

**ORIGINAL ARTICLE**

# Validation of the Conversion between the Mini-Mental State Examination and Montreal Cognitive assessment in Korean Patients with Parkinson's Disease

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**ABSTRACT**

**Objective** Two conversion tables between the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) have recently been established for Parkinson's disease (PD). This study aimed to validate them in Korean patients with PD and to evaluate whether they could be influenced by educational level.

**Methods** A total of 391 patients with PD who undertook both the Korean MMSE and the Korean MoCA during the same session were retrospectively assessed. The mean, median, and root mean squared error (RMSE) of the difference between the true and converted MMSE scores and the intraclass correlation coefficient (ICC) were calculated according to educational level (6 or fewer years, 7–12 years, or 13 or more years).

**Results** Both conversions had a median value of 0, with a small mean and RMSE of differences, and a high correlation between the true and converted MMSE scores. In the classification according to educational level, all groups had roughly similar values of the median, mean, RMSE, and ICC both within and between the conversions.

**Conclusion** Our findings suggest that both MMSE-MoCA conversion tables are useful instruments for transforming MoCA scores into converted MMSE scores in Korean patients with PD, regardless of educational level. These will greatly enhance the utility of the existing cognitive data from the Korean PD population in clinical and research settings.

**Key Words** Parkinson disease; Mini-Mental State Examination; Montreal Cognitive Assessment; conversion.

Cognitive dysfunction is one of the most common non-motor symptom in Parkinson's disease (PD).<sup>1</sup> It occurs in 20–57% of patients with PD within the first 3–5 years after diagnosis, and approximately 80% of those develop dementia in the advanced stage.<sup>2</sup> Cognitive deficits in PD is associated with functional impairment and poor quality of life, and thus, it is important to recognize the symptoms for optimal management.<sup>3</sup>

The Mini-Mental State Examination (MMSE) and Montreal

Cognitive Assessment (MoCA) are widely used to assess global cognitive function in patients with PD.<sup>4</sup> Despite the remarkable development in imaging technologies and biomarkers, both cognitive screening tests still play an important role in detecting dementia in PD. Recently, two MMSE-MoCA conversion tables, in which MoCA scores adjusted for education were transformed into the equivalent MMSE scores, have been established with reasonably good validity in patients with PD

Received: June 19, 2017 Revised: August 9, 2017 Accepted: August 28, 2017

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(Table 1).<sup>5-7</sup> These will facilitate not only the continuity of cognitive tracking in clinical settings but also the comparison and integration of cognitive data from heterogeneous longitudinal studies. However, the MMSE-MoCA conversion tables have not been validated in Korean patients with PD. This is essential for their use because the MMSE and MoCA can be affected by differences in culture and language.<sup>8</sup> Furthermore, most of the published data for the MMSE or MoCA in patients with PD were obtained from highly educated subjects; however, many Korean PD patients have a low level of education.<sup>9</sup> Thus, the current study aimed to validate the two MMSE-MoCA conversion tables in Korean patients with PD. Additionally, we further assessed whether they could be influenced by the level of education.

**Table 1.** Conversion from MoCA to MMSE

Adjusted MoCA score	Equivalent MMSE score by van Steenoven et al. <sup>5</sup>	Equivalent MMSE score by Lawton et al. <sup>6</sup>
1	6*	1*
2	9*	2*
3	11*	4*
4	12*	10*
5	13*	13*
6	14*	14*
7	15*	15*
8	15*	16
9	16*	17
10	17	18
11	18	18
12	18	19
13	19	20
14	20	20
15	21	21
16	22	22
17	22	22
18	23	23
19	24	24
20	25	24
21	26	25
22	26	26
23	27	26
24	28	27
25	28	28
26	29	28
27	29	29
28	30	29
29	30	30
30	30	30

MoCA scores were adjusted by adding 1 point in patients with 6 or fewer years of education. \*Scores were derived from extrapolated data. MoCA: Montreal Cognitive Assessment, MMSE: Mini-Mental State Examination.

## MATERIALS & METHODS

### Participants

We retrospectively reviewed the medical records of patients with PD who visited Seoul National University Hospital from Jan 2014 to Dec 2016. We included patients who undertook both the Korean MMSE (K-MMSE) and the Korean MoCA (MoCA-K) in the same session. The patients who had received deep brain stimulation or were illiterate were excluded because these factors could influence the results. The study protocol was approved by the Seoul National University Hospital Institutional Review Board (IRB No. 1705-111-855) and conformed to the principles of the Declaration of Helsinki.

### Neuropsychological assessment

The K-MMSE and MoCA-K are brief, multidomain cognitive screening tests with a score range of 0–30. The K-MMSE consists of items such as orientation (time and place), memory (immediate and delayed verbal recall of three words), attention and calculation (a serial subtraction task), naming (pencil, watch) and language (sentence repetition, following a written instruction, following a three-step command, and sentence writing), and drawing (two intersecting pentagons copy). The MoCA-K includes items on visuospatial/executive function (alternating Trail-Making, cube copy, and clock-drawing task), naming (lion, rhinoceros, and camel) and language (sentence repetition and verbal fluency) memory (immediate and delayed verbal recall of five words), attention (forward and backward digit span, target detection using tapping, and a serial subtraction task), abstraction, and orientation (time and place). The MoCA-K scores were adjusted by adding 1 point in patients with 6 or fewer years of education (maximum of 30).<sup>10</sup>

### Statistical analysis

We validated the MMSE-MoCA conversion tables using the same method described by Lawton et al.<sup>6</sup> The mean, standard deviation, median, interquartile range (IQR), and root mean squared error (RMSE) were calculated using the difference between the true and equivalent MMSE scores. Smaller absolute values of the mean, median, and RMSE indicate a more accurate conversion from MoCA to MMSE. Furthermore, we evaluated the intraclass

**Table 2.** Demographic data of study subjects

Variables	Educational level			Total (n = 391)
	≤ 6 years (n = 127)	7–12 years (n = 156)	≥ 13 years (n = 108)	
Age, year	68.8 ± 5.4	66.5 ± 6.2	66.6 ± 7.4	67.3 ± 8.1
Sex (M:F)	32:95	76:80	70:38	178:213
Disease duration, year	10.2 ± 5.6	8.1 ± 4.2	7.3 ± 4.4	8.3 ± 5.4
K-MMSE score (range)	24.7 ± 2.7 (11–30)	26.4 ± 2.5 (12–30)	27.7 ± 1.6 (20–30)	26.2 ± 3.4 (11–30)
MoCA-K adjusted score (range)	20.3 ± 4.0 (5–29)	22.2 ± 4.0 (5–30)	25.2 ± 2.8 (13–30)	22.4 ± 5.1 (5–30)
BDI score	18.5 ± 7.9	18.0 ± 7.6	16.1 ± 8.1	17.6 ± 7.9

Data are shown as the mean ± standard deviation. K-MMSE: Korean version of Mini-Mental State Examination, MoCA-K: Korean version of Montreal Cognitive Assessment, BDI: Beck Depression Inventory.

**Table 3.** Validation of the MoCA to MMSE conversion

MMSE-equivalent MMSE	Conversion by van Steenoven et al. <sup>5</sup>	Conversion by Lawton et al. <sup>6</sup>
Total		
Mean (SD)	0 (0.4)	0.4 (0.1)
Median (IQR)	0 (-1, 1)	0 (-1, 1)
RMSE	1.89	1.90
Education ≤ 6 years		
Mean (SD)	-0.1 (0.2)	0.3 (0.2)
Median (IQR)	0 (-2, 1)	0 (-1, 1)
RMSE	2.15	2.02
6 years < education ≤ 12 years		
Mean (SD)	0.3 (0.1)	0.7 (0.1)
Median (IQR)	0 (-1, 1)	1 (0, 2)
RMSE	1.66	1.81
12 years < education		
Mean (SD)	-0.2 (0.2)	0.2 (0.2)
Median (IQR)	0 (-1, 1)	0 (-1, 1)
RMSE	1.88	1.89

MoCA: Montreal Cognitive Assessment, MMSE: Mini-Mental State Examination, SD: standard deviation, IQR: interquartile range, RMSE: root mean squared error.

correlation coefficient (ICC) between the true and equivalent MMSE and the proportion of the patients whose score difference was within ± 2 points. Calculations were performed using SPSS 18.0 (SPSS Inc., Chicago, IL, USA).

## RESULTS

### Patients' characteristics

A total of 391 patients were included in this study. Their mean age was 67.3 ± 8.1 years, and 178 (45.5%) patients were men. The mean K-MMSE and MoCA-K scores were 26.2 ± 3.4 (range, 11–30) and 22.4 ± 5.1 (range, 5–30), respectively. According to the educational level, the participants were classified into three groups: 6 or fewer years of education (n = 127), 7–12 years of education (n = 156), and 13 or more years of education (n = 108). Eleven of the patients with 6 or fewer years of education were completely

uneducated. The demographic data according to the educational level are presented in Table 2.

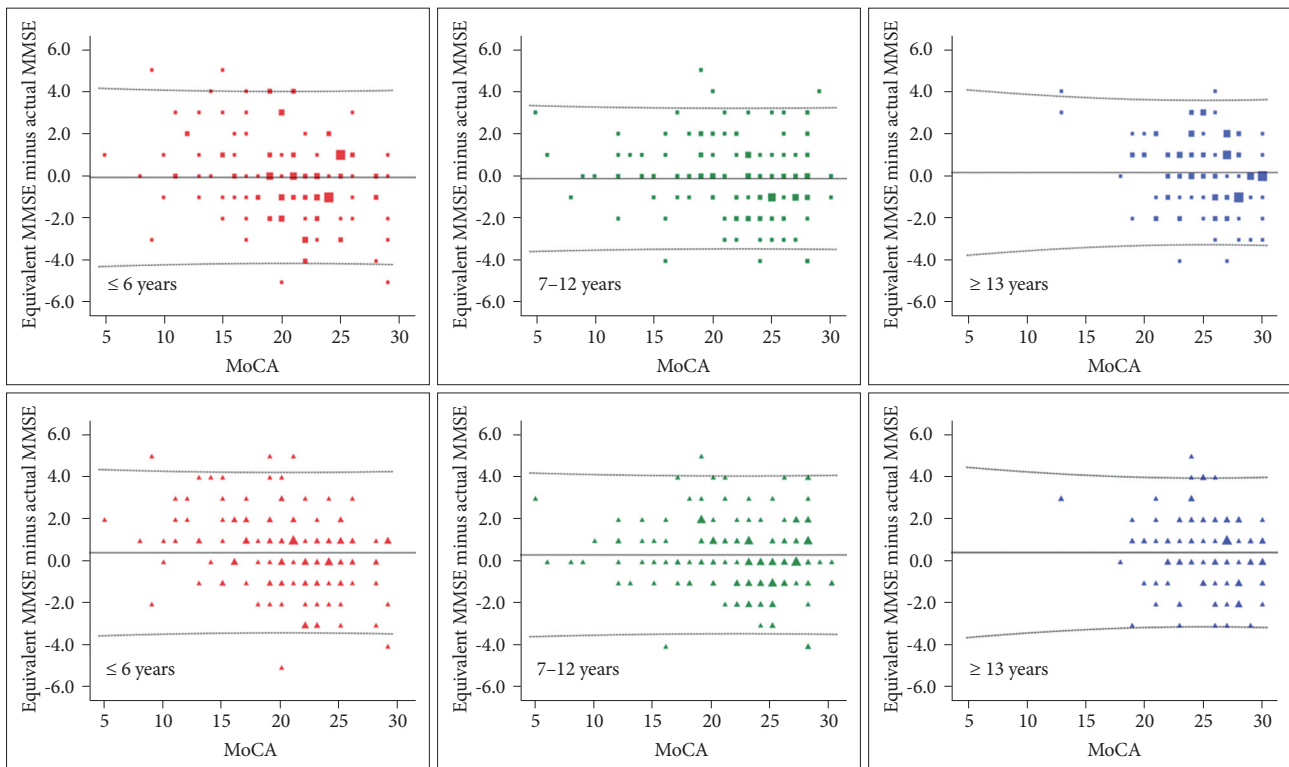
### Validation of the MoCA to MMSE conversion

Table 3 shows the validation of the MoCA to MMSE conversions. The median difference was 0 (IQR, -1 to 1) in both conversions, and the values of the mean difference and RMSE were very similar. In the classification according to educational level, the median difference was also 0 in all, except for the Lawton conversion in the 7–12 years of education group, where the median difference was 1. All educational levels had similar values of mean difference and RMSE both within and between the conversions (Figure 1).

The van Steenoven conversion showed that 9.7% of the equivalent MMSE scores were more than 2 points higher than the true MMSE, 82.6% were within 2 points, and 7.7% were more than 2 points lower. The Lawton conversion showed that 11.3% were more than 2 points higher, 83.6% were within 2 points, and 5.1% were more than 2 points lower. The ICC between the true and equivalent MMSE was 0.85 [95% confidence interval (CI): 0.83–0.88] for the van Steenoven conversion and 0.85 (95% CI: 0.82–0.88) for the Lawton conversion. Based on the educational level, the van Steenoven conversion had an ICC of 0.82 (95% CI: 0.76–0.87) for 6 or fewer years of education, 0.90 (95% CI: 0.86–0.92) for 7–12 years of education, and 0.67 (95% CI: 0.55–0.76) for 13 or more years of education. Similarly, the Lawton conversion had an ICC of 0.83 (95% CI: 0.77–0.88) for 6 or fewer years of education, 0.88 (95% CI: 0.84–0.91) for 7–12 years of education, and 0.66 (95% CI: 0.53–0.75) for 13 or more years of education.

## DISCUSSION

The present study validated two MMSE-MoCA



**Figure 1.** Scatter plots of the difference between the equivalent MMSE score and the actual MMSE score according to the MoCA score. The solid line indicates the mean difference and the dotted lines indicates the 95% confidence intervals. Square indicates the values when using the van Steenoven conversion, whereas triangle indicates the values when using the Lawton conversion. The size of the plotted symbol is proportional to the number of observations. MMSE: Mini-Mental State Examination, MoCA: Montreal Cognitive Assessment.

conversion tables for PD by using retrospective data from a large number of Korean patients with PD. The results showed that both conversions had a median value of 0, with a small mean difference and RMSE, which is very close to the results reported by Lawton et al.<sup>6</sup> In addition, they had a good correlation between the true and equivalent MMSE scores, and a high proportion of the score differences was within 2 points. These findings indicate that both the van Steenoven and Lawton conversion tables have adequate validity for transforming MoCA scores into the equivalent MMSE scores in Korean patients with PD.

The MMSE-MoCA conversion table for PD was first established by van Steenoven et al.<sup>5</sup> in 2014. However, its interpretation might be limited in patients with PD who have low scores on the cognitive screening test because the minimum score on the MoCA was 10 in their study. Subsequently, the conversion table suggested by Lawton et al.<sup>6</sup> was constructed based on a wider range of MoCA and MMSE scores, which enhanced its generalizability. Howev-

er, as shown in Table 1, there is no remarkable difference on equivalent MMSE scores between the conversions, especially for MoCA scores greater than 4 points. Accordingly, it is not surprising that the conversion tables had a similar validity in Korean patients with PD, given that the minimum score on the MoCA was 5 in the current study.

The educational level can influence MoCA and MMSE performance.<sup>11</sup> However, most of the data for MMSE-MoCA conversions were obtained from well-educated patients, which limits the generalizability of the results. Considering that approximately 30% of the patients in this study had 6 or fewer years of education, it is crucial to evaluate whether the conversions have satisfactory validity in less-educated patients with PD. Our results showed that all educational levels had roughly similar values for the mean, median, and RMSE. In addition, the ICC for 6 or fewer years of education was reasonably good. These findings demonstrated that MoCA to MMSE conversions have adequate validity even in less-educated patients with PD, and that they could

be useful regardless of the patients' educational level.

This study had some limitations. It was a single-center study with a retrospective design. Additionally, it is unclear whether MMSE-MoCA conversions are valid in patients PD with dementia. Although demented patients with PD who have abnormal MoCA scores can have normal MMSE scores,<sup>12</sup> the current study could not validate the conversions for those because we did not have sufficient information on the participants to apply the diagnostic criteria for PD dementia. Further trials are warranted to validate MMSE-MoCA conversions in patients with PD dementia. Finally, there is a significant difference between individuals who had been educated for 1–6 years and those with no formal education, but we could not separate them into different groups because only a small number of patients with no formal education was included in this study. Nevertheless, our results suggest that both the van Steenoven and Lawton conversion tables are useful instruments for transforming MoCA scores into the equivalent MMSE scores in Korean patients with PD, regardless of educational level. These findings will greatly enhance the utility of the existing cognitive data from the Korean PD population in both clinical and research settings.

### Conflicts of Interest

The authors have no financial conflicts of interest.

### Acknowledgments

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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