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The Montreal Cognitive Assessment (MoCA): Creating a Crosswalk with the Mini-Mental State Examination

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Abstract

Background/Objectives—The Mini Mental State Examination (MMSE) has been the most widely used cognitive screening instrument for more than three decades. However, the MMSE is no longer freely available, potentially creating a barrier for its routine use. The Montreal Cognitive Assessment (MoCA) is a relatively new cognitive screening instrument that is gaining popularity. Although a cut-point for impairment exists, MoCA scores that correspond to well-established cut-points on the Mini-Mental State Examination (MMSE) have not been established. We created a crosswalk linking individual scores on the MoCA to the MMSE.

Design, Setting, Participants and Measurements—We enrolled 199 patients aged 75 years old admitted to the general medical service of a large teaching hospital. The MoCA (range 0–30) and the MMSE (range 0–30) were administered within 2 hours of each other. The Abbreviated MoCA (A-MoCA; range 0–22), was calculated from the full MoCA. Scores from the three tests were analyzed using equipercentile equating, a statistical method for determining comparable scores on different tests of a similar construct by estimating percentile equivalents.

Results—Participants had a mean age of 84 years, and 63% were female. Scores on the MoCA were lower (mean = 19, standard deviation = 5.8) than the MMSE (mean = 24, standard deviation = 6.6). Traditional MMSE cut-points of 27 for MCI and 23 for dementia corresponded to MoCA scores of 23 and 17, respectively.

Conclusion—Scores on the full and abbreviated versions of the MoCA can be linked directly to the MMSE. The MoCA may be more sensitive to changes in cognitive performance at higher levels of functioning.

Expert Testimony	X	X	X	X	X	X	X	X	X
Board Member	X	X	X	X	X	X	X	X	X
Patents	X	X	X	X	X	X	X	X	X
Personal Relationship	X	X	X	X	X	X	X	X	X
Keywords:									
Elements of Financial/Personal Conflicts	Author 5 Tamara G. Fong		Author 6 Emese Nemeth		Author 7 Ariel Hodara		Author 8 Long Ngo		
Cognition; Screening; Measurement	Yes	No	Yes	No	Yes	No	Yes	No	No
Employment or Affiliation	X		X		X		X		X
Grants/Funds	X		X		X		X		X
Honoraria	X		X		X		X		X
Speaker Forum	X		X		X		X		X
Consultant	X		X		X		X		X
Stocks	X		X		X		X		X
Royalties	X		X		X		X		X
Expert Testimony	X		X		X		X		X
Board Member	X		X		X		X		X
Patents	X		X		X		X		X
Personal Relationship	X		X		X		X		X
Elements of Financial/Personal Conflicts	Author 9 Edward R. Marcantonio								
	Yes	No							
Employment or Affiliation	X								
Grants/Funds	X								
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Board Member	X								
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INTRODUCTION

With increasing evidence from clinical and epidemiologic studies for an association between cognitive status and clinical, functional and quality of life outcomes, screening instruments for assessment of cognitive function have proliferated. The most widely used global cognitive screening instrument is the Mini Mental State Examination (MMSE).¹ However, the MMSE is now under copyright restrictions and is no longer freely available, potentially limiting routine use of the MMSE in clinical and research settings. In addition, the MMSE is limited in its ability to detect Mild Cognitive Impairment (MCI) and is not well validated for telephone administration. The Montreal Cognitive Assessment Battery (MoCA),² was developed for assessment of MCI and includes expanded assessments of visuospatial and executive function. The MoCA has excellent sensitivity for MCI (90%) and mild Alzheimer's disease (100%) compared to a clinical evaluation in a memory clinic.² Recently, a telephone version of the MoCA has been validated, expanding the settings and circumstances in which patients can be evaluated.³

Prior studies have compared the sensitivity and specificity of the MoCA and MMSE in detecting MCI and dementia.^{4–11} However, a direct linkage of scores and cut-points on the two measures does not exist. The MMSE, along with its well-established cut-points for impairment, has been used by frontline physicians and researchers for decades and a direct linkage of scores on the MoCA to the MMSE would help clinicians and researchers better understand patient scores on the increasingly popular MoCA. We directly linked scores on the MMSE and MoCA in a sample of 199 inpatients, providing a crosswalk for scores on the full and abbreviated (using the items included in the telephone version) versions of the MoCA to corresponding scores on the MMSE.

METHODS

Study Population

Participants 75 year olds admitted to general medicine services were enrolled from a teaching hospital in Boston, Massachusetts and have been previously described.¹² The study protocol and informed consent procedures were approved by the Institutional Review Board.

Participant Interviews

Eligible and consenting participants were interviewed in-person by trained study staff during their hospitalization. This interview included both the MoCA and the MMSE (administered within 2 hours of each other) in addition to assessments of depressive symptoms (Geriatric Depression Scale¹³), functional status (Activities of Daily Living, ADL and Instrumental Activities of Daily Living, IADL),^{14, 15} vision and hearing impairment, and demographics (age, sex, education, race).

Mini-Mental State Examination (MMSE)

The MMSE is a well-validated and widely used assessment of global cognitive function.¹ The MMSE takes approximately 10–15 minutes to administer and has a maximum score of

30 points, with lower scores representing poorer performance. The MMSE includes items assessing orientation, memory, attention (assessed uniformly in this study as spelling WORLD backwards), language, and visuospatial abilities.

Montreal Cognitive Assessment (MoCA)

The MoCA is a screening test assessing global cognitive function that assesses memory, visuospatial ability, executive function, attention, concentration, working memory and orientation.² The MoCA takes approximately 20 minutes to administer and has a maximum score of 30, with lower scores representing poorer performance. The abbreviated MoCA (A-MoCA) includes a subset (those able to be administered verbally) of the items from the full test, and takes approximately 10 minutes to administer and has been validated as a telephone version of the MoCA.³ (Appendix Table 1) The A-MoCA was calculated from the full MoCA. The total MoCA score also accounts for level of education, with a point added for high school education or less. The education-adjusted MoCA scores were used for all analyses.

Diagnosis of Dementia and Delirium

Diagnosis of delirium was adjudicated by a study panel using criteria from the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition.¹⁶ The panel decision was based on information from an extensive face to face interview, medical record review, and input from the patient's nurse and family members. The panel also adjudicated the absence or presence of dementia or Mild Cognitive Impairment (MCI) using the National Institute on Aging and Alzheimer's Association criteria.^{17, 18}

Statistical Analysis

Direct comparison of scores between the MMSE and the MoCA and the A-MoCA were performed using an equipercentile equating method which allows for a direct crosswalk, or comparison, from a score on one test to a score on a different test based on percentile rankings.^{19, 20} All analyses were conducted using SAS Version 9.3 (SAS Institute, Cary, NC), R v3.0.2, the equate (v1.2.0) and ggplot2 (v0.9.3.1) packages.^{21–23}

RESULTS

A total of 201 patients were enrolled and of these, 199 were administered both the MMSE and the MoCA and comprise the sample. Patients were 84 years on average (SD=5), 63% were female and 88% were white. (Table 1)

Scores on the MMSE were higher, in general, than scores on the MoCA. The average score on the MMSE was 24 (SD=6, observed range =2–30), on the MoCA was 19 (SD=7; observed range =0–30) and on the A-MoCA was 14 (SD=5; observed range =0–22). (Table 1) Mean scores on the MMSE and MoCA are presented by cognitive (dementia) and delirium status in Appendix Table 1. Expectedly, scores on both tests are lower in patients with dementia and/or delirium.

There was a high correlation between the MMSE and the MoCA ($r=.84$, 95% CI =.80–.88) and the A-MoCA ($r=.82$, 95% CI =.77–.86). Clinically relevant cut-points on the MMSE and corresponding scores, based on percentile rankings, on the MoCA and A-MoCA are presented in Table 2. As expected, scores in the same percentile ranking were lower on the MoCA compared to the MMSE. For example, 70% of the sample had a score below 27 on the MMSE and the corresponding cut-point (i.e., the score under which approximately 70% of the sample fell) on the MoCA was 23 and on the A-MoCA was 17. Figure 1 presents a more detailed crosswalk for each score on the MMSE to corresponding scores on the MoCA and A-MoCA.

The MoCA was less limited by ceiling effects than the MMSE. Nine percent of patients achieved the maximum score on the MMSE while only 0.5% had a perfect score on the in-person MoCA. In addition, the full and abbreviated versions of the MoCA had more precision at higher levels of performance compared to the MMSE. For instance, in-person MoCA scores ranged from 27–30 among patients who scored a 30 on the MMSE. (Figure 1) The crosswalk estimates were less stable at the lower end of scores, likely due in part to few patients scoring 10 on the MMSE.

In sensitivity analyses we examined the stability of scores on the crosswalk when patients with delirium ($n=40$) were excluded. (data not shown) Cross walk scores for patients scoring 10 and higher were stable. There were very few participants without delirium who had low score. For instance, there were no patients without delirium with an MMSE score <8 . Therefore, the scores at the lower end of the scale (≤ 10) were unstable when patients with delirium were excluded.

DISCUSSION

We created a crosswalk between scores on the MMSE to the full and abbreviated versions of the MoCA. Average scores on the MoCA were lower than those on the MMSE. Well established cut-points on the MMSE of 27, 23 and 17 (out of 30) corresponded to cut-points of 23, 17 and 9 (out of 30), respectively, on the in-person version of the MoCA.

The MMSE is the most widely used cognitive screening instrument with established cut-points for impairment that are well known to many clinicians and healthcare providers. The MoCA, a relatively new instrument, is becoming widely used due to its sensitivity to MCI, lesser ceiling effects and availability in the public domain. However, many clinicians were trained on the MMSE and its scores and cutpoints are well understood. Scores on the relatively new MoCA have not been linked to functional outcomes and clinical diagnoses as well as have scores on the MMSE. In addition, lack of familiarity with the clinical meaning of a specific MoCA score makes its use MoCA more challenging. The ability to link scores from the MoCA to the MMSE is important to help interpret patients' performance and facilitate use of this newer instrument. A number of studies have examined the psychometric properties (e.g., sensitivity and specificity) of the MoCA compared to the MMSE for the diagnosis of dementia and MCI.^{4–11} We extend the existing literature by providing a crosswalk linking each score on the full and abbreviated versions of the MoCA to the

MMSE and also provide cut-points that correspond to clinically relevant cut-points on the MMSE.

Telephone versions of cognitive screening batteries are important to enable a combination of in-person and telephone screening. Indeed, with increasing attention to transitions in care, post-hospital syndrome²⁴ and reversible cognitive dysfunction during acute illness,²⁵ hybrid approaches to cognitive screening that include in-person and telephone assessments have assumed heightened importance. Although two telephone versions of the MMSE exist,^{26, 27} validation has concentrated on impaired populations and one of the telephone adaptations²⁶ added additional items limiting its comparability. The telephone version of the MoCA allows for a combination of in-person and telephone screening without adding additional items and is available publicly. Our crosswalk data can also be used to link scores on the full and abbreviated versions of the MoCA.

Our study is strengthened by the rigorous assessment of cognitive function that included multiple cognitive screening instruments administered within 2 hours of one another in a sample that includes a range of comorbidity and cognitive function. We use state-of-the-art analytic techniques to provide a crosswalk of scores on the MoCA to the MMSE and examined both the full and abbreviated versions of the MoCA.

The results of this study should be interpreted with several limitations in mind. We created the abbreviated version of the MoCA by using a subset of the items from an in-person administration, not by telephone administration. The MMSE was always administered after the MMSE, which could have led to practice effects. However, it is established that the MoCA is a more difficult test than the MMSE,^{5, 7, 10} thus differences in scores are unlikely to be entirely due to practice effects. Our sample was enrolled from a general medicine population from a single hospital, potentially limiting the generalizability of the findings. The Telephone version of the MoCA has been validated in stroke and TIA patients and thus further validation in general medical and community dwelling older persons is necessary. Both the MoCA and MMSE lack linear performance characteristics with a 1-point change at the lower and upper ends of the scales not representing the same degree of difference in performance. Since the MoCA is a relatively new test, more work needs to be done to establish the linear measurement properties of the test.²⁸ In addition, assessing cognitive function in the hospital may not be reflective of a patient's baseline, as scores may be depressed by acute illness or delirium; however, performance on both the MMSE and the MoCA would have been impacted. Nonetheless, our results should be replicated in an out-patient setting and, ideally, the MoCA should be administered along with the MMSE in a large-scale study so population based norms for the MoCA can be developed.

CONCLUSION

We provide a crosswalk of scores on the MMSE to corresponding scores on the MoCA. Our results will facilitate easier interpretation of MoCA scores and comparison across studies using these two brief global cognitive instruments. With increasing attention to the importance of cognitive assessment in both in- and out-patient settings,^{24, 29} the ability to

compare scores across instruments is crucial and will facilitate clinical and research efforts to improve the care and outcomes of older patients.

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Figure 1.

Crosswalk of corresponding scores of the full and abbreviated versions of the MoCA with the MMSE. (N=199)

Note. MoCA = Montreal Cognitive Assessment; MMSE = Mini Mental State Exam

Figure 2 illustrates the crosswalk for scores on the full MoCA and the abbreviated version of the MoCA (A-MoCA) to those on the MMSE. The crosswalk was derived with equipercentile equating methods using scores on the MoCA and the MMSE from 199 hospitalized older patients. The middle of the crosswalk shows the range of scores from 0–30 in the MMSE. The left side of the crosswalk shows the range of scores on the in-person version of the MoCA (0–30) that correspond with the respective MMSE scores. The right side of the crosswalk shows the range of scores on the abbreviated version of the MoCA (A-

MoCA, 0–22) that correspond with the respective MMSE scores. For example, the lines that radiate from a score of 27–30 on the MoCA correspond with score of 30 on the MMSE.

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Table 1

Sample Characteristics (N=199)

Characteristic	
Age, mean (SD)	84 (5)
Sex, N(%) female	125 (63)
Race, N(%) White	175 (88)
Education, years N(%)	
< High School	20 (10)
High School Graduate	75 (38)
Some College or higher	98 (49)
Vision limitations	5 (2)
Hearing limitation	18 (9)
English second language	10 (5)
Charlson comorbidity, mean (SD)	3 (2.3)
ADL Impairment, N(%)	110 (55)
IADL Impairment, N(%)	161 (81)
Cognitive Tests	
MMSE, mean (SD)	24 (5.8)
MMSE, median (range)	26 (2–30)
MoCA, mean (SD)	19 (6.6)
MoCA, median (range)	20 (0–30)
Abbreviated MoCA, mean (SD)	14 (5.1)
Abbreviated MoCA, median (range)	15 (0–22)

Note. Education status was missing on six participants (3%)

SD = standard deviation; ADL – Activities of Daily Living¹⁴; IADL = Instrument Activities of Daily Living¹⁵; MMSE = Mini Mental State Exam¹, MoCA = Montreal Cognitive, Assessment². MMSE range = 0–30; MoCA range = 0–30; Abbreviated MoCA³ range = 0–22

Table 2
Cut Points and Cumulative Distribution of MMSE and Corresponding MoCA and Abbreviated-MoCA Scores.

Cognitive Status	MMSE Range: 0–30		MoCA Range: 0–30		Abbreviated MoCA Range 0–22	
	Score	Cumulative Percent	Score	Cumulative Percent	Score	Cumulative Percent
Normal	30	100%	30	100%	22	100%
MCI	27	70.8%	23	70.4%	17	70.8%
Mild Dementia	23	32.2%	17	33.2%	12	29.6%
Moderate Dementia	17	9.6%	9	8.5%	6	9.0%

Note. MoCA = Montreal Cognitive Assessment Battery; MMSE = Mini Mental State Examination; MCI = Mild Cognitive Impairment

Appendix Table 1

Mean and median MoCA and MMSE scores by cognitive and delirium status. N=199

	MoCA Mean (SD)	MMSE Mean (SD)
Normal/MCI (N=145)	21.6 (5.0)	25.9 (3.9)
No Delirium (N=131)	23 (6.0)	27 (3.5)
Delirium (N=14)	15.5 (5.3)	21 (5.3)
Dementia (N=54)	13.2 (6.3)	19.4 (7.1)
No Delirium (N=28)	17 (4.3)	24 (3.8)
Delirium (N=26)	9.5 (8.0)	16 (10.5)
No Delirium (N=159)	21.6 (4.4)	26.0 (3.0)
Delirium (N=40)	10.4 (5.9)	16.6 (7.7)

Note. MMSE = Mini Mental State Examination; MoCA = Montreal Cognitive Assessment