Neurology Asia 2016; 21(4) : 357 – 365

Clock drawing test to screen for dementia in parkinsonian patients with low educational backgrounds

[1]Han-Yeong Jeong *MD*, [1]Jee-Young Lee *MD PhD*, [2]Hee Kyung Park *MD PhD*, [3]Sohee Oh*PhD*, [4]Jun-Young Lee *MD PhD*

[1]Department of Neurology, Seoul National University-Seoul Metropolitan Government Boramae Medical Center, Seoul National University College of Medicine, Seoul; [2]Department of Neurology, Inje University Ilsan Paik Hospital, Goyang; [3]Department of Biostatistics & [4]Department of Psychiatry, Seoul National University-Seoul Metropolitan Government Boramae Medical Center, Seoul National University College of Medicine, Seoul, South Korea

Abstract

Objectives: This study was aimed to assess the usefulness of the quantitative assessment of clock drawing test (CDT) combined with the Mini-Mental State Examination (MMSE) compared to that of the Montreal Cognitive Assessment (MoCA) or the MMSE alone for screening of dementia in Parkinson disease (PD) in patients with a low educational level. *Methods:* A representative sample of 91 PD patients was administered MMSE, MoCA and CDT. The discriminative validity of the MMSE, MoCA, and a MMSE+CDT combination for dementia screening was determined by estimating the sensitivity and specificity of each test and by testing integrated discrimination improvement (IDI). *Results:* The mean age and educational years were 69.0 (years) and 7.3 in the study population. The best screening cut-off points for the MMSE, MoCA, and MMSE+CDT were 25/26, 21/22 and 41/42. In a group of patients with educational years ≤6, the sensitivity and specificity of the MMSE+CDT were 94.4 and 54.8 with area under the curve (AUC) 0.806 (95% confidence interval, 0.686-0.925), whereas those of the MMSE and MoCA were 94.4 and 45.2 with AUC 0.767 (0.635-0.899), and 83.3 and 35.5 with AUC 0.773 (0.634-0.913), respectively. Compared with the MMSE alone, the IDI of the MMSE+CDT showed a significant improvement in the low-educational level group whereas the IDI of the MoCA did not show such an improvement in this group.
Conclusions: In low educational level population, a combination of the quantitative CDT and MMSE is a good screening tool for dementia in PD.

INTRODUCTION

The cumulative prevalence of cognitive impairment in Parkinson disease (PD) has been reported to be 80–90%.[1,2] Dementia is associated with psychosis, nursing home admission, and increased mortality risk in PD[3,4], and has a major impact on the quality of life of both patients and their caregivers.[5] Even though a low educational level is an important risk factor for dementia in PD, an appropriate screening test for dementia in PD patients with a low educational level has not been reported. This is of particular importance in Korea as many Korean elderly were deprived of educational opportunities because of conditions during the colonial rule of Japan and the Korean War. The Mini-Mental State Examination (MMSE)[6] primarily assesses memory domain, thus it is inadequate for early detection of dementia in PD patients because cognitive impairment usually begins in frontal and executive functions in PD.[7,8] In contrast, the Montreal Cognitive Assessment (MoCA) includes assessments of frontal/executive functions, higher-level language abilities, and complex visuospatial function. Some reports have indicated that the MoCA is a better cognitive screening tool than the MMSE in PD.[7,9] However, the usefulness of the MoCA in subjects with a low educational level is questionable because MoCA may be difficult to implement, and its diagnostic value is inferior to that of the MMSE in low educational level elderly populations.[7,10] Aneffect of educational level on MoCA score was observed in the Korean MoCA (MoCA-K) validation study.[10] The mean educational level in the original MoCA study

Address correspondence to: Jee-Young Lee, M.D., Ph.D., Department of Neurology, Seoul National University-Seoul Metropolitan Government Boramae Medical Center, College of Medicine, Seoul National University. Dongjak-gu, Shindaebang-dong, Boramae 5 road 20, 156-707, Seoul, Republic of Korea. Tel: +82-2-870-2476, E-mail:wieber04@snu.ac.kr

population was 13.3 years[7], whereas that in the MoCA-K study was 8.3 years.[10] The difference in optimal cut-off values for dementia screening between these two studies was noticeable (25/26 vs. 22/23, respectively).

The clock drawing test (CDT) can be performed easily and administered quickly, typically taking less than 2 min in an elderly subject.[11,12] Moreover, the CDT is reported to be unaffected by cultural differences, environmental backgrounds, and educational level.[11] Motor programming, executive function, visuospatial ability, and visual memory can be evaluated by this single test.[13-15]Accordingly, if the CDT is combined with the MMSE, it could complement the low specificity of the MMSE in PD patients with low educational backgrounds. Therefore, we assessed the usefulness of the MMSE+CDT combination, compared to that of the MoCA and the MMSE alone, to screen for dementia in PD patients grouped by educational level.

METHODS

Study subjects

Consecutive91 PD patients who visited a movement disorders clinic between January 2011 and December 2011 were enrolled in this study. Subjects were enrolled if they were diagnosed with PD[16], and had been followed-up for at least six months. Exclusion criteria were subjects with a typical parkinsonism (dementia with Lewy bodies, corticobasal degeneration, progressive supranuclear palsy, and multiple system atrophy), secondary parkinsonism, diseases other than PD affecting the brain, medical conditions that could affect cognitive function such as mental illness (depression, schizophrenia), under psychiatric care, structural brain lesions relating to stroke, brain tumors, encephalitis, and serious medical illnesses including thyroid, kidney and liver diseases. To exclude pseudo-dementia such as depression in PD, all subjects were assessed by geriatric depression scale. Clinical data including gender, age, educational level, PD duration, and Hoehn & Yahr (HY) stage were collected for each subject. Four of the 91 subjects did not complete the three screening tests; therefore, data for 87 patients was analyzed. Study protocol was approved by the Institutional Review Board of the SNU Boramae Hospital, and informed consent was obtained from all participating subjects.

Cognitive screening tests

Blinded trained research staff (HYJ and TJK) administered three cognitive screening tests to each subject. The Korean MMSE (K-MMSE), the CDT, and the MoCA-K were sequentially administered using previously reported protocols.[6,10,17,18] In the MoCA-K, the phonemic fluency task was replaced with a semantic fluency task, because phonemic fluency is more influenced by educational level than semantic fluency.[19] The CDT method consists of the "command" and "copy" conditions. In the command condition, subjects draw a clock face, add all numbers to the face, and set the hands for 10 past 11. After subjects finished the command condition, the copy condition was administered. In the copy condition, subjects were instructed to copy, as accurately as possible, a clock face from a model in which the hands were set for 10 past 11. In this study, scoring of the CDT results followed the rating criteria proposed by Rouleau *et al*.[20] That quantitative rating method has a 10-point scoring system for each condition.[20] Errors in the CDT are separately identified in both command and copy conditions for each of six error categories: 1) clock size, 2) graphic difficulties, 3) stimulus-bound response, 4) conceptual deficit, 5) spatial and/or planning deficit, and 6) perseveration. Spatial and/or planning deficit errors were further evaluated by assessing five aspects: 1) neglect of the left hemisphere, 2) deficit in planning, 3) deficit in spatial layout of numbers, 4) numbers written outside the clock face, and 5) numbers written counterclockwise.

Three screening tests are iterative tasks (e.g. orientation in the K-MMSE and in the MoCA-K, CDT command condition in the MoCA-K). Thus, to minimize the putative learning effects of each test and with consideration of possible cognitive fluctuation, the K-MMSE+CDT and the MoCA-K were performed at the same time of different days within a month. Results of the CDT were independently analyzed by two different neurologists who were blind to the patient's diagnosis and the score assigned by the other neurologist. The CDT command and copy conditions in the quantitative analysis were each given 10 points, resulting in a total score for the K-MMSE+CDT combination range of 0 to 50 points.

Defining the presence of dementia

The neurologists who did not know about the results of the cognitive tests, classified whether the subjects had dementia or not.

The presence of dementia in our subjects was defined according to the diagnostic criteria for probable PD dementia.[21,22] Briefly, subjects who had core features (PD and a dementia syndrome with insidious onset and slow progression) and cognitive deficits in at least two of the four cognitive domains (i.e., attention, executive function, visuo-spatial function, and memory), which can affect daily living activities, were diagnosed as having PD dementia. The presence of dementia was determined by neurologists who were unaware of the score of each screening tests. The CDT score was not used for defining the presence of dementia.

Data analysis

Intergroup comparisons were undertaken by using a Pearson $\chi 2$ test and a Fisher's exact test for categorical variables, or an independent-sample t-test and Mann-Whitney test for continuous variables. The reliability between two raters was assessed using intraclass correlation coefficient (ICC).

The sensitivity and specificity of the three tests (K-MMSE, MoCA-K and K-MMSE+CDT) were estimated. Receiver operating characteristics (ROC) along with area under the curve (AUC, 95% confidence interval) were plotted, and the positive predictive value (PPV) and negative predictive value (NPV) were derived for each test. The optimal screening cut-off point was defined as the lowest value that achieved >80% sensitivity and >80% NPV, whereas the optimal diagnostic cut-off point was defined as the highest value that achieved >80% specificity and >80% PPV.

Subgroup analysis was used to assess the effectiveness of the screening tests according to the subgroup's educational level: a low-educational level group (LOW, ≤6 years of education) and high-educational level group (HIGH, >6 years of education). Based on the previously derived optimal screening cut-off point, the sensitivity, specificity, PPV, and NPV of the K-MMSE, MoCA-K, and K-MMSE+CDT tests were determined for each subgroup. ROC curve with AUC was obtained for each subgroup, and the effects of improved prediction of dementia were assessed using the integrated discrimination improvement (IDI).[23] Finally, errors in the subject's CDT results were compared between each subgroup. All statistical analyses were performed by using SPSS 21.0 version for Windows (SPSS Inc., Chicago, IL, USA), and R version 3.2.1 (http://www.r-project.org), and a $p < 0.05$ was considered significant.

RESULTS

Subject characteristics

The characteristics of the 87 subjects are summarized in Table 1. One third ($n = 29$) of the subjects met the diagnostic criteria for probable PD dementia. Seven (8.0%) subjects had already on anti-dementia medication. The dementia group was significantly older than the non-dementia group; however, PD duration, HY stage, and education years were not significantly different between the two groups. Patients' age, duration of PD, and HY stages were not different between the HIGH and LOW groups. The ICC for the reliability of the CDT scoring was 0.994 ($p < 0.001$) for the command condition and 0.981 ($p < 0.001$) for the copy condition.

Sensitivity and specificity of cognitive tests

The neuropsychometric properties of the study population screened for the detection of dementia are shown in Table 2. Regarding the K-MMSE results, the optimal screening cut-off point for probable PD dementia was 25/26. The optimal diagnostic cut-off point could not be calculated because no value achieved a >80%PPV. The MoCA-K results indicated an optimal screening cut-off point of 21/22 and an optimal diagnostic cut-off point of 13/14. The K-MMSE+CDT combination produced optimal screening and diagnostic cut-off points of 41/42 and 30/31, respectively (Table 2). In the total study population, the ROC AUC (95% confidence interval) were 0.790 (0.690–0.891) for the K-MMSE, and 0.814 (0.723–0.905) for the MoCA-K, and 0.808 (0.711–0.904) for the K-MMSE+CDT results.

Subgroup analysis according to the educational level

The educational level subgroup analyses were based on the obtained optimal screening cut-off points for the three screening tests. In the LOW group, the overall discriminative validity was highest for the K-MMSE+CDT compared with the MoCA-K and MMSE (Table 3). When we analyzed the IDI, the IDI of the K-MMSE+CDT combination showed a significant improvement than that of the K-MMSE in the LOW group ($p = 0.040$) whereas the IDI of the K-MoCA were not different from that of the K-MMSE in this group.

On the contrary, in the HIGH group, the overall best discriminative validity was seen for the

Table 1: Characteristics of the subjects included in the analysis

Characteristics	All patients *n*=87	Nonde-mented *n*=58 (66.7%)	Demented *n*=29 (33.3%)	*P*-value	LOW *n*=49 (56.3%)	HIGH *n*=38 (43.7%)	*P*-value
Age, y, (range)	69.0 (41-84)	67.2 (41-84)	72.6 (57-84)	0.002[a]	70.3 (54-84)	67.4 (41-84)	0.112[b]
Sex, n, (% male)	42 (48.3%)	26 (44.8%)	16 (55.1%)	0.363[c]	15 (30.6%)	27 (71.1%)	<0.001[c]
Education, y, (range)	7.3 (0-16)	7.6 (0-16)	6.7 (0-16)	0.463[a]	3.7 (0-6)	12.0 (9-16)	<0.001[b]
PD duration, y, (range)	4.2 (1-15)	4.0 (1-14)	4.7 (1-15)	0.166[a]	4.0 (1-14)	4.5 (1-15)	0.445[b]
Dementia, n, (% demented)	-	-	-	-	18 (36.7%)	11 (28.9%)	0.445[c]
HY stage, n, (%)							
1	11 (12.6%)	7 (12.1%)	4 (13.8%)		4 (8.2%)	7 (18.4%)	
1.5	8 (9.2%)	4 (6.9%)	4 (13.8%)		7 (14.3%)	1 (2.6%)	
2	40 (46.0%)	26 (44.8%)	14 (48.3%)	0.246[d]	23 (46.9%)	17 (44.7%)	0.235[d]
2.5	9 (10.3%)	4 (6.9%)	5 (17.2%)		6 (12.2%)	3 (7.9%)	
3	14 (16.1%)	12 (20.7%)	2 (6.9%)		7 (14.3%)	7 (18.4%)	
4	4 (4.6%)	4 (6.9%)			1 (2.0%)	3 (7.9%)	
5	1 (1.1%)	1 (1.7%)			1 (2.0%)		
K-MMSE score, (range)	24.2 (14-30)	25.5 (15-30)	21.6 (14-29)	<0.001[a]	23.2 (14-29)	25.6 (17-30)	0.003[b]
MoCA-K score, (range)	19.4 (7-30)	21.7 (7-30)	14.9 (7-23)	<0.001[a]	17.6 (7-30)	21.7 (8-29)	0.001[b]
CDT-command score (range)	7.5 (0-10)	8.3 (0-10)	6.1 (0-10)	<0.001[a]	6.8 (0-10)	8.5 (4-10)	0.003[b]
CDT-copy score (range)	7.8 (0-10)	8.7 (1-10)	6.2 (0-10)	<0.001[a]	7.1 (0-10)	8.7 (3-10)	0.003[b]
K-MMSE+CDT score (range)	39.6 (14-50)	42.5 (16-50)	33.9 (14-48)	<0.001[a]	37.1 (14-49)	42.8 (24-50)	0.001[b]

[a]Mann-Whitney test, [b]independent-sample t-test, [c] Pearson χ^2 test, [d] Fisher's exact test

LOW = low-educational level group; HIGH = high-educational level group; PD = Parkinson disease; HY = Hoehn & Yahr; K-MMSE = Korean Mini-Mental State Examination; MoCA-K = Korean version of Montreal Cognitive Assessment; CDT = clock drawing test

Table 2: Discriminant validity of the K-MMSE, MoCA-K and K-MMSE+CDT for dementia screening in Parkinson disease patients

K-MMSE												
Cut-off	18/19	19/20	20/21	21/22	22/23	23/24[a]	24/25	25/26[b]	26/27	27/28	28/29	
Sensitivity	17.2	31.0	34.5	51.7	62.1	65.5	75.9	89.7	89.7	93.1	96.6	
Specificity	96.6	94.8	89.7	86.2	84.5	82.8	65.5	56.9	44.8	37.9	20.7	
PPV	71.4	75.0	62.5	65.2	66.7	65.5	52.4	51.0	44.8	42.9	37.8	
NPV	70.0	73.3	73.2	78.1	81.7	82.8	84.4	91.7	89.7	91.7	92.3	
AUC(95% CI)	0.790 (0.690-0.891)											
MoCA-K												
Cut-off	13/14[c]	14/15	15/16	16/17[a]	17/18	18/19	19/20	20/21	21/22[b]	22/23	23/24	
Sensitivity	44.8	55.2	58.6	65.5	65.5	69.0	69.0	79.3	82.8	93.1	100.0	
Specificity	94.8	89.7	89.7	86.2	79.3	75.9	67.2	62.1	53.4	48.3	43.1	
PPV	81.3	72.7	73.9	70.4	61.3	58.8	51.3	51.1	47.1	47.4	46.8	
NPV	77.5	80.0	81.3	82.1	83.0	81.3	85.7	86.1	93.3	100.0	100.0	
AUC (95% CI)	0.814 (0.723-0.905)											
K-MMSE+CDT (all)												
Cut-off	30/31[c]	31/32	32/33	33/34	34/35	35/36	36/37	37/38	38/39	39/40	40/41	41/42	42/43[a]
Sensitivity	27.6	27.6	27.6	37.9	37.9	44.8	51.7	55.2	58.6	69.0	75.9	82.8	93.1
Specificity	96.6	94.8	93.1	93.1	93.1	91.4	87.9	84.5	82.8	75.9	69.0	67.2	62.1
PPV	82.0	72.7	66.7	73.3	73.3	72.2	68.2	64.0	63.0	58.8	55.0	55.8	55.1
NPV	72.7	72.4	72.0	75.0	75.0	76.8	78.5	79.0	80.0	83.0	85.1	88.6	94.7
AUC (95% CI)	0.808 (0.711-0.904)												
K-MMSE+CDT (command)												
Cut-off	24/25[c]	25/26	26/27	27/28	28/29	29/30	30/31	31/32	32/33[a,b]	33/34	34/35	35/36	
Sensitivity	27.6	27.6	34.5	41.4	41.4	51.7	58.6	72.4	82.8	86.2	93.1	93.1	
Specificity	96.6	94.8	93.1	91.4	87.9	84.5	84.5	74.1	69.0	60.3	53.4	50.0	
PPV	80.0	72.7	71.4	70.6	63.2	62.5	65.4	58.3	57.1	52.1	50.0	48.2	
NPV	72.7	72.4	74.0	75.7	75.0	77.8	80.3	84.3	88.9	89.7	93.9	93.5	
AUC (95% CI)	0.797 (0.696-0.899)												
K-MMSE+CDT (copy)												
Cut-off	24/25	25/26	26/27[c]	27/28	28/29	29/30	30/31	31/32	32/33[a]	33/34[b]	34/35	35/36	
Sensitivity	27.6	27.6	27.6	34.5	44.8	58.6	58.6	65.5	79.3	86.2	89.7	93.1	
Specificity	96.6	96.6	96.6	91.4	91.4	87.9	82.8	81.0	75.9	67.2	53.4	50.0	
PPV	80.0	80.0	80.0	66.7	72.2	70.8	63.0	63.3	62.2	56.8	49.1	48.2	
NPV	72.7	72.7	72.7	73.6	76.8	81.0	80.0	82.5	88.0	90.7	91.2	93.5	
AUC (95% CI)	0.822 (0.729-0.914)												

[a]Point of maximum combined sensitivity and specificity.
[b]Optimal screening cut-off point.
[c]Optimal diagnostic cut-off point
PPV = positive predictive value; NPV = negative predictive value; AUC = area under the curve; CI = confidence interval.

Table 3: Sensitivity, specificity, positive predictive value, and negative predictive values of the K-MMSE, MoCA-K, and K-MMSE+CDT in Parkinson disease patients grouped by educational level

	Sensitivity	Specificity	PPV	NPV	AUC (95% CI)	IDI *p*-value[a]
Low-educational level group (education year 6, *n*=49)						
K-MMSE	94.4	45.2	50.0	93.3	0.767 (0.635-0.899)	
MoCA-K	83.3	35.5	42.9	78.6	0.773 (0.634-0.913)	0.216
K-MMSE+CDT	94.4	54.8	54.8	94.4	0.806 (0.686-0.925)	0.040
High-educational level group (education year >6, *n*=38)						
K-MMSE	81.8	70.4	52.9	90.5	0.800 (0.621-0.979)	
MoCA-K	81.8	56.3	74.1	90.9	0.892 (0.793-0.992)	0.017
K-MMSE+CDT	63.6	81.5	58.3	84.6	0.790 (0.609-0.970)	0.198

Cut-off points; K-MMSE = 25/26, MoCA-K = 21/22, K-MMSE+CDT = 41/42
PPV = positive predictive value; NPV = negative predictive value; AUC = area under the curve; CI = confidence interval; IDI = integrated discrimination improvement
[a]Comparison with the K-MMSE

MoCA-K compared with the other two screening tests (Table 3). The IDI of the MoCA-K was significantly higher than that of the K-MMSE in the HIGH group (p = 0.017).

Errors in CDT

The most common error was graphic difficulty, which was found in 55 (63.2 %, command condition) and 53 (60.9 %, copy condition) of the study subjects, and there was no difference in the severity of graphic errors between the command and copy conditions. Spatial and/or planning deficit errors were the second most common error in both the command (36%) and copy (37%) conditions. Most deficits were in planning (command, 19 subjects; copy, 18 subjects) and in spatial layout of numbers (command, 23 subjects; copy, 20 subjects). Uncommon errors were numbers written outside the clock face (command, 4 subjects; copy, 4 subjects), numbers written counterclockwise (command, 1 subject) and neglect (copy, 1 subject). Clock size abnormalities (n = 17 *vs.* 8, respectively), stimulus-bound response (n = 9 *vs.* 3, respectively), and conceptual deficit (n = 12 *vs.* 4, respectively) were more frequent under the command than under the copy conditions.

There was a tendency of more CDT errors in the non-dementia group than the dementia group (Figure 1A and 1B). The deficits in spatial layout of numbers tended to be frequent in low-educated dementia group under the command condition, and the planning errors tended to be frequent in low-educated non-dementia group under the copy condition (Figure 1C and 1D). However there were no statistical differences among the groups. Typical errors in PD patients are shown in Figure 2.

DISCUSSION

The results of this study reveal that the K-MMSE+CDT combination has good overall discriminant validity for PD dementia screening in a low educated Korean population. It has been raised that the CDT can supplement the MMSE for dementia screening in poorly educated non-English speakers.[12,24] The present study has an advantage over previous studies in that three brief screening tests were simultaneously compared according to educational level in Asian PD population.

In our study, we detected significant correlations between CDT scores and all items (except orientation) in the MoCA-K (correlation coefficients ranging from 0.4 to 0.65) and observed a complementary effect of the K-MMSE+CDT combination in the LOW group. Unlike the K-MMSE+CDT, the MoCA-K did not show such a complementary effect in the LOW group. However in the HIGH group, the discriminative validity of the MoCA-K was superior to that of the K-MMSE, which was similar to the previous reports.[7,9] Patients' age, severity of PD, and frequency of dementia were not different significantly between the HIGH and LOW groups. However, in our LOW group patients, the MoCA-K tended to

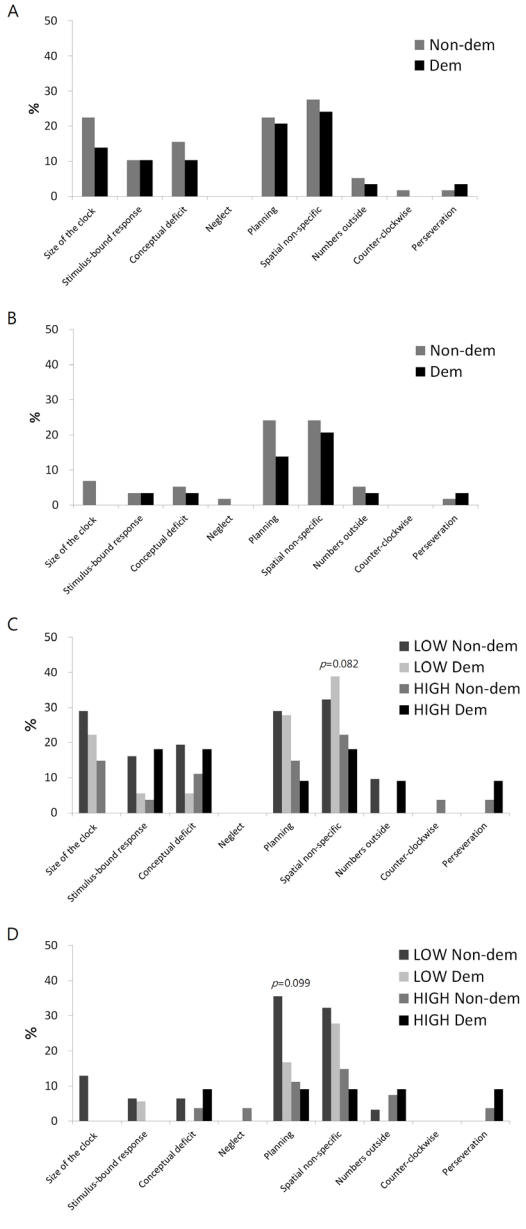

Figure 1. Type and frequency of clock drawing errors in patients with dementia (Dem) and without dementia (Non-dem). Errors in the command condition (A and C) and in the copy condition (B and D). LOW=low educational level, HIGH=high educational level

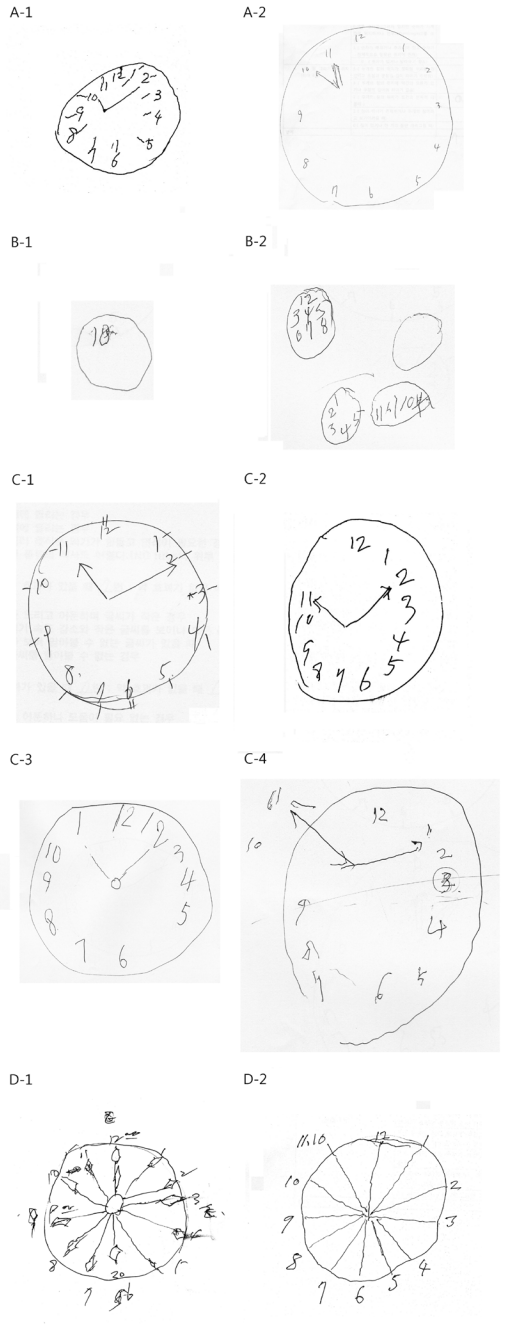

Figure 2. Typical clock drawing errors in Parkinson disease patients. A. Stimulus-bound response errors; (A-1) 11 after 10 instead of 10 after 11 and (A-2) 11 to 10 instead of 10 after 11. B. Conceptual deficit errors (B-1 and B-2). C. Visuospatial errors; (C-1) Mild planning deficit, (C-2 and C-3) deficit in the spatial layout of numbers and (C-4) numbers written outside the clock face D. Perseverative errors with numbers written outside the clock face (D-1 and D-2).

over estimate cognitive impairment. The optimal cut-off point of the MoCA-K in the present study was 21/22, similar to that reported in a previous MoCA-K validation study.[10] Our cut-off was 5 points lower than the original MoCA cut-off of 26/27.[18] The mean educational years in the present and the original MoCA study were 7.3 and 13.3, respectively. As the MoCA requires completion of

complex executive tasks, the cognitive function evaluated in the MoCA has been correlated with the subject's educational level.[25,26] The usefulness of the K-MMSE+CDT combination compared with the MoCA-Kin the LOW group may be due to complexity of the MoCA-K test.

Our analysis of CDT errors indicates that such an analysis can detect spatial and/or planning deficits in PD patients. This result is consistent with previous reports indicating that, compared to Alzheimer's disease (AD) patients, PD patients can make more planning errors, although the global scores of the two patient groups are not significantly different.[27] Though other types of errors showed a tendency to decrease in copy condition, spatial and/or planning deficit errors were still higher in both the command and copy condition in our study. A high prevalence of planning errors was also detected in vascular dementia (VD)[14], dementia with Lewy bodies, and Huntington's disease (HD) patients[20], which suggests more subcortical involvement than cortical involvement in these disorders. Another longitudinal study of CDT and MMSE reported that, at every follow-up evaluation, spatial and/or planning deficits were the most frequent errors in PD dementia, whereas conceptual deficits were most frequent in AD.[28] In addition, impairment of clock-face drawing, specifically the production of postmeridian digits, has been shown to appear earlier in relation to cognitive status in PD than in AD patients, suggesting a disturbance of cognitive switching and impairment inattentional set shifting.[29] Graphic difficulty was common in our PD patients regardless of educational level and dementia status, thus suggesting that this difficulty is more likely related to a parkinsonian motor symptom than a cognitive symptom. In summary, the types and frequencies of CDT errors observed in our PD patients are similar to those reported in HD and VD patients, suggesting that frontal/executive and visuospatial impairments have a role in the poor clock drawing results in PD patients.

There were no differences in the type or frequency of CDT errors detected between the dementia group and non-dementia groups, and it seemed that the non-demented subjects made more mistakes under the certain conditions. This might be a result from a small sample size of our study. However, more likely because the CDT error was counted as 'absent' in this study when the subjects could not draw the clock, there could be a bias in the qualitative CDT in the dementia group. The qualitative CDT analysis without quantitative CDT score may be insufficient to detect dementia in PD patients.

The CDT is reported to be sufficiently sensitive to detect mild cognitive impairment (MCI) in PD patients with >6 years of education.[30,31] However, whether CDT errors have discriminative validity in detecting MCI in PD subjects with a low educational background, needs to be investigated further because the current study was only designed to compare the validities of three brief screening test approaches to dementia screening.

The present study results should be interpreted with caution. The results may not be generalizable because the enrolled patients were limited to ethnic Koreans, and all were recruited from a single movement disorders clinic. The majority of patients had mild to moderate PD; thus, there were few subjects displaying severe motor disabilities. Additionally, we did not have a matched non-PD control group; thus, we were unable to examine whether the CDT errors were specific to PD or were common in a low educational level population. In addition, the sample size was rather small; however this was expected as the study subjects were recruited as a representative sample of low educational level Koreans with PD. To confirm the usefulness of a MMSE+CDT combination, and to reveal the clinical significance of CDT errors in PD, further studies involving a larger number of subjects and incorporating detailed neuropsychological evaluations are warranted.

DISCLOSURE

Conflict of interest: none

REFERENCES

1. Buter TC, van den Hout A, Matthews FE, *et al.* Dementia and survival in Parkinson disease: a 12-year population study. *Neurology* 2008; 70:1017-22.
2. Hely MA, Reid WG, Adena MA, *et al*. The Sydney multicenter study of Parkinson's disease: the inevitability of dementia at 20 years. *Mov Disord* 2008; 23:837-44.
3. Stern Y, Albert M, Brandt J, *et al*. Utility of extrapyramidal signs and psychosis as predictors of cognitive and functional decline, nursing home admission, and death in Alzheimer's disease:prospective analyses from the Predictors Study. *Neurology* 1994; 44:2300-7.
4. Zahodne LB, Ornstein K, Cosentino S, *et al*. Longitudinal relationships between Alzheimer disease progression and psychosis, depressed mood, and agitation/aggression. *Am J Geriatr Psychiatry* 2015; 23:130-40.
5. Goldman JG, Holden S. Treatment of psychosis and

dementia in Parkinson's disease. *Curr Treat Options Neurol* 2014; 16:281.
6. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; 12:189-98.
7. Hoops S, Nazem S, Siderowf AD, *et al*. Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology* 2009; 73:1738-45.
8. Nazem S, Siderowf AD, Duda JE, *et al*. Montreal cognitive assessment performance in patients with Parkinson's disease with "normal" global cognition according to mini-mental state examination score. *J Am Geriatr Soc* 2009; 57:304-8.
9. Dalrymple-Alford JC, MacAskill MR, Nakas CT, *et al*. The MoCA: well-suited screen for cognitive impairment in Parkinson disease. *Neurology* 2010; 75:1717-25.
10. Lee JY, Lee DW, Cho SJ, *et al*. Brief screening for mild cognitive impairment in elderly outpatient clinic: validation of the Korean version of the Montreal Cognitive Assessment. *J Geriatr Psychiatr Neurol* 2008; 21:104-10.
11. Shulman KI, Shedletsky R, Silver IL. The challenge of time: Clock-drawing and cognitive function in the elderly. *Int J Geriatr Psychiatry* 1986; 1:135-40.
12. Shulman KI. Clock-drawing: is it the ideal cognitive screening test? *Int J Geriatr Psychiatry* 2000; 15:548-61.
13. Peters R, Pinto EM. Predictive value of the Clock Drawing Test. A review of the literature. *Dement Geriatr Cogn Disord* 2008; 26:351-5.
14. Kitabayashi Y, Ueda H, Narumoto J, *et al*. Qualitative analyses of clock drawings in Alzheimer's disease and vascular dementia. *Psychiatry Clin Neurosci* 2001; 55:485-91.
15. De Pandis MF, Galli M, Vimercati S, *et al*. A new approach for the quantitative evaluation of the clock drawing test: preliminary results on subjects with Parkinson's disease. *Neurol Res Int* 2010; 2010:283890.
16. Hughes AJ, Daniel SE, Kilford L, *et al*. Accuracy of clinical diagnosis of idiopathic Parkinson's disease: a clinico-pathological study of 100 cases. *J Neurol Neurosurg Psychiatry* 1992; 55:181-4.
17. Kang Y, Na DL, Hahn S. A validity study on the Korean Mini-Mental State Examination (K-MMSE) in dementia patients. *J Korean Neurol Assoc* 1997; 15:300-8.
18. Nasreddine ZS, Phillips NA, Bedirian V, *et al*. The Montreal Cognitive Assessment, MoCA: abrief screening tool for mild cognitive impairment. *J Am Geriatr Soc* 2005; 53:695-9.
19. Ratcliff G, Ganguli M, Chandra V, *et al*. Effects of literacy and education on measures of word fluency. *Brain Lang* 1998; 61:115-22.
20. Rouleau I, Salmon DP. Quantitative and qualitative analyses of Clock Drawings in Alzheimer's and Huntington's disease. *Brain Cogn* 1992; 18:70-87.
21. Emre M, Aarsland D, Brown R, *et al*. Clinical diagnostic criteria for dementia associated with Parkinson's disease. *Mov Disord* 2007; 22:1689-707.
22. Dubois B, Burn D, Goetz C, *et al*. Diagnostic procedures for Parkinson's disease dementia: recommendations from the movement disorder society task force. *Mov Disord* 2007; 22:2314-24.
23. Pencina MJ, D'Agostino RB Sr, D'Agostino RB Jr, *et al*. Evaluating the added predictive ability ofa new marker: from area under the ROC curve to reclassification and beyond. *Stat Med* 2008; 27:157-72.
24. Borson S, Brush M, Gil E, *et al*. The Clock Drawing Test: utility for dementia detection in multiethnic elders. *J Gerontol A Biol Sci Med Sci* 1999; 54:M534-40.
25. Wu Y, Wang M, Ren M, *et al*. The effects of educational background on Montreal Cognitive Assessment screening for vascular cognitive impairment, no dementia, caused by ischemic stroke. *J Clin Neurosci* 2013; 20:1406-10.
26. Rossetti HC, Lacritz LH, Cullum CM, *et al*. Normative data for the Montreal Cognitive Assessment (MoCA) in a population-based sample. *Neurology* 2011; 77:1272-5.
27. Cahn-Weiner DA, Williams K, Grace J, *et al*. Discrimination of dementia with lewy bodies from Alzheimer disease and Parkinson disease using the clock drawing test. *Cogn Behav Neurol* 2003; 16:85-92.
28. Lee JH, Oh ES, Jeong SH, *et al*. Longitudinal changes in clock drawing test (CDT) performance according to dementia subtypes and severity. *Arch Gerontol Geriatr* 2011; 53:e179-82.
29. Saur R, Maier C, Milian M, *et al*. Clock test deficits related to the global cognitive state in Alzheimer's and Parkinson's disease. *Dement Geriatr Cogn Disord* 2012; 33:59-72.
30. Saka E, Elibol B. Enhanced cued recall and clock drawing test performances differ in Parkinson's and Alzheimer's disease-related cognitive dysfunction. *Parkinsonism Relat Disord* 2009; 15:688-91.
31. Stella F, Gobbi LT, Gobbi S, *et al*. Early impairment of cognitive functions in Parkinson's disease. *Arq Neuropsiquiatr* 2007; 65:406-10.