spacing and sequencing of numbers, are specific criteria. A score of 8 or above is considered within normal limits, indicating normal cognitive function.[3] Another widely recognized method is known as the Shulman method.[27] This method evaluates the clock drawing based on the presence and correctness of the clock circle, numbers, clock hands, and the spacing of numbers. Each component is scored 0 or 1, resulting in a total score range from 0 to 5, with higher scores indicating better cognitive performance.

The criteria include a correctly drawn clock circle, correctly ordered and positioned numbers, both drawn clock hands indicating the specified time, and evenly spaced numbers. The Shulman method was chosen for this assessment due to its ease of use, easy assessment providing an efficient way to screen for cognitive impairment quickly and straightforwardly. It is especially effective in recognizing early signs of cognitive deterioration in patients with PD, where visuospatial and executive functions are often affected; also, this method ensures consistency and reliability in scoring. For this reason, all the patients with CDT were evaluated using Shulman's method. According to the Shulman method, CDTs were scored by a researcher who was blinded to all other patient information except for age and education level. The scoring was conducted using a five-point scale for evaluation. To prevent bias, the CDTs of patients and control subjects were presented to the blinded researcher in a randomized manner.

Statistical Analysis

Detailed evaluation data served as the gold standard for assessing the effectiveness of CDT in detecting cognitive impairment.

Statistical analyses were conducted using IBM SPSS Version 23 (Chicago, USA). The Kolmogorov-Smirnov and Shapiro-Wilk tests assessed the normality of the data within each group.

Descriptive statistics were presented as mean±standard deviation or median (minimum-maximum) for quantitative variables, while qualitative variables were expressed as the number of cases (percentage).

When normal distribution assumptions were met, the Student's t-test was employed to determine if there was a statistically significant difference between the PD and healthy control groups regarding quantitative variables.

The relationship between two qualitative variables was assessed using the chi-square or Fisher's exact test. A statistical significance level of $p<0.05$ was considered for all analyses.

Results

A total of 150 participants were included in the study, comprising 106 healthy controls and 44 individuals diagnosed with PD. Within the control group, 50.9% were female (n=54) and 49.1% were male. In contrast, among the PD-diagnosed group, 36.4% (n=16) were female, and 63.6% were male. The mean age of participants in the control group was 69.23±6.01 years (range: 58-86), while the PD group had a mean age of 69.25±7.87 years (range: 55-89). Statistical analysis revealed no significant differences between the two groups in terms of age (p=0.984), gender (p=0.073), and educational status (p=0.065) (Table 1).

Among the healthy control group, as assessed by the blind investigator, 72 out of 106 patients (67.9%) reported no cognitive complaints, while 34 patients (32.1%) reported cognitive complaints. The CDT scores of patients and the blind investigator's evaluation in this group are summarized in Table 2.

In contrast, among the PD group evaluated by the blind researcher, only 2 out of 44 patients (4.5%) reported no cognitive complaints, with the remaining 42 patients (95.5%) reporting cognitive complaints. Table 3 presents the blind investigator's evaluation and the CDT scores of individuals in this group.

CDT demonstrated a positive predictive value of 55.3% and a negative predictive value of 97.3%. Its sensitivity was calculated at 95.5%, while its specificity was 67.9%.

We have included that 30 of the Parkinson's patients were identified as having dementia, and 14 were diagnosed with MCI. However, in the blind assessment, 2 of the MCI cases were erroneously classified as normal. Notably, in the evaluations, all instances of PD-D were identified solely through

Table 1. Demographic data and Clock Drawing Test scores of the Parkinson's disease patients and the healthy controls

	Parkinson's disease patients (n=44)	Healthy Control (n=106)	p
Age mean±SD (min-max)	69.25±7.87 (55-89)	69.23±6.01(58-86)	0.984*
Gender F, n (%)	16 (36.4)	54 (50.9)	0.073**
Education, n (%)		0.065**	
Literate	3 (6.8)	6 (5.7)	
Elementary	31 (70.5)	49 (46.2)	
Middle school	4 (9.1)	20 (18.9)	
High school	2 (4.5)	16 (15.1)	
University	4 (9.1)	15 (14.2)	
Clock Drawing Test score	1.66±1.46 (0-5)	3.93±1.35 (0-5)	<0.001*

* Student t test; ** Chi square test.

Table 2. Comparison of the investigator's evaluation with the CDT scores of the control group

Control group	Clock Drawing Score						Total
	0	1	2	3	4	5	
The Blind Investigator's Evaluation-Cognitive Impairment							
nono							
No							
n	0	0	0	1	42	29	72
%	0.0	0.0	0.0	1.4	58.3	40.3	100.0
% of Total	0.0	0.0	0.0	0.9	39.6	27.4	67.9
Yes							
n	1	3	8	7	14	1	34
%	2.9	8.8	23.5	20.6	41.2	2.9	100.0
Total	0.9	2.8	7.5	6.6	13.2	0.9	32.1
Total							
Cou							
n	1	3	8	8	56	30	106
%	0.9	2.8	7.5	7.5	52.8	28.3	100.0
Total	0.9	2.8	7.5	7.5	52.8	28.3	100.0

CDT: Clock Drawing Test.

the CDT. However, two patients diagnosed with MCI were erroneously classified as normal based on CDT results.

Comparison of the investigator's evaluation with the CDT score in detecting newly diagnosed cognitive impairment is summarized (Table 4).

Discussion

In this study, our primary objective was to assess the sensitivity of the CDT as a standalone tool in detecting cognitive impairment among individuals with PD, comparing them with a normal healthy control (HC) group.

Our findings revealed that while the CDT scores of all PD patients diagnosed with dementia were consistently low, two patients with MCI were erroneously classified

as normal based on the CDT results. In contrast, 67.9% of participants in the control group exhibited no cognitive complaints, while 32.1% reported cognitive complaints as detected solely by the CDT. On the other hand, cognitive impairment was detected in approximately one-third of the control group, according to the CDT.

The CDT's performance metrics demonstrated a positive predictive value of 55.3% and a negative predictive value of 97.3%. The CDT's sensitivity was notably high at 95.5%, indicating its effectiveness in identifying cognitive impairment. However, its specificity was found to be 67.9%, suggesting a moderate level of accuracy in distinguishing between individuals with and without cognitive impairment.

Overall, our study underscores the utility of the CDT as a

Table 3. Comparison of the investigator's evaluation with the CDT scores of the Parkinson's group

Parkinson's Group	CDT Score						Total
	0	1	2	3	4	5	
The Blind Investigator's Evaluation-Cognitive Impairment							
no							
n	0	0	0	0	2	0	2
%	0.0	0.0	0.0	0.0	100.0	0.0	100.0
Total	0.0	0.0	0.0	0.0	4.5	0.0	4.5
yes							
n	15	6	7	11	3	0	42
%	35.7	14.3	16.7	26.2	7.1	0.0	100.0
Total	34.1	13.6	15.9	25.0	6.8	0.0	95.5
Total							
n	15	6	7	11	5	0	44
%	34.1	13.6	15.9	25.0	11.4	0.0	100.0
Total	34.1	13.6	15.9	25.0	11.4	0.0	100.0

CDT: Clock Drawing Test.

Table 4. Comparison of the investigator's evaluation with the CDT score in detecting newly diagnosed cognitive impairment

	New Diagnosis		Total
	Subjective	Parkinson	
The Blind Investigator's Evaluation-Cognitive Impairment			
no			
n	72	2	74
%	97.3	2.7	100.0
Total	48.0	1.3	49.3
yes			
n	34	42	76
%	44.7	55.3	100.0
Total	22.7	28.0	50.7
Total			
n	106	44	150
%	100.0	100.0	100.0
Total	70.7	29.3	100.0

CDT: Clock Drawing Test.

sensitive tool for detecting cognitive impairment in PD patients. However, the presence of false-negative results highlights the importance of combining CDT with other assessment measures for comprehensive evaluation and diagnosis of cognitive impairment in PD.

(PD is frequently accompanied by cognitive impairment, which can manifest as dementia (PD-D) or moderate cognitive impairment (PD-MCI). These cognitive deficits are often characterized by executive dysfunction and visuospatial impairment. The increasing recognition of cognitive impairment in PD is of significant concern due to its pro-found impact on social functioning, daily activities, quality of life, and mortality rates.[12]

CDT is a valuable tool for rapidly assessing cognitive function, particularly in screening for frontoparietal lobe dysfunction. It is commonly employed alongside other cognitive test batteries to differentiate between individuals with normal cognition, MCI, and dementia in PD.[12,13] Studies have consistently demonstrated that individuals with cognitive impairment, including those with PD-related cognitive deficits, tend to perform worse on the CDT compared to individuals with normal cognitive function.[28]

In this study, among the participants in the normal healthy control (HC) group, 28.3% achieved a perfect score of 5 on the CDT, while 52.8% attained a score of 4. Among the participants in the normal healthy control (HC) group, nearly 80% scored 4 or 5 on the CDT. Conversely, in the PD group, only 6.8% of the 42 individuals with cognitive complaints scored a four on the CDT. Notably, none of the patients in the PD group with cognitive complaints scored five on the CDT. Furthermore, while only one participant with cognitive complaints in the HC group received a score of 0, a substantial 34.1% of all PD patients diagnosed with dementia scored 0 on the CDT.

In this study, the CDT exhibited a positive predictive value (PPV) of 55.3%, a negative predictive value (NPV) of 97.3%, a sensitivity of 95.5%, and a specificity of 67.9%. Notably, compared to previous studies, our study reported lower sensitivity values, ranging from 48.9% to 71.3%, while specificity values were partially consistent with our findings, ranging from 55.8% to 77.3%. Additionally, similar PPVs (43.9%) and NPVs (86.9%) were observed.[29]

In this study, two patients with MCI from the PD group were not detected to have cognitive complaints by the blind researcher, both of whom were primary school graduates. Conversely, within the healthy control (HC) group, 41.2% of patients with cognitive impairment received a CDT score of 4, while over half scored three or below by the blind researcher. This circumstance illustrates that the CDT can be employed not for detecting cognitive impairment but rather for cognitive impairment screenings.

Cognitive testing in PD necessitates careful consideration to minimize the confounding effects of motor demands. Test selection should account for the cognitive, emotional, motor, and sensory capabilities of advanced PD patients, ensuring their ability to effectively engage with the assessment.[30-33] The Montreal Cognitive Assessment (MoCA) demonstrates adequate psychometric properties as a screening tool for detecting dementia, including PD-D and PD-MCI.[8,34,35] However, due to its complexity and lengthy administration time (typically at least 10 minutes), MoCA may not be suitable for routine use in general practice, particularly for individuals with lower levels of education.[12] Furthermore, MoCA requires review by a qualified health professional, further limiting its applicability in busy outpatient settings.

In contrast, the CDT emerges as a rapid and cost-effective cognitive screening tool. Originally developed to detect frontoparietal deficits related to executive functions and visuospatial abilities, CDT offers several advantages. Importantly, it is largely unaffected by factors such as education, ethnicity, and socioeconomic status. This directional feature is particularly advantageous, as patients can easily recognize the clock face, even if they cannot tell the time or share the same language as the assessor.[36,37]

In this study, all 44 patients in the PD group participated in the CDT assessment. Among them, three patients were literate, 31 were primary school graduates, 4 were secondary school graduates, 2 were high school graduates, and 4 were university graduates, highlighting the feasibility of CDT across various education levels.

In a study investigating performance discrimination using the CDT, individuals with PD scored lower than controls, with a significant correlation observed between CDT scores and Mini-Mental State Examination (MMSE) scores.[35] Similarly, another study comparing 97 PD patients with 54 healthy controls (HCs) found that PD patients performed worse on the CDT compared to controls.[13] These findings suggest that the MMSE may be less sensitive in detecting cognitive difficulties in PD.

In this study, patients in the healthy control group achieved higher scores on the CDT compared to those in the PD group. Specifically, 30 patients in the control group achieved a perfect score of 5 on the CDT, while none of the patients in the PD group attained a score of 5. The highest CDT score observed in the PD group was 4, recorded in 5 individuals. Given that our PD group included patients with cognitive complaints, it is anticipated that these individuals would exhibit lower CDT scores.

The primary limitation of this study is the inclusion of only PD patients with cognitive complaints, omitting those without cognitive complaints. Additionally, the study did not conduct a separate analysis of patients with and without depression. It is plausible that patients in the control group who exhibited cognitive complaints may have experienced attention deficits secondary to depression.

Conclusion

In conclusion, despite its low positive predictive value, the CDT demonstrates a high negative predictive value and can be utilized as a screening test for cognitive impairment. However, it's essential to note that a low score on the CDT alone does not definitively indicate the presence of cognitive complaints. A comprehensive neurological evaluation and detailed cognitive assessment are essential for confirming the diagnosis of dementia. The CDT can be utilized as a screening tool even in a busy outpatient clinic environment.

Disclosures

Ethics Committee Approval: The study protocol received approval from the Lokman Hekim University Non-interventional Clinical Research Ethics Committee (Number: 2021/026, date: 10.03.2021).

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