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RESEARCH ARTICLE

Cognitive Assessment Has Never Been Faster! The Clock Drawing Test as a Screening Test for Cognitive Impairment in MS Clinical Practice

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Abstract

Objective: Cognitive changes are commonly seen in patients with multiple sclerosis (MS), which is a chronic autoimmune, demyelinating disease. The Clock Drawing Test (CDT) is an easy to use and highly reliable cognitive assessment tool that evaluates planning, visuospatial abilities, and abstract thinking. In this study, the CDT was scored with the Shulman, Manos-Wu, and Watson methods, which are the most frequently used scoring methods, and the correlation was examined between clinical evaluation tests.

Materials and Methods: A total of 109 participants with a diagnosis of MS were included in the study. Participants were followed longitudinally, three times in total, at intervals of 3-6 months. Clinical tests and the CDT (scored with the Shulman, Manos-Wu, and Watson methods) were applied to the participants. The relationships between the CDT, the clinical evaluations, and the demographic data were analyzed by Pearson's correlation analysis. Differences between the participants' first and follow-up clinical tests and the CDT scores were assessed by repeated-measures analysis of variance.

Results: Significant moderate to strong correlations were detected between the CDT score and the Expanded Disability Status Scale, the Nine Hole Peg Test, the 25-Foot Walk Test, education, age, and disease duration. No significant differences were observed between the baseline and follow-up CDT or the clinical evaluation test scores.

Conclusion: The CDT scored by three different methods was moderate to strongly correlated with clinical tests frequently used to assess motor symptoms. This finding suggests that the CDT is a useful cognitive evaluation tool that is closely related to general clinical evaluation tests.

Keywords: Clock drawing test, multiple sclerosis, cognition

Introduction

Cognitive changes are common in patients with multiple sclerosis (MS), starting with the development of the radiological and clinically isolated syndrome. The prevalence of cognitive impairment in the adult MS population ranges from 34% to 65% and varies according to the method applied. Difficulties in attention, memory, information processing speed, verbal fluency, visuospatial perception, social cognition, and executive functions have been reported in patients with MS (1,2).

Cognitive disorders impair work life, social relationships, and activities of daily living independently of a physical disability. It is thought that evaluating cognitive functions from the early period in patients with MS not only enables diagnosis of the cognitive disorder but also provides information about disease progression and better treatment management (3).

An evaluation of cognitive functions cannot be made objectively using the Expanded Disability Status Scale (EDSS) score during the follow-up of MS patients and is ignored particularly when physical disability progresses. The Mini-Mental State Examination

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(MMSE) is the most widely used cognitive assessment tool to determine cognitive impairment in patients with a neurological disorder. The MMSE cannot be used to evaluate executive or memory functions in patients with MS. Many tests used to evaluate cognitive functioning in patients with MS are superior to the MMSE, such as the Symbol Digit Modalities Test (SDMT), the Brief Repeatable Battery of Neuropsychological Tests (BRN-B), the Brief International Cognitive Assessment for MS, the Minimal Assessment of Cognitive Function in MS, and the MS neuropsychological screening questionnaire (4).

The problems encountered when applying these tests in an intensive outpatient clinic include the need for a quiet environment, practitioner training, and time. Practical, rapid, and non-specific tests and regular cognitive control of patients are a necessity for physicians and patients during follow-up. The Clock Drawing Test (CDT) is a paper-pencil test, which has long been recommended for evaluating general cognitive functions, as it is easy, quick, and has high validity and reliability.

In our study, we measured the usability of the CDT for distinguishing cognitive impairment and longitudinal tracking in MS clinical practice. The CDT can be used to evaluate high-level cognitive functions, such as planning, sequencing, visuospatial perception, and abstract thinking (5). The CDT offers the opportunity to obtain detailed information about the cognitive level of MS patients. Different methods have been developed to evaluate the CDT. The three most widely used CDT scoring methods are Shulman, Manos-Wu, and Watson. In this study, all three methods were used to score the CDT. The EDSS, SDMT, Nine Hole Peg Test (NHPT), and 25-Foot Walk Test (25 FWT) are routine tests used during follow-up to evaluate MS patients. However, no study has compared which of these three tests is the best. In this study, our first aim was to investigate the utility of the CDT for detecting cognitive impairment. The second aim was to show the compatibility of the results with the MS clinical evaluation parameters and the ease of scoring in clinical practice using the three different methods.

Materials and Methods

Participants

In total, 109 participants who were followed up with the diagnosis of MS were enrolled in our study. All patients were aged 18-61 years and were diagnosed with relapsing-remitting MS according to the McDonald (2017) criteria. The exclusion criteria were a history of dementia, concomitant comorbid disease, or an attack in the last 3 months.

This study included the results of an evaluation performed at 3-6 month intervals from prospectively collected patient follow-up charts. The participants were followed longitudinally, three times in total, at intervals of 3-6 months. The EDSS, SDMT, 25 FWT, NHPT, and CDT were administered to the participants.

All participants provided informed consent following the Declaration of Helsinki. This study was approved by the Bursa Yuksek Ihtisas Training and Research Hospital Ethical Committee (protocol number: 2011-KAEK-25 2022/06-13 date: 29.06.2022).

The demographic and clinical data of the participants are presented in Table 1.

Clinical and Cognitive Tests

a. EDSS: The EDSS is a clinical evaluation test that assesses the degree of disability in individuals with MS. The EDSS score ranges from 0 to 10 with a higher score indicating a higher degree of disability.

b. SDMT: The SDMT evaluates cognitive speed and information processing speed. It is widely used in patients with MS.

c. 25 FWT: The 25 FWT is used to assess leg functioning and mobility. The individuals taking the 25 FWT were asked to walk as quickly as possible. The times for two trials were averaged to obtain the score. However, in this explanatory study, we used the forward and backward scores separately.

d. NHPT: The NHPT is widely used to assess finger dexterity in patients with MS. Time is recorded in seconds and the individual is asked to perform the test as quickly as possible.

e. CDT: The CDT is administered using plain white paper and the patient was asked to draw an analog clock. After drawing the clock, the individual was asked to show the time as 11.10. The clocks were evaluated with the three different scoring methods. (Figure 1: CDT evaluation).

The scoring methods of the tests are given below:

Shulman

Five points indicated a faultless clock and were considered "perfect". A clock with minor errors scored 4 points. Three points were given if the individual could not accurately show 10 past 11 but the number organization of the clock and the dial plate were correct. Two points were given if the numbers were present yet the accurate representation of 10 past 11 was impossible due to the organization of the numbers. One point

Table 1. Demographic and clinical characteristics of the participants

RRMS (n=109)	Mean (SD)
Age (years)	39.50 (10.05)
Education (years)	8.31 (4.18)
Age at first symptom (years)	29.89 (9.03)
Disease duration	9.73 (5.86)
Treatment duration (years)	8.27 (5.67)
EDSS	2.89 (2.09)
Gender (F/M)	82/27

Data presented as mean, SD: Standard deviation, RRMS: Relapsing-remitting multiple sclerosis EDSS: Expanded Disability Status Scale, F: Female, M: Male

for severe impairment in organization and 0 points was given if there was no representation of a clock (6).

Watson

A pre-drawn circle was given to the individuals following the Watson method. Drawing of the hands was not included in the score for this method. The circle/dial plate was divided into four quadrants. The fourth quadrant consisted of the numbers 9-12 and was the most important one for scoring. One point was given for errors made in quadrants 1, 2, or 3. Errors made in quadrant 4 received a score of 4. The scores ranged from 0 to 7, and a higher score indicated more abnormalities (7).

Manos-Wu

The Manos-Wu method (8) of CDT scoring included a transparent dial that perfectly fit the clock drawing of the participant. If the hands were correct and the organization of the numbers was accurate, the individual was given 10 points. Some significant errors cannot be scored if there was an error that made the transparent circle inapplicable. However, this method successfully discriminates dementia at a rate of 78% (9).

Statistical Analysis

The possible differences between the baseline, first follow-up, and second follow-up clinical tests and between the different CDT scoring approaches (Schulman, Watson, and Manos-Wu) were assessed with separate repeated-measures analyses of variance (ANOVAs) with time as a factor defined by the three levels as baseline, first follow-up, and second follow-up. Bonferroni post-hoc analyses were applied. The correlations between the CDT scoring technique, the clinical test score (EDSS, SDMT, 25 FW, and NHPT), and the demographic variables (age and education) were assessed by Pearson's correlation analysis. All hypotheses in the correlation analyses were a priori. Thus, no corrective methods were used for the correlation analysis. A p-value <0.05 was considered significant.

Results

Clinical Evaluations and the CDT Scores over Time

A significant difference was detected between the EDSS score [F (2,96)=3.471, p=0.043]. However, post-hoc analysis indicated no significant differences between the baseline, first follow-up and second follow-up EDSS scores. Repeated-measures ANOVA showed a significant difference between the baseline, first follow-up, and second follow-up of the 25 FW-Backward score, but the post-hoc analysis revealed no difference.

No significant differences were detected between the baseline, first follow-up, and second follow-up scores on the SDMT [F (2,104)=0.896, p=0.391], NHPT-right [F (2,100)=0.47, p=0.952], NHPT-left [F (2,98)=0.19, p=0.968], or 25 FW-Forwards [F (2,98)=3.480, p=0.066] tests.

No differences were observed between the baseline, first follow-up, and second follow-up scores on the CDT-Schulman

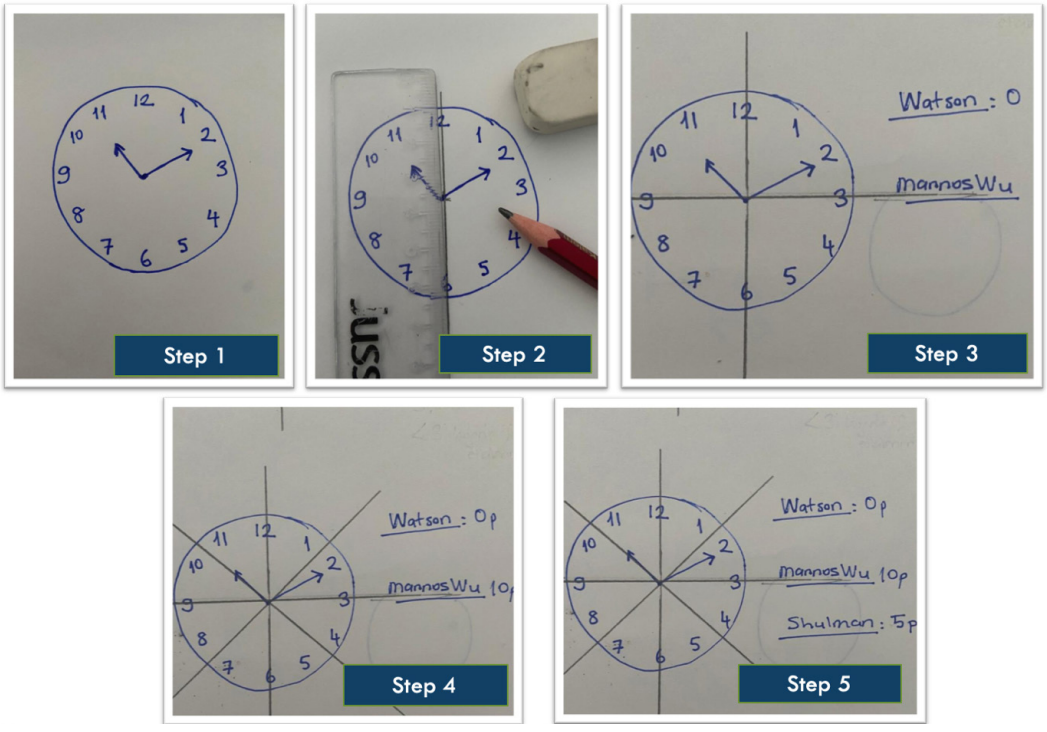

Figure 1. The midpoint of the clock was found with a compass, and it was divided into four dials with a ruler. The test was scored first according to Watson, then Mannos-Wu, and finally by the Shulman evaluation methods. Tests and clock drawings were repeated at regular follow-ups with controls

[F (2,98)=2.983, p=0.067], CDT-Watson [F (2,98)=2.029, p=0.138], or CDT-Manos-Wu [F (2,100)=2.546, p=0.088].

Correlation Analysis

Moderate to strong correlations were detected between the CDT-Manos-Wu and the EDSS (r=-0.449, p<0.001), NHPT-right (r=-0.233, p=0.016), NHPT-left (r=-0.262, p=0.007), 25 FW-backward (r=-0.289, p=0.003), SMDT (r=0.575, p<0.001), age (r=-0.264, p=0.006), education (r=0.295, p=0.002), and disease duration (r=-0.253, p=0.009). In addition, moderate to strong correlations were observed between the CDT-Schulman and the EDSS (r=-0.434, p<0.001), NHPT-right (r=-0.272, p=0.005), NHPT-left (r=-0.252, p=0.009), 25 FW-Forwards (r=-0.252, p=0.040), 25 FW-Backward (r=-0.277, p=0.005), SDMT (r=0.575, p<0.001), age (r=-0.386, p<0.001), education (r=0.295, p=0.002), and disease duration (r=-0.202, p=0.037). Low to moderate correlations were detected between the CDT-Watson and the EDSS (r=0.291, p=0.002), NHPT-right (r=0.280, p<0.001), SMDT (r=-0.352, p<0.001), and age (r=0.349, p<0.001) (Table 2).

Discussion

We found that the CDT, which evaluates visuomotor skills and executive functions, such as planning, sequencing, and abstract thinking, was moderate to strongly correlated with the tests frequently used to assess motor and cognitive skills in patients with MS, particularly when scored with the Manos, Wu, or Schulman methods. Following our hypotheses, the results revealed no longitudinal differences in the CDT scores in our sample, but a moderate-strong correlation with the clinical tests was observed, which also had no longitudinal differences This finding supports our view that the CDT is an effective neuropsychological test for patients with MS.

Cognitive functions should be evaluated during the diagnosis and follow-up of neurological and neuropsychiatric diseases. Ideal assessment methods are expected to be quickly applicable, repeatable, well tolerated, unaffected by education, culture, and language, easily scored, sensitive, specific, with no inter-rater differences, and correlated with other cognitive screening tests. Many studies have been conducted on whether the CDT is an ideal test to evaluate cognitive functions. As a result, the CDT can be used to evaluate high-level cognitive functions, such as planning, sequencing, visuospatial relationships, and abstract thinking, in diseases, such as vascular dementia, Alzheimer's type dementia, Huntington's disease, Parkinson's disease, stroke, traumatic brain injury, and delirium. This result suggests that the CDT is a good screening test to evaluate cognitive functions and provide an early diagnosis of cognitive disorder (5,6).

Cognitive disorders in patients with MS have gained popularity in the last 20 years, which has facilitated research on the topic. Cognitive functions are affected at varying levels from the early stages of the disease. A comparative study with the BRN-B to evaluate cognitive impairment in MS was performed by Barak et al. (5). In that study, evaluations were made using the Shulman method. As results, the CDT-Shulman scores were not correlated with age, gender, disease duration, or the EDSS score, but they were significantly correlated with the EDSS mental functional system score. A moderate-strong correlation was demonstrated between the CDT-Shulman score and age, disease duration, and education level. In the same study, significant correlations were detected between the BRN-B test and the CDT, as well as a positive correlation was observed between the Paced Auditory Serial Addition Test and the CDT (5). In addition, the CDT has sensitivity of 93.4% and specificity of 85.8% in discriminating cognitively intact from impaired MS patients, as defined by the EDSS.

In a study from our country, Baysal Kırac et al. (10) reported no significant difference between the CDT scores of early MS patients and healthy controls. Although 19.6% of the patients were impaired according to the Rey Auditory and Verbal Learning Test (RAVLT-1), which interprets learning, and 17.4% were impaired on the RAVLT-2, which interprets long-term memory, the results were not significant when compared with the control group (10).

Many different scoring methods are available, fueling a debate about which is the best. Researchers have shown that the scoring method described by Shulman is superior to the Watson method for diagnosing cognitive impairment (11).

Table 2. Comparisons between the Clock Drawing Test scores and the clinical assessment scales

	Manos-Wu	Shulman	Watson
EDSS	r=-0.449	r=-0.434	r=0.291
NHPT-R	r=-0.233	r=-0.272	r=0.280
NHPT-L	r=-0.262	r=-0.252	-
25 FWT		r=-0.252	-
SDMT	r=0.575	r=0.575	r=-0.352
Age	r=-0.264	r=-0.386	r=0.349
Education	r=0.295	r=0.295	-
Disease duration	r=-0.253	r=-0.202	-

EDSS: Expanded Disability Status Scale, NHPT: Nine Hole Peg Tests, 25 FWT: 25-Foot Walk Test, SDMT: Symbol Digit Modalities Test, R: Right, L: Left

Although it is easy to use and to score and draws objectively from the Watson method, our study showed that it may not be as comprehensive as the others (6).

Emek Savas et al. (12) investigated the validity and reliability of the most frequently used CDT methods, including the Manos-Wu and Shulman methods. They found that the CDT scores of healthy individuals were significantly affected by age and education using the Manos-Wu method, whereas only education affected the scores according to the Shulman method. In both cases, test-retest reliability and inter-rater reliability were high, and the two tests were strongly correlated with each other (12).

Study Limitations

Several limitations of this study should be discussed. The CDT was not compared with the EDSS cognitive sub-functional score. Patients were not screened for fatigue, depression, or anxiety disorder. An upper extremity disability may have impacted the CDT results. Cognitive test results may not be reliable in MS patients with cerebellar or upper extremity dysfunction, and patients in this group should be evaluated separately. The absence of a healthy control group was a limitation of this study. However, the evaluation of prospectively obtained follow-up tests and a comparison with the frequently used SDMT, which has become routine to evaluate cognitive function in MS outpatient clinics, are the strengths of our work.

The CDT is a useful, brief, and sensitive cognitive assessment tool for screening cognitive functions quickly in MS patients at follow-up clinics. As cognitive functioning changes with motor functioning in patients with MS, longitudinal use of the CDT may suggest disease progression. Further studies should focus on the longitudinal changes in the CDT and correlate clinical test results to determine how the CDT is affected.

Conclusion

This study showed the relationships between the CDT score and the clinical tests used to evaluate MS. The findings support our view that the CDT is a good assessment tool for patients with MS. We think that comparing individuals with MS and individuals without neurological disease in future studies is very important to determine the discrimination validity of the CDT.

Ethics

Ethics Committee Approval: This study was approved by the Bursa Yuksek Ihtisas Training and Research Hospital Ethical Committee (protocol number: 2011-KAEK-25 2022/06-13 date: 29.06.2022).

Informed Consent: All participants provided informed consent following the Declaration of Helsinki.

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Authorship Contributions

Surgical and Medical Practices: M.S., A.O.S., D.O., Y.O.I., Concept M.S., A.O.S., D.O., Y.O.I., Design: M.S., A.O.S., D.O., Y.O.I., Data Collection or Processing: M.S., A.O.S., D.O., Y.O.I., Analysis or Interpretation: M.S., A.O.S., D.O., Y.O.I., Literature Search: M.S., A.O.S., D.O., Y.O.I., Writing: M.S., A.O.S., D.O., Y.O.I.

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