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Differential Validity of K-MoCA-22 Compared to K-MoCA-30 and K-MMSE for Screening MCI and Dementia

Haeyoon Kim [1], **Kyung-Ho Yu** [2], **Yeonwook Kang** [1]

[1]Department of Psychology, Hallym University, Chuncheon, Korea
[2]Department of Neurology, Hallym University Sacred Heart Hospital, Anyang, Korea

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Correspondence to
Yeonwook Kang
Department of Psychology, Hallym University, 1 Hallymdaehak-gil, Chuncheon 24252, Korea.
Email: ykang@hallym.ac.kr

ORCID iDs
Haeyoon Kim
https://orcid.org/0000-0002-1817-8654
Kyung-Ho Yu
https://orcid.org/0000-0002-8997-5626
Yeonwook Kang
https://orcid.org/0000-0003-4426-9127

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The authors have no potential conflicts of interest.

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ABSTRACT

Background and Purpose: Since the onset of the coronavirus disease 2019 pandemic, the Telephone-Montreal Cognitive Assessment (T-MoCA) has gained popularity as a remote cognitive screening tool. T-MoCA includes items from the original MoCA (MoCA-30), excluding those requiring visual stimuli, resulting in a maximum score of 22 points. This study aimed to assess whether the T-MoCA items (MoCA-22) demonstrate comparable discriminatory power to MoCA-30 and Mini-Mental State Examination (MMSE) in screening for mild cognitive impairment (MCI) and dementia.
Methods: Participants included 233 cognitively normal (CN) individuals, 175 with MCI, and 166 with dementia. All completed the Korean-MoCA-30 (K-MoCA-30) and Korean-MMSE (K-MMSE), with the Korean-MoCA-22 (K-MoCA-22) scores derived from the K-MoCA-30 responses. A receiver operating characteristic (ROC) curve analysis was conducted.
Results: K-MoCA-22 showed a strong correlation with K-MoCA-30 and a moderate correlation with K-MMSE. Scores decreased progressively from CN to MCI and dementia, with significant differences between groups, consistent with K-MoCA-30 and K-MMSE. The study also explored modified K-MoCA-22 index scores across 5 cognitive domains. ROC curve analysis revealed that the area under the curve (AUC) for K-MoCA-22 was significantly smaller than that for K-MoCA-30 in distinguishing both MCI and dementia from CN. However, no significant difference in AUC was found between K-MoCA-22 and K-MMSE, indicating similar discriminatory power. Additionally, the discriminability of K-MoCA-22 varied by education level.
Conclusions: These results indicate that K-MoCA-22, although slightly less effective than K-MoCA-30, still shows good to excellent discriminatory power and is comparable to K-MMSE in screening for MCI and dementia.

Keywords: MoCA-22; MoCA; MMSE; Differential Validity

INTRODUCTION

The Montreal Cognitive Assessment (MoCA),[1] which was originally developed to detect mild cognitive impairment (MCI), is the most widely used paper-and-pencil screening tool for cognitive impairment, alongside the Mini-Mental State Examination (MMSE).[2] The National Institute of Neurological Disorders and Stroke-Canadian Stroke Network consortium

recommends the MoCA over the MMSE for assessing vascular cognitive impairment due to its emphasis on frontal and executive functions.[3] Additionally, Julayanont et al.[4] have developed a method to derive 6 cognitive domain scores from MoCA items, enhancing its utility as a brief yet comprehensive assessment tool.[5] As a result, the MoCA is increasingly utilized across diverse clinical populations worldwide.

The MoCA-Blind version (MoCA-B or MoCA-22)[6] was developed specifically for visually impaired patients prior to the coronavirus disease 2019 (COVID-19) pandemic. This version excludes 4 subtests from the original MoCA that require motor responses or visual stimuli—namely, Alternating Trail Making, Cube Copying, Clock Drawing, and Naming—resulting in a maximum score of 22, compared to the original MoCA's maximum score of 30. Previous research studies indicate that the MoCA-22 effectively differentiates individuals with MCI from those with normal cognition, as well as distinguishing MCI from early-stage dementia.[6-9]

Since the onset of the COVID-19 pandemic, there has been a growing demand for remote cognitive testing,[10-12] leading to increased attention to the telephone version of the MoCA (T-MoCA).[13-15] The T-MoCA[16] utilizes the same items as the MoCA-22. However, it is administered remotely via telephone, while the MoCA-22 is conducted face-to-face. Previous research studies have demonstrated that the T-MoCA has adequate sensitivity and specificity for detecting MCI in patients with vascular cognitive impairment,[16,17] atrial fibrillation,[18] and community-dwelling older adults.[19,20] Even as the COVID-19 pandemic has largely subsided, T-MoCA is increasingly being used in epidemiological studies[21] and clinical trials[22-24] due to the convenience of remote testing.

Despite a growing interest in the T-MoCA in Korea, there is a lack of domestic studies examining its efficacy in Korean elderly populations and clinical groups. Therefore, the present study aimed to determine whether the MoCA-22, a paper-and-pencil version consisting of the same items, has similar discriminatory power to the full MoCA (K-MoCA-30) and K-MMSE before validating and implementing the T-MoCA in Korea. Given that previous studies have reported variability in discriminatory power of the MoCA based on education level,[25] we further investigated how the discriminatory power of the MoCA-22 varies by education. Additionally, we examined how the removal of certain items from the MoCA affects the discriminatory power of index scores across 6 cognitive domains in the MoCA-22.

METHODS

Participants

A total of 574 subjects were analyzed, consisting of 291 men and 283 women, with a mean age of 73.14±7.29 years and an average of 9.22±4.25 years of education. Participants were categorized into 3 groups: 233 individuals were considered cognitively normal (CN), 175 were diagnosed with MCI, and 166 with dementia.

The CN group was recruited through community outreach in accordance with Christensen's health screening criteria, with all participants scoring within the normal range on the K-MMSE. The MCI and dementia groups were selected from patients attending the Neurology Department of a university hospital. MCI patients were diagnosed based on modified Petersen's criteria,[26] including all subgroups: amnestic, non-amnestic, single-domain, and multiple-domain MCI. Dementia diagnoses were made based on the Diagnostic and

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Statistical Manual of Mental Disorders, 5th Edition.[27] Both MCI and dementia groups included patients with various conditions associated with cognitive impairment, including Alzheimer's disease, vascular disorders, and Parkinson's disease.

Participants in the MCI and dementia groups underwent a comprehensive evaluation, including a clinical interview by a neurologist, a neurological examination, brain imaging, and neuropsychological testing. Final diagnoses were established by a neurologist. The MCI group comprised individuals with a Clinical Dementia Rating (CDR)[28] score of 0 or 0.5, while the dementia group included those with a CDR score of 1.0 or 2.0.

Measures

The Korean-MoCA (K-MoCA)[29] and Korean-MMSE (K-MMSE)[30] were administered to all participants, with at least a 2-hour gap between these 2 tests. The order of administration was counterbalanced. Both tests have a maximum score of 30 points. Responses to the MoCA-22, which excluded 4 subtests (Alternating Trail Making, Cube Copying, Clock Drawing, and Naming) from the full MoCA, were extracted from K-MoCA (hereafter referred to as K-MoCA-30) responses, resulting in a K-MoCA-22 score with a maximum of 22 points. For MCI and dementia groups, a comprehensive neuropsychological assessment was administered using the Seoul Neuropsychological Screening Battery, 2nd edition.[31]

Statistical analysis

Analyses of variance (ANOVA) and Pearson's χ^2 test were used to assess differences in demographic variables (age, sex, and education level) and CDR across diagnostic groups. *Post hoc* comparisons were conducted using Bonferroni's test for significant ANOVA results. Correlation analyses were performed to examine relationships among the K-MoCA-22, K-MoCA-30, and K-MMSE. To assess differences in scores between diagnostic groups for each test, K-MoCA-22, K-MoCA-30, and K-MMSE scores were compared using analysis of covariance (ANCOVA) after controlling for age, sex, and education level as covariates. Additionally, multivariate ANCOVA (MANCOVA) was used to evaluate group differences in index scores across the 6 cognitive domains of the K-MoCA-30 and K-MoCA-22. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminability of each test, namely K-MoCA-22, K-MoCA-30, and K-MMSE. Area under the curve (AUC) was calculated while controlling for age and education level. The AUCs for K-MoCA-22, K-MoCA-30, and K-MMSE were compared using the method proposed by Hanley and McNeil.[32]

SPSS version 25.0 (IBM Corp., Armonk, NY, USA) was used for ANOVA, simple correlations, Pearson's χ^2 tests, and MANCOVA. ROC analysis was conducted using SAS software version 9.2 (SAS Institute Inc., Cary, NC, USA).

Ethics statement

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Hallym University Sacred Heart Hospital (HIRB-2019-03-011-001) and Hallym University (HIRB-2019-44).

RESULTS

The demographical characteristics and CDR scores of the participants are shown in **Table 1**. Sex and education level showed no significant differences between groups. However, group

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Table 1. Demographical characteristics, CDR-GS, and GDS-SB of participants (n=574)

Variables	CN[a] (n=233)	MCI[b] (n=175)	Dementia[c] (n=166)	*F* or χ^2	*Post hoc* (Bonferroni)
Age (yr)	71.79±7.18	73.08±6.58	75.94±7.28	22.09***	a < b < c
Sex (M/F)	116/117	92/83	83/83	χ^2=0.36	-
Education (yr)	9.59±4.17	9.07±4.17	8.85±4.44	1.64	-
<9	84	84	86		
≥9	149	91	80		
CDR-GS	-	0.49±0.65	1.00±0.10	3338.89***	b < c
CDR-SB	-	1.75±1.02	5.46±1.17	972.66***	b < c

CDR-GS: Clinical Dementia Rating-Global Score, CDR-SB: Clinical Dementia Rating-Sum of Boxes, CN: cognitively normal, MCI: mild cognitive impairment.
***p<0.001.

Table 2. Correlation coefficients (*r*) of K-MoCA-22 with K-MoCA-30 and K-MMSE for CN, MCI, and dementia

Groups	CN (n=233)	MCI (n=175)	Dementia (n=166)
K-MoCA-22 with K-MoCA-30	0.94	0.83	0.84
K-MoCA-22 with K-MMSE	0.48	0.52	0.59
K-MoCA-30 with K-MMSE	0.48	0.58	0.59

All correlations were significant at p<0.001.
K-MoCA-22: Blind version of Korean-Montreal Cognitive Assessment, K-MoCA-30: Korean-Montreal Cognitive Assessment, K-MMSE: Korean-Mini Mental State Examination, CN: cognitively normal, MCI: mild cognitive impairment.

differences were found for age (age order: dementia group > MCI group > CN group). When comparing differences in dementia severity, the dementia group had higher CDR-Global Score and CDR-Sum of Boxes scores than the MCI group.

Table 2 shows correlations of K-MoCA-22 with K-MoCA-30 and K-MMSE. In all 3 groups (dementia, MCI, and CN), K-MoCA-22 was very strongly correlated with K-MoCA-30 (CN: r=0.94, p<0.001, MCI: r=0.84, p<0.01, dementia: r=0.84, p<0.001) and significantly but moderately correlated with K-MMSE (CN: r=0.48, p<0.001, MCI: r=0.52, p<0.001, dementia: r=0.59, p<0.001).

Table 3 shows the scores by group for the K-MoCA-22, K-MoCA-30, and K-MMSE, respectively. ANCOVA controlling for age, sex, and education level revealed significant group differences in K-MoCA-22, K-MoCA-30, and K-MMSE scores (F=269.94, p<0.001). *Post hoc* analyses showed that the NC group scored higher than the MCI group, and the MCI group performed better than the dementia group on all 3 tests.

The K-MoCA-30 generates index scores for 6 cognitive domains. In contrast, the K-MoCA-22 excludes 4 subtests, preventing the calculation of a visuospatial index score (VIS). This exclusion alters the components of the language index score (LIS) and executive function index score (EIS), leading to different scores compared to those from the K-MoCA-30. As a result, a MANCOVA was conducted for the 5 index scores from the K-MoCA-22, which included orientation index score (OIS), attention index score (AIS), and memory index score (MIS) that corresponded to scores from the K-MoCA-30, along with the newly modified-language

Table 3. Group differences in K-MoCA-22, K-MoCA-30, and K-MMSE

Tests	CN[a] (n=233)	MCI[b] (n=175)	Dementia[c] (n=166)	*F*	*Post hoc*(Bonferroni)
K-MoCA-22	16.73±2.33	14.06±2.51	11.02±2.44	269.94***	a > b > c
K-MoCA-30	23.81±2.76	20.27±3.12	15.99±3.38	366.49***	a > b > c
K-MMSE	27.56±1.77	25.69±1.77	22.21±2.68	286.43***	a > b > c

K-MoCA-22: Blind version of Korean-Montreal Cognitive Assessment, K-MoCA-30: Korean-Montreal Cognitive Assessment, K-MMSE: Korean-Mini Mental State Examination, CN: cognitively normal, MCI: mild cognitive impairment.
***p<0.001.

Table 4. Group differences in index scores of K-MoCA-22

Index scores	CN[a] (n=233)	MCI[b] (n=175)	Dementia[c] (n=166)	*F*	*Post hoc* (Bonferroni)
OIS	5.84±0.42	5.47±0.74	3.89±1.32	230.31***	a > b >c
AIS	15.53±1.80	14.28±2.24	12.87±2.89	54.81***	a > b >c
m-LIS	2.33±0.75	2.18±0.71	1.97±0.76	6.78**	a = b > c
MIS	9.21±3.75	5.52±3.31	2.83±2.22	165.36***	a > b > c
m-EIS	7.21±1.28	6.00±1.69	5.30±1.93	69.73***	a > b > c

K-MoCA-22: Blind version of Korean-Montreal Cognitive Assessment, CN: cognitively normal, MCI: mild cognitive impairment, OIS: orientation index score, AIS: attention index score, m-LIS: modified language index score, MIS: memory index score, m-EIS: modified executive function index score.
**p<0.01; ***p<0.001.

index score (m-LIS) and modified-executive function index score (m-EIS) from the K-MoCA-22 (λ=0.35, F=79.04, p<0.001, partial η^2=0.41). Univariate tests yielded the following results: OIS (F=230.31, p<0.001, partial η^2=0.45), AIS (F=54.81, p<0.001, partial η^2=0.16), m-LIS (F=6.78, p=0.001, partial η^2=0.02), MIS (F=165.36, p<0.001, partial η^2=0.37), and m-EIS (F=69.73, p<0.001, partial η^2=0.20; **Table 4**). Significant between-group differences were found for all index scores except m-LIS, with scores decreasing in the order of CN, MCI, and dementia. For m-LIS, the dementia group score was lower than those of both CN and MCI, with no significant difference between CN and MCI. The LIS (F=25.84, p<0.001, partial η^2=0.08) and EIS (F=105.59, p<0.001, partial η^2=0.27) derived from the K-MoCA-30 showed group differences that were comparable to those seen in the m-LIS and m-EIS calculated from the K-MoCA-22.

The ROC curve analysis (**Table 5**) demonstrated that the K-MoCA-22 exhibited good discriminatory power for distinguishing between CN and MCI (AUC=0.86) and excellent power for distinguishing between CN and dementia (AUC=0.99). However, The AUCs for K-MoCA-22 were significantly smaller than those for K-MoCA-30 in both comparisons: CN vs. MCI (0.86 vs. 0.89; χ^2=9.22, p=0.002) and CN vs. dementia (0.99 vs. 1.00; χ^2=6.09, p=0.01), whereas no significant differences in AUC values were observed for distinguishing between MCI and dementia. Additionally, the ROC analysis indicated that there were no significant differences in AUC values between K-MoCA-22 and K-MMSE for discriminating between MCI and CN, between CN and dementia, and between MCI and dementia.

To examine the impact of education on the discriminatory power of K-MoCA-22, we divided each diagnostic group (CN, MCI, and dementia) into 2 subgroups based on 9 years of compulsory education in Korea: those with less than 9 years and those with 9 years or more.

Table 5. Discriminability of K-MoCA-22, K-MoCA-30, and K-MMSE

Group comparisons	K-MoCA-22			K-MoCA-30			K-MMSE			K-MoCA-22 vs. K-MoCA-30		K-MoCA-22 vs. K-MMSE	
	AUC	95% CI		AUC	95% CI		AUC	95% CI		χ^2	p	χ^2	p
		LL	UL		LL	UL		LL	UL				
Total													
CN vs. MCI	0.86	0.82	0.89	0.89	0.85	0.92	0.83	0.80	0.87	9.22	0.002	1.73	0.19
CN vs. Dementia	0.99	0.98	1.00	1.00	0.99	1.00	0.99	0.98	1.00	6.09	0.01	0.74	0.39
MCI vs. Dementia	0.89	0.85	0.92	0.90	0.87	0.93	0.92	0.89	0.95	1.57	0.21	2.99	0.08
< 9 yr of education													
CN vs. MCI	0.87	0.82	0.92	0.93	0.89	0.96	0.86	0.80	0.92	11.20	0.001	0.13	0.71
CN vs. Dementia	1.00	0.99	1.00	1.00	1.00	1.00	0.99	0.97	1.00	1.45	0.23	2.56	0.11
MCI vs. Dementia	0.92	0.88	0.96	0.92	0.88	0.96	0.95	0.92	0.98	0.11	0.74	1.98	0.16
≥ 9 yr of education													
CN vs. MCI	0.90	0.86	0.94	0.90	0.86	0.94	0.86	0.82	0.91	0.01	0.91	2.76	0.10
CN vs. Dementia	0.99	0.98	1.00	1.00	0.99	1.00	1.00	0.99	1.00	2.96	0.09	1.07	0.30
MCI vs. Dementia	0.91	0.87	0.95	0.94	0.90	0.97	0.91	0.87	0.96	3.95	0.047	0.001	0.98

K-MoCA-22: Blind version of Korean-Montreal Cognitive Assessment, K-MoCA-30: Korean-Montreal Cognitive Assessment, K-MMSE: Korean-Mini Mental State Examination, AUC: area under the curve, CI: confidence interval, LL: lower limit, UL: upper limit, CN: cognitively normal, MCI: mild cognitive impairment.

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We then conducted ROC analysis for K-MoCA-22, K-MoCA-30, and K-MMSE separately for each subgroup within each diagnostic group. In both subgroups, K-MoCA-22 demonstrated good to excellent discrimination between CN and MCI, CN and dementia, and MCI and dementia (AUC: 0.87–1.00). However, in the subgroup with less than 9 years of education, K-MoCA-22 showed inferior performance compared to K-MoCA-30 in discriminating between CN and MCI (0.87 vs. 0.93; χ^2=11.20, p=0.001). In the subgroup with 9 or more years of education, K-MoCA-22 also tended to perform less effectively in discriminating between MCI and dementia than K-MoCA-30 (0.91 vs. 0.94; χ^2=3.95, p=0.046). In contrast, K-MoCA-22 did not show any difference in discriminatory power compared to K-MMSE across subgroups based on education.

DISCUSSION

This study aimed to validate the discriminatory power of the MoCA-22 in Korean older adults with normal cognition, MCI, and dementia. It also compared the effectiveness of the MoCA-22 to that of the original MoCA and MMSE. In normal elderly, MCI, and dementia groups, K-MoCA-22 demonstrated a very strong correlation with K-MoCA-30, suggesting that it can effectively screen for overall cognitive function and assess cognitive abilities very similarly to K-MoCA-30, despite excluding items that require visual stimuli and motor responses. In contrast, K-MoCA-22 showed a moderate correlation with K-MMSE (r=0.48 to 0.59), which was lower than the correlation observed with K-MoCA-30. This difference is likely due to different items between MoCA and MMSE. While both have a maximum score of 30, the MoCA assesses a broader range of cognitive functions and includes more items related to executive functions than the MMSE.[2,3,33]

The K-MoCA-22 showed significant score differences between CN, MCI, and dementia groups, similar to those observed with the K-MoCA-30 and K-MMSE. Furthermore, the newly derived m-LIS and m-EIS from the K-MoCA-22 yielded results consistent with the original LIS and EIS from the K-MoCA-30 regarding group differences in scores. These findings suggest that the 5 cognitive index scores derived from K-MoCA-22 can provide information equivalent to corresponding index scores from K-MoCA-30, although the VIS could not be calculated due to exclusion of certain subtests.

The ROC analysis results indicated that K-MoCA-22 effectively distinguished between CN and MCI as well as between CN and dementia, consistent with previous studies.[7-9] However, K-MoCA-22 had lower discriminatory power than K-MoCA-30 in differentiating MCI and dementia from CN. Notably, K-MoCA-22 and K-MMSE did not show any significant differences in discriminatory ability. This suggests that while K-MoCA-22 has comparable discriminatory power to K-MMSE for distinguishing CN from MCI and dementia, its discriminatory ability is significantly reduced compared to K-MoCA-30 due to exclusion of certain items related to visuospatial construction, executive function, and naming ability.

When divided by education level, K-MoCA-30 showed a higher discriminatory power than K-MoCA-22 in differentiating between CN and MCI in individuals with less than 9 years of education. In contrast, for those with 9 years of education or more, K-MoCA-30 outperformed K-MoCA-22 in distinguishing between MCI and dementia. A previous study has indicated that lower education levels are linked to more rapid decreases in verbal abilities, particularly naming, and non-verbal abilities such as copying and drawing in MCI

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populations.[34] These findings indicate that K-MoCA-22, which omits tasks such as Cube Copying, Clock Drawing, and Naming, has significantly lower discriminatory power than K-MoCA-30 in those with less than 9 years of education.

In the group with 9 years or more of education, K-MoCA-22 and K-MoCA-30 showed no significant difference in their discriminatory power for differentiating between CN and MCI, consistent with findings of Katz et al.,[19] but different from results for the group with less than 9 years of education. For individuals with higher education, the difficulty of MoCA items is relatively low, suggesting that omitting specific items in K-MoCA-22 likely has no significant impact on its performance at the MCI level compared to K-MoCA-30. However, K-MoCA-22 demonstrates significantly lower discriminatory power than K-MoCA-30 in distinguishing between MCI and dementia. This may be attributed to omission of relatively difficult items in K-MoCA-22 at the dementia level, resulting in fewer detected cognitive deficits compared to K-MoCA-30, which includes all items.

This study compared the discriminability of K-MoCA-22 in differentiating normal elderly individuals from patients with MCI and dementia against K-MoCA-30 and K-MMSE to confirm the differential validity of K-MoCA-22. The results indicated that while both K-MoCA-22 and K-MoCA-30 exhibited a high level of discriminatory ability, K-MoCA-22 showed a slightly lower discriminatory power compared to K-MoCA-30 in differentiating between specific groups, with variations in performance based on education level. Nevertheless, K-MoCA-22 still showed sufficient discriminatory power comparable to that of K-MMSE.

Although MoCA-22 was initially designed for visually impaired individuals, findings of this study suggest its potential as a reliable cognitive screening test for patients with stroke or motor neuron disease who may struggle with motor skills. Additionally, MoCA-22 can effectively provide specific information about various cognitive domains through cognitive domain index scores.

A significant aspect of this study is that, unlike previous research that focused only on the discriminatory ability of MoCA-22 or T-MoCA, it not only examined the discriminatory power of MoCA-22 in Korea for the first time, but also compared its discriminatory power with those of the full MoCA (K-MoCA-30) and K-MMSE. Furthermore, this study highlighted how the discriminatory ability of K-MoCA-22 varied with education level and examined the potential utility of its index scores for 5 cognitive domains.

This study included patients with cognitive impairment due to various conditions, including Alzheimer's disease, vascular disorders, and Parkinson’s disease. While we believe that our findings provide valuable insights applicable to diverse patient populations, further investigation into each specific condition is needed to enhance our understanding.

Since MoCA-22 shares the same items as T-MoCA, the results of this study can be directly applied to T-MoCA. However, it is questionable whether telephone cognitive tests can provide accurate information similar to that obtained from in-person assessments, especially for Korean elderly individuals who may lack familiarity with phone-based testing formats. Building on this study, it is crucial to conduct an equivalence study between MoCA-22 and T-MoCA. If the equivalence is proven, T-MoCA could be utilized as a reliable and discriminative remote cognitive test, serving as a viable alternative to in-person evaluations for screening and managing dementia patients in the community.

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