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ORIGINAL ARTICLE

Thai Mental State Examination Performance in Patients with Parkinson's Disease according to Montreal Cognitive Assessment Score in Detecting Mild Cognitive Impairment

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ABSTRACT

Objectives: Mild cognitive impairment (MCI) is common among individuals with Parkinson's disease (PD), affecting approximately 20%-70%, and often progress to PD dementia. Routine cognitive evaluation is essential for early detection and management of PD with MCI. Although various cognitive screening tools are available, including the Montreal Cognitive Assessment (MoCA) and Thai Mental State Examination (TMSE), the validity of the TMSE in detecting MCI among PD patients has not been established.

Materials and Methods: A cross-sectional study of 100 patients with PD at Vajira Hospital was conducted. Cognitive function was assessed using the Thai versions of the MoCA (Thai-MoCA) and TMSE. Patients with dementia or advanced PD were excluded. The diagnostic performance of TMSE in identifying MCI was evaluated using the Thai-MoCA as the reference screening test, with sensitivity, specificity, and predictive values calculated. Optimal cutoff scores were determined using Youden's index.

Results: Of the 81 patients identified with MCI by Thai-MoCA, only 19 (23.5%) were classified as having MCI by TMSE, while 62 (76.5%) were not. The TMSE showed a sensitivity of 23.5% (95% confidence interval (CI): 14.8–34.2) and specificity of 100% (95% CI: 82.4–100). The positive predictive value was 100% (95% CI: 82.4–100), negative predictive value was 23.5% (95% CI: 14.8–34.2), and overall accuracy was 38.0% (95% CI: 28.5–48.3). The optimal TMSE cutoff score of < 28 improved sensitivity to 77.8% (95% CI: 67.2–86.3) while maintaining specificity at 100% (95% CI: 82.4–100).

Conclusion: The TMSE exhibited low sensitivity for identifying MoCA-defined MCI among patients with PD when using standard criteria. However, adjusting the cutoff score to < 28 substantially increased sensitivity while maintaining high specificity. This modified cutoff may improve the sensitivity of TMSE for identifying MoCA-defined MCI in PD patients, although further validation in independent populations is required.

Keywords: cognitive assessment, mild cognitive impairment, Parkinson's disease

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INTRODUCTION

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by cardinal motor symptoms such as bradykinesia, tremor, and rigidity, along with a broad spectrum of non-motor manifestations, including sleep disturbances, mood disorders, autonomic dysfunction, and cognitive decline.[1] Cognitive impairment in PD, ranging from mild cognitive impairment (PD-MCI) to PD dementia, is common and significantly affects patients' daily functioning, quality of life, and long-term outcomes.[2-5] PD-MCI has been reported in approximately 20%–70% of patients with PD and often develops in the later stages of the disease.[6-13] Longitudinal data show that 39%–50% of patients with PD-MCI develop dementia within 5 years, whereas 11%–27.8% may revert to normal cognition over the same period.[6,14] Considering the high prevalence and clinical relevance of cognitive decline in PD, regular cognitive screening is essential for early detection and intervention.

According to the Movement Disorder Society (MDS) Task Force 2012 Guideline, the diagnosis of PD-MCI requires a confirmed diagnosis of PD per the United Kingdom Parkinson's Disease Society Brain Bank (UKPDSBB) criteria, evidence of gradual cognitive decline (reported by the patient, an informant, or observed by the clinician), and objective cognitive deficits on neuropsychological testing without loss of functional independence.[8] Two levels of diagnostic criteria are defined: Level I, based on impairment detected by a validated global cognitive screening test suitable for PD, and Level II, which includes comprehensive testing across five cognitive domains. For practical use in clinical settings, Level I criteria are commonly employed due to their simplicity and time efficiency.[15]

The Montreal Cognitive Assessment (MoCA) is a widely used screening tool for detecting MCI and early Alzheimer's disease.[16,17] In Thailand, the Thai version of the MoCA (Thai-MoCA) is widely used as a cognitive screening instrument for detecting MCI. The recommended cutoff score is < 25 points, with an additional point added for individuals with ≤ 6 years of education according to the Thai Clinical Practice Guideline for Dementia.[18] Although comprehensive neuropsychological testing based on MDS Level II criteria remains the diagnostic gold standard for PD-MCI, the Thai-MoCA is commonly used in clinical practice as a practical screening tool.

Another commonly used screening tool is the Mini-Mental State Examination (MMSE), though studies have shown that it has lower sensitivity and specificity for detecting PD-MCI compared to MoCA.[19-24] The Thai Mental State Exam (TMSE), adapted from the MMSE, is widely used in Thailand with score below 24 indicates MCI but it has not been validated for screening PD-MCI.[25]

Compared with the MoCA, the TMSE is simpler and faster to administer, requiring only 6–8 min versus approximately 15 min for the MoCA. However, the TMSE assesses fewer domains of visuospatial and executive function and lacks cueing for recall memory, which may limit its sensitivity in detecting mild cases of MCI. Considering its convenience and time efficiency, this study aims to evaluate the performance of the TMSE in detecting MCI among patients with PD, using the Thai-MoCA as the reference screening tool. We hypothesized that the standard TMSE cutoff score (< 24) may have low sensitivity for identifying MoCA-defined PD-MCI, and that a higher cutoff score may improve its diagnostic performance.

MATERIALS AND METHODS

This cross-sectional study was approved by the Ethics Committee of the Faculty of Medicine Vajira Hospital, Navamindradhiraj University (Certificate of approval number 179/2565). The sample size of 100 participants was determined using a formula based on the reported prevalence of PD-MCI[26] and the sensitivity and specificity of cognitive screening tools.[16] Participants were consecutively recruited from the Movement Disorders Clinic of Vajira Hospital between February 15, 2023, and October 31, 2023. The diagnosis of PD was established according to the UKPDSBB criteria by movement disorder specialists. Patients were included if they self-reported or had caregiver-reported cognitive complaints. Exclusion criteria included dementia with impairment of daily functioning and other neurological comorbidities such as prior cerebrovascular accident, Alzheimer's disease, or intellectual disability. Disease severity was rated using the Hoehn and Yahr (H&Y) scale (ranging from 1 to 5, with higher scores indicating greater severity); patients with H&Y stage 5 were excluded. Cognitive impairment was defined per the MDS Task Force 2012 Level I criteria, using the Thai-MoCA and TMSE. Thai-MoCA evaluates multiple cognitive domains including visuospatial/executive function, naming, attention, language, abstraction, memory, and orientation, with a total score of 30 points. TMSE evaluates multiple cognitive domains includes

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orientation, registration, attention, calculation, language, and recall domains, with a total possible score of 30 points. The recommended cutoff for cognitive impairment is < 25 for Thai-MoCA (with education adjustment) and < 24 for TMSE according to Thai clinical practice guidelines.[18,25] Both assessments were administered by trained neurology residents using standardized testing instructions under supervision of movement disorder specialists during the same outpatient visit. The order of testing was fixed, with TMSE administered first followed by Thai-MoCA after a 15-minute interval. Because both assessments were conducted during the same visit, the assessor of the Thai-MoCA was not blinded to TMSE results. Participants were instructed to take their PD medications as prescribed before assessment to ensure evaluation during their "on" state (Figure 1).

The primary outcome was the diagnostic performance of the TMSE in identifying MoCA-defined PD-MCI, using the Thai-MoCA as the reference standard. Secondary outcomes included determination of the optimal cutoff value for identifying PD-MCI, as well as evaluation of the correlation (Pearson's r) and agreement (intraclass correlation coefficient) between TMSE and Thai-MoCA total and domain-specific scores (language, attention, and memory recall). Specifically, the TMSE attention score included both attention and calculation components, while the Thai-MoCA language score included language-related tasks such as naming, language and abstraction. The Thai-MoCA and TMSE were used with permission from the original developers and in accordance with institutional and research governance policies.

All analyses were performed using Stata version 13.0 for Windows (StataCorp, College Station, TX, USA). Qualitative data were summarized as frequencies and percentages, while quantitative variables were presented as mean ± standard deviation or median with interquartile range. The performance of TMSE relative to Thai-MoCA was evaluated through sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and receiver operating characteristic (ROC) analysis with the area under the curve (AUC) and corresponding 95% confidence interval (95% CI). The correlation between TMSE and Thai-MoCA total and specific domain scores were analyzed using Pearson correlation coefficients. Agreement between continuous scores was evaluated using intraclass correlation coefficients (ICC) with 95% CI. The optimal TMSE cutoff value for identifying MoCA-defined PD-MCI was determined using Youden's index.

RESULTS

A total of 100 patients with PD were enrolled between February 15, 2023, and October 31, 2023. Participants were predominantly elderly (mean age, 72.82 8.90 ± years), slightly overweight (mean body mass index, 23.65 4.19 ± kg/m^2), and most had at least one comorbidity (88%). Females comprised 54% of the cohort, and educational levels varied. The mean age of

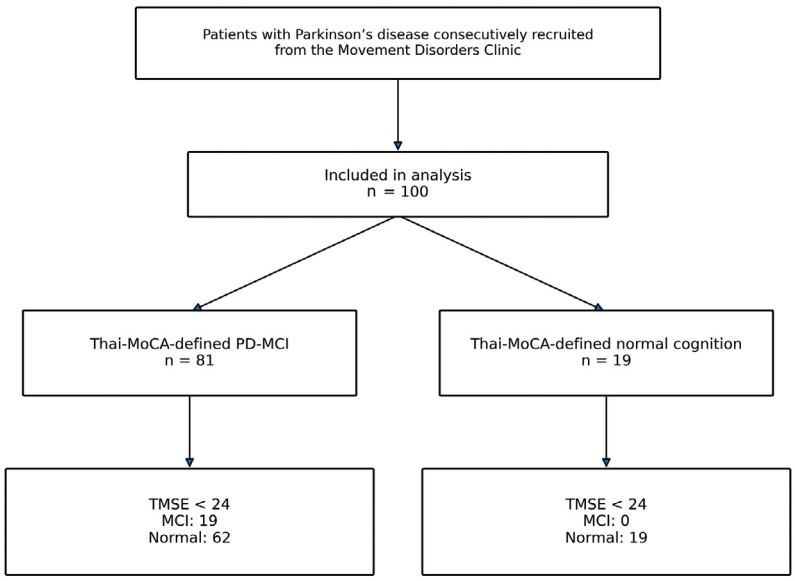


Figure 1 Flow Diagram of Participant Recruitment

PD onset was 68.06 9.63 ± years, and the median disease duration was 3 years (interquartile range (IQR): 1.5–6.5), with 71% having a disease duration ≤ 5 years. Most patients were classified as H&Y stage 1 (62%), exhibited a tremor-dominant phenotype (36%), and had right-sided onset (55%). The median levodopa equivalent daily dose (LEDD) was 372.5 mg (IQR: 200–757), and more than half (51%) received < 400 mg/day (Table 1).

The mean Thai-MoCA score was 19.41 ± 4.91 points (Table 2). Subdomain mean scores were as follows: visuospatial 2.36 ± 1.64, naming 2.80 ± 0.57, attention 4.42 ± 1.40, language 1.43 ± 0.98, abstraction 1.10 ± 0.75, delayed recall 1.37 ± 1.46, orientation 5.54 ± 1.06, and memory index 7.55 ± 4.44. Based on the Thai-MoCA cutoff (< 25), 81% of patients met criteria for PD-MCI.

For the TMSE, the mean score was 25.88 ± 3.08 points. Subdomain scores were: orientation 5.61 ± 0.75, registration 2.95 ± 0.30, attention 4.81 ± 0.71, calculation 1.92 ± 1.06, language 9.41 ± 0.89, and recall 1.18 ± 1.04. Using the conventional TMSE cutoff (< 24), 19% of patients were classified as having MCI.

The Thai-MoCA and TMSE total scores showed a strong positive correlation (r = 0.86, 95% CI: 0.80–0.90, p < 0.001) (Table 3). Domain-specific analysis also revealed significant correlations. Attention scores (Thai-MoCA 4.42 ± 1.40; TMSE 6.73 ± 1.35) demonstrated a strong positive correlation (r = 0.77, 95% CI: 0.67–0.84, p < 0.001). Language scores (Thai-MoCA 5.33 ± 1.68; TMSE 9.41 ± 0.89) had a moderate correlation (r = 0.55, 95% CI: 0.39–0.67, p < 0.001). Memory scores (Thai-MoCA 1.37 ± 1.46; TMSE 1.18 ± 1.04) also showed a moderate correlation (r = 0.54, 95% CI: 0.39–0.67, p < 0.001).

Table 1 Demographic and Clinical Characteristics of Patients with Parkinson's Disease

Characteristics	Total (n = 100)
Age (years), Mean ± SD	72.82 ± 8.9
Min-Max	(48-91)
< 65	14 (14.0)
65-74	43 (43.0)
75-84	36 (36.0)
> 85	7 (7.0)
Gender	
Female	54 (54.0)
Male	46 (46.0)
Education level	
Below grade 4	22 (22.0)
Grade 4-6	17 (17.0)
Grade 7-9	10 (10.0)
Grade 10-12	20 (20.0)
Above grade 12	31 (31.0)
BMI (kg/m^2), Mean ± SD	23.65 ± 4.19
Min-Max	(14.95-42.68)
Normal (18.5-22.9)	47 (47.0)
Overweight (23.0-24.9)	23 (23.0)
Obesity (≥ 25)	30 (30.0)

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Table 1 Demographic and Clinical Characteristics of Patients with Parkinson's Disease (cont.)

Characteristics	Total (n = 100)
Comorbidity	88 (88.0)
Hypertension	61 (61.0)
Diabetes mellitus	29 (29.0)
Dyslipidemia	52 (52.0)
Coronary artery disease	9 (9.0)
Atrial fibrillation	5 (5.0)
Chronic kidney disease	13 (13.0)
Chronic obstructive pulmonary disease	4 (4.0)
Thyroid disease	4 (4.0)
Fatty liver	2 (2.0)
Others	22 (22.0)
Onset age (years), Mean ± SD	68.06 ± 9.63
Duration (years), Median (IQR)	3 (1.5-6.5)
≤ 5	71 (71.0)
> 5	29 (29.0)
H&Y stage	
1	62 (62.0)
2	20 (20.0)
3	10 (10.0)
4	8 (8.0)
Phenotype	
Tremor	36 (36.0)
Akinetic rigid	33 (33.0)
Mixed	31 (31.0)
Lateralization	
Right	55 (55.0)
Left	45 (45.0)
Family history	7 (7.0)
Levodopa equivalent dose	372.5 (200-757)
< 400	51 (51.0)
400-599	13 (13.0)
≥ 600	36 (36.0)

Abbreviations: BMI, body mass index; H&Y, Hoehn and Yahr; IQR, interquartile range; kg, kilogram; m^2, square meter; Max, maximum; Min, minimum; n, number; SD, standard deviation

Data are presented as number (%), mean ± standard deviation or median (interquartile range).

Table 2 Thai-Montreal Cognitive Assessment, Thai Mental State Examination Scores and Cognitive Impairments among Patients with Parkinson's Disease

Variables	Total (n = 100)		
	Mean ± SD	Min	Max
Thai-MoCA			
Visuospatial (0-5)	2.36 ± 1.64	0	5
Naming (0-3)	2.80 ± 0.57	0	3
Attention (0-6)	4.42 ± 1.40	1	6
Language (0-3)	1.43 ± 0.98	0	3
Abstraction (0-2)	1.10 ± 0.75	0	2
Delayed recall (0-5)	1.37 ± 1.46	0	5
Orientation (0-6)	5.54 ± 1.06	0	6
Total score (0-30)	19.02 ± 5.12	3	28
Total score (education-adjusted)	19.41 ± 4.91	4	28
Memory index score (0-15)	7.55 ± 4.44	0	15
< 7 - n (%)	38 (38.0)		
≥ 7 - n (%)	62 (62.0)		
Cognitive impairments by Thai-MoCA, n (%)			
Mild cognitive impairment	81 (81.0)		
Normal	19 (19.0)		
TMSE			
Orientation (0-6)	5.61 ± 0.75	3	6
Registration (0-3)	2.95 ± 0.30	1	3
Attention (0-5)	4.81 ± 0.71	1	5
Calculation (0-3)	1.92 ± 1.06	0	3
Language (0-10)	9.41 ± 0.89	6	10
Recall (0-3)	1.18 ± 1.04	0	3
Total score (0-30)	25.88 ± 3.08	12	30
Cognitive impairments by TMSE, n (%)			
Mild cognitive impairment	19 (19.0)		
Normal	81 (81.0)		

Abbreviations: Max, maximum; Min, minimum; MoCA, Montreal cognitive assessment; n, number; SD, standard deviation; TMSE, Thai mental state examination

Data are presented as number (%), mean ± standard deviation or median (interquartile range).

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Table 3 Correlation and Agreement between Thai Mental State Examination and Thai- Montreal Cognitive Assessment Total and Domain Scores

	TMSE score Mean ± SD	MoCA score Mean ± SD	r (95%CI)	P-value	ICC (3,1) (95%CI)	P-value
Total score	25.88 ± 3.08	19.41 ± 4.91	0.86 (0.80, 0.90)	< 0.001	0.772 (0.679, 0.841)	< 0.001
Attention[a]	6.73 ± 1.35	4.42 ± 1.40	0.77 (0.67, 0.84)	< 0.001	0.766 (0.671, 0.837)	< 0.001
Language[b]	9.41 ± 0.89	5.33 ± 1.68	0.55 (0.39, 0.67)	< 0.001	0.452 (0.281, 0.595)	< 0.001
Memory	1.18 ± 1.04	1.37 ± 1.46	0.54 (0.39, 0.67)	< 0.001	0.511 (0.351, 0.643)	< 0.001

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; MoCA, Montreal cognitive assessment; r, Pearson correlation coefficient; SD, standard deviation; TMSE, Thai mental state examination

[a] Attention scores for TMSE include attention and calculation components.

[b] Language scores for Thai-MoCA include naming, language and abstraction components.

Based on the Thai-MoCA reference (< 25), 81 patients were classified as having PD-MCI. Among them, only 19 patients (23.5%) met the TMSE criterion for MCI (< 24). The TMSE demonstrated a sensitivity of 23.5% (95% CI: 14.8–34.2), specificity of 100% (95% CI: 82.4–100), PPV of 100% (95% CI: 82.4–100), NPV of 23.5% (95% CI: 14.8–34.2), and overall accuracy of 38.0% (95% CI: 28.5–48.3) (Table 4).

The ROC curve for TMSE in identifying MoCA-defined PD-MCI using Thai-MoCA as the reference screening test is shown in Figure 2, with an AUC of 0.92 (95% CI: 0.86–0.97). Based on Youden's index, the optimal TMSE cutoff for identifying MoCA-defined PD-MCI was < 28, resulting in markedly improved diagnostic performance: sensitivity 77.8% (95% CI: 67.2–86.3), specificity 100% (95% CI: 82.4–100), PPV 100% (95% CI: 94.3–100), and NPV 51.4% (95% CI: 34.4–68.1) (Table 5).

The performance of the TMSE test in identifying MoCA-defined PD-MCI using a cutoff score of < 28 varied by educational level. Among patients with ≤ 6 years of education, the TMSE demonstrated a sensitivity of 89.2% (95% CI: 74.6–97.0), specificity of 100% (95% CI: 15.8–100), PPV of 100% (95% CI: 89.4–100), and NPV of 33.3% (95% CI: 4.3–77.7). In patients with > 6 years of education, sensitivity was

Table 4 Diagnostic Classification of MCI by TMSE Compared with Thai-MoCA

TMSE classification	Thai-MoCA MCI	Thai-MoCA Normal	Total
MCI	19	0	19
Normal	62	19	81
Total	81	19	100
Sensitivity (95%CI)	23.5 (14.8-34.2)		
Specificity (95%CI)	100 (82.4-100)		
Positive predictive value (95%CI)	100 (82.4-100)		
Negative predictive value (95%CI)	23.5 (14.8-34.2)		
Accuracy (95%CI)	38 (28.5-48.3)		

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; MoCA, Montreal cognitive assessment; TMSE, Thai mental state examination

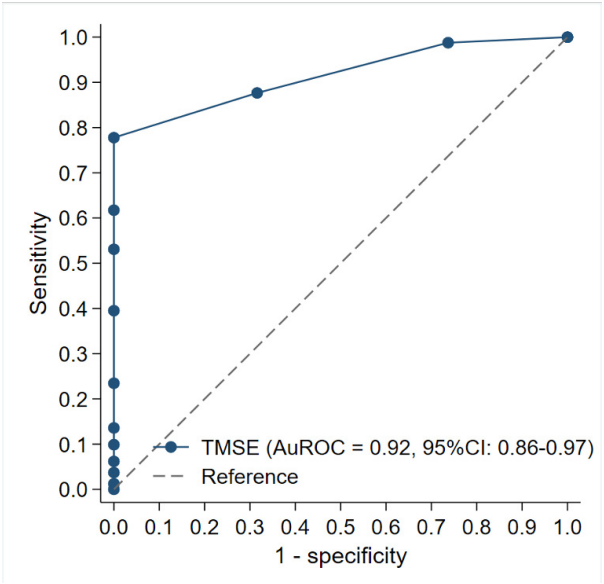


Figure 2 Receiver Operating Characteristic (ROC) Curve of TMSE for Identifying MoCA-Defined PD-MCI Using Thai-MoCA as the Reference Standard. The area under the curve (AUC) was 0.92 (95% CI: 0.86–0.97).

lower at 68.2% (95% CI: 52.4–81.4), while specificity remained 100% (95% CI: 80.5–100), with PPV of 100% (95% CI: 88.4–100) and NPV of 54.8% (95% CI: 36.0–72.7).

Details of subgroup analyses are summarized in Table 6. TMSE performance was superior among patients < 70 years old, showing a sensitivity of 80.0% (95% CI: 56.3–94.3), specificity of 100% (95% CI: 75.3–100), PPV of 100% (95% CI: 79.4–100), and NPV of 76.5% (95% CI: 50.1–93.2). Patients with disease duration > 5 years also demonstrated better performance, with a sensitivity of 87.5% (95% CI: 67.6–97.3), specificity of 100% (95% CI: 47.8–100), PPV of 100% (95% CI: 83.9–100), and NPV of 62.5% (95% CI: 24.5–91.5).

Similarly, those with more advanced H&Y stages (3–4) showed the highest sensitivity at 94.1% (95% CI: 71.3–99.9), specificity of 100% (95% CI: 2.5–100), PPV of 100% (95% CI: 79.4–100), and NPV of 50.0% (95% CI: 1.3–98.7). TMSE performance also varied with LEDD. The best diagnostic accuracy was observed among patients receiving LEDD < 400 mg/day, with a

Table 5 TMSE Performance in Patient with Parkinson's Disease according to Thai-MoCA Score in Identifying MoCA-Defined MCI by Cutoff Point

Cutoff	Sensitivity % (95%CI)	Specificity % (95%CI)	PPV % (95%CI)	NPV % (95%CI)	Youden Index J
All patients					
< 24	23.5 (14.8-34.2)	100 (82.4-100)	100 (82.4-100)	23.5 (14.8-34.2)	0.235
< 25	39.5 (28.8-51)	100 (82.4-100)	100 (89.1-100)	27.9 (17.7-40.1)	0.395
< 26	53.1 (41.7-64.3)	100 (82.4-100)	100 (91.8-100)	33.3 (21.4-47.1)	0.531
< 27	61.7 (50.3-72.3)	100 (82.4-100)	100 (92.9-100)	38 (24.7-52.8)	0.617
< 28[a]	77.8 (67.2-86.3)	100 (82.4-100)	100 (94.3-100)	51.4 (34.4-68.1)	0.778
< 29	87.7 (78.5-93.9)	68.4 (43.4-87.4)	92.2 (83.8-97.1)	56.5 (34.5-76.8)	0.561
< 30	98.8 (93.3-100)	26.3 (9.2-51.2)	85.1 (76.3-91.6)	83.3 (35.9-99.6)	0.251
Patients with education level < grade 6					
< 24	37.8 (22.5-55.2)	100 (15.8-100)	100 (76.8-100)	8 (1-26)	0.378
< 25	56.8 (39.5-72.9)	100 (15.8-100)	100 (83.9-100)	11.1 (1.4-34.7)	0.568
< 26	67.6 (50.2-82)	100 (15.8-100)	100 (86.3-100)	14.3 (1.8-42.8)	0.676
< 27	70.3 (53-84.1)	100 (15.8-100)	100 (86.8-100)	15.4 (1.9-45.4)	0.703
< 28[a]	89.2 (74.6-97)	100 (15.8-100)	100 (89.4-100)	33.3 (4.3-77.7)	0.892
< 29	91.9 (78.1-98.3)	50.0 (1.3-98.7)	97.1 (85.1-99.9)	25 (0.6-80.6)	0.419
< 30	NA	NA	NA	NA	

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Table 5 TMSE Performance in Patient with Parkinson's Disease according to Thai-MoCA Score in Identifying MoCA-Defined MCI by Cutoff Point (cont.)

Cutoff	Sensitivity % (95%CI)	Specificity % (95%CI)	PPV % (95%CI)	NPV % (95%CI)	Youden Index J
Patients with education level > grade 6					
< 24	11.4 (3.8-24.6)	100 (80.5-100)	100 (47.8-100)	30.4 (18.8-44.1)	0.114
< 25	25 (13.2-40.3)	100 (80.5-100)	100 (71.5-100)	34 (21.2-48.8)	0.25
< 26	40.9 (26.3-56.8)	100 (80.5-100)	100 (81.5-100)	39.5 (25-55.6)	0.409
< 27	54.5 (38.8-69.6)	100 (80.5-100)	100 (85.8-100)	45.9 (29.5-63.1)	0.545
< 28[a]	68.2 (52.4-81.4)	100 (80.5-100)	100 (88.4-100)	54.8 (36-72.7)	0.682
< 29	84.1 (69.9-93.4)	70.6 (44-89.7)	88.1 (74.4-96)	63.2 (38.4-83.7)	0.547
< 30	97.7 (88-99.9)	29.4 (10.3-56)	78.2 (65-88.2)	83.3 (35.9-99.6)	0.271

Abbreviations: CI, confidence interval; NA, not applicable; NPV, negative predictive value; PPV, positive predictive value
[a] The best threshold value was determined using Youden Index (Youden Index J = Sensitivity + Specificity − 1)

Table 6 Subgroup Analysis of TMSE Diagnostic Performance for Identifying MoCA-Defined PD-MCI According to Patient Characteristics

TMSE < 28	n	Sensitivity % (95%CI)	Specificity % (95%CI)	PPV % (95%CI)	NPV % (95%CI)
All patients	100	77.8 (67.2-86.3)	100 (82.4-100)	100 (94.3-100)	51.4 (34.4-68.1)
Age (years)					
< 70	33	80 (56.3-94.3)	100 (75.3-100)	100 (79.4-100)	76.5 (50.1-93.2)
≥ 70	67	77 (64.5-86.8)	100 (54.1-100)	100 (92.5-100)	30 (11.9-54.3)
Education level					
> Grade 6	61	68.2 (52.4-81.4)	100 (80.5-100)	100 (88.4-100)	54.8 (36-72.7)
< Grade 6	39	89.2 (74.6-97)	100 (15.8-100)	100 (89.4-100)	33.3 (4.3-77.7)
Duration (years)					
≤ 5	71	73.7 (60.3-84.5)	100 (76.8-100)	100 (91.6-100)	48.3 (29.4-67.5)
> 5	29	87.5 (67.6-97.3)	100 (47.8-100)	100 (83.9-100)	62.5 (24.5-91.5)
H&Y scale					
1-2	72	73.4 (60.9-83.7)	100 (81.5-100)	100 (92.5-100)	51.4 (34-68.6)
3-4	18	94.1 (71.3-99.9)	100 (2.5-100)	100 (79.4-100)	50 (1.3-98.7)
Levodopa equivalent dose					
< 400	51	87.2 (72.6-95.7)	100 (73.5-100)	100 (89.7-100)	70.6 (44-89.7)
400-599	13	60 (26.2-87.8)	100 (29.2-100)	100 (54.1-100)	42.9 (9.9-81.6)
≥ 600	36	71.9 (53.3-86.3)	100 (39.8-100)	100 (85.2-100)	30.8 (9.1-61.4)

Abbreviations: CI, confidence interval; H&Y, Hoehn and Yahr; MoCA, Montreal cognitive assessment; n, number; NPV, negative predictive value; PD-MCI, Parkinson's disease mild cognitive impairment; PPV, positive predictive value; TMSE, Thai mental state examination

sensitivity of 87.2% (95% CI: 72.6–95.7), specificity of 100% (95% CI: 73.5–100), PPV of 100% (95% CI: 89.7–100), and NPV of 70.6% (95% CI: 44.0–89.7).

DISCUSSION

This study found the TMSE demonstrated poor performance compared with the Thai-MoCA in identifying MoCA-defined MCI among patients with PD. Only 19% of patients were classified as having MCI by the TMSE, whereas 81% were identified using the Thai-MoCA. This large discrepancy likely results from the TMSE's limited evaluation of executive and visuospatial functions, which are among the earliest domains affected in PD.[27] Consequently, patients may achieve inflated TMSE scores and be misclassified as cognitively normal during the early disease stages.

The high prevalence of PD-MCI (81%) observed in this study likely reflects the characteristics of the study population, which consisted of patients attending a tertiary movement disorders clinic and was enriched with individuals reporting cognitive complaints. This selection may increase the observed prevalence of cognitive impairment and influence the predictive values of the screening test. Therefore, this estimate should not be interpreted as representative of the broader PD population.

Cognitive test performance may also be influenced by demographic and clinical factors including age, sex, education level, disease duration, and disease severity. In addition, non-motor symptoms such as sleep disturbances, mood disorders, and depression may affect cognitive performance in patients with PD. These potential confounding factors were not adjusted for in the present analysis and should be considered when interpreting the findings.

Patients scored notably higher in the TMSE language domain (mean 9.41/10) than in the Thai-MoCA language domain (mean 5.33/8). This difference can be attributed to the Thai-MoCA's more demanding linguistic tasks, including verbal fluency, digit span, vigilance, and sentence repetition, which are more sensitive to subtle cognitive decline. Orientation and calculation performance were similar between the two tests despite differences in task complexity. In the memory domain, both tests produced comparable scores; however, the Thai-MoCA provided an additional Memory Index Score (MIS) that assesses recall with cueing. Most participants showed preserved recall when cues were provided (MIS ≥ 7 in 62% of patients), suggesting that their memory impairment was primarily due to retrieval rather than encoding deficits.[17,28] This pattern supports the hypothesis that Lewy body pathology in PD leads to widespread cortical dysfunction rather than focal hippocampal and entorhinal damage typically observed in Alzheimer's disease.[29,30]

Although both instruments showed a strong overall correlation (r = 0.86), domain-specific correlations—particularly in language and memory—were only moderate, likely due to differences in task structure and cognitive demands.

The optimal TMSE cutoff value for identifying MoCA-defined PD-MCI was identified as < 28, which significantly improved sensitivity while maintaining high specificity. This finding corroborates with previous evidence that the traditional TMSE cutoff of < 24 is too low to identify early cognitive impairment, particularly in PD. Subgroup analyses revealed that TMSE performance was superior among individuals with lower education levels, longer disease duration, and more advanced H&Y stages (3–4). In contrast, higher education and milder disease were associated with higher TMSE scores and lower sensitivity, suggesting that TMSE interpretation should account for educational background. Although specificity reached 100%, the number of patients classified as cognitively normal was relatively small, resulting in wide CIs; therefore, this finding should be interpreted cautiously. Moreover, these specific-subgroup findings should be interpreted cautiously because of the small sample sizes within each subgroup and should be considered exploratory.

This study has several limitations. First, most participants were Asian, relatively well educated, and in early PD stages, which may restrict the generalizability of our findings. Second, a comprehensive neuropsychological battery was not employed as the gold standard for MCI diagnosis; instead, the Thai-MoCA served as the reference measure. Third, the absence of a healthy control group limited comparative analysis. In addition, the TMSE and Thai-MoCA were administered during the same visit with a 15-minute interval. Although this approach minimized variability in clinical status, the short interval may have introduced potential carryover or learning effects between the two tests. However, because the TMSE and Thai-MoCA differ substantially in task structure and cognitive domains assessed, the magnitude of this effect is likely limited. Future studies may consider randomizing the order of test administration or increasing the interval between assessments to further reduce potential bias, include larger and more

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heterogeneous populations and use Level II MDS criteria to validate the diagnostic performance of TMSE.

MCI is a common and clinically significant non-motor feature of PD, often preceding dementia. Early detection allows timely counseling, personalized management, and potential interventions to delay cognitive decline. Therefore, routine cognitive screening should be integrated into comprehensive PD care. TMSE is widely used in Thailand due to its simplicity and short administration time, clinicians should be aware that the conventional cutoff may miss early cognitive impairment in PD. Adjusting the cutoff threshold may improve its usefulness as a preliminary screening tool in routine clinical practice.

CONCLUSION

The TMSE showed limited sensitivity in identifying MoCA-defined MCI among patients with PD compared with the Thai-MoCA. However, adjusting the TMSE cutoff to < 28 significantly improved its diagnostic accuracy while maintaining high specificity, and this proposed cutoff requires validation in independent populations before clinical adoption. Despite its simplicity, speed, and practicality, TMSE results should be interpreted cautiously—particularly in individuals with higher educational attainment or early-stage PD. Educational background should also be considered when interpreting TMSE scores. Routine cognitive screening using validated instruments is recommended to facilitate early detection and management of cognitive decline in PD.

Conflict of Interest

The authors have no financial interest related to the topic of this manuscript.

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Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to restrictions.

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