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Screening utility of the Montreal Cognitive Assessment (MoCA): in place of – or as well as – the MMSE?

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ABSTRACT

Background: This aim of this study was to assess the clinical utility of the Montreal Cognitive Assessment (MoCA) as a screening instrument for cognitive impairment in patients referred to a memory clinic, alone and in combination with the Mini-Mental State Examination (MMSE).

Methods: This was a pragmatic prospective study of consecutive referrals attending a memory clinic (n = 150) over an 18-month period. Patients were diagnosed using standard clinical diagnostic criteria for dementia (DSM-IV) and mild cognitive impairment (MCI; cognitive impairment prevalence = 43%) independent of MoCA test scores.

Results: MoCA proved acceptable to patients and was quick and easy to use. Using the cut-offs for MoCA and MMSE specified in the index paper (≥26/30), MoCA was more sensitive than MMSE (0.97 vs 0.65) but less specific (0.60 vs 0.89), with better diagnostic accuracy (area under Receiver Operating Characteristic curve 0.91 vs 0.83). Downward adjustment of the MoCA cut-off to ≥20/30 maximized test accuracy and improved specificity (0.95) for some loss of sensitivity (0.63). Combining MoCA with the MMSE – either in series or in parallel – did not improve diagnostic utility above that with either test alone.

Conclusions: In a memory clinic population, MoCA proved sensitive for the diagnosis of cognitive impairment. Use of a cut-off lower than that specified in the index study may be required to improve overall test accuracy and specificity for some loss of sensitivity in populations with a high prior probability of cognitive impairment. Combining the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) with the MMSE did not improve diagnostic utility.

Key words: cognitive testing, memory clinics, MoCA

Introduction

The Montreal Cognitive Assessment (MoCA; Nasreddine *et al.*, 2005) is a brief (10–15 minute) 30-point cognitive screening instrument which has proved useful in identifying patients with dementia and – unlike the Mini-Mental State Examination (MMSE; Folstein *et al.*, 1975) – patients with mild cognitive impairment (MCI). MoCA is easily accessed and available in multiple languages (www.mocatest.org). As well as its utility in cognitive clinic populations (Nasreddine *et al.*, 2005; Smith *et al.*, 2007; Damian *et al.*, 2011), MoCA has also been reported to identify cognitive impairment in specific clinical conditions, including Parkinson's disease (Zadikoff *et al.*, 2008; Gill *et al.*, 2008; Nazem *et al.*, 2009), REM sleep behavior disorder (Gagnon *et al.*, 2010), cerebrovascular disease (Wong *et al.*, 2009; Pendlebury *et al.*, 2010; Dong *et al.*, 2010), Huntington's disease (Videnovic *et al.*, 2010), and brain metastases (Olson *et al.*, 2008).

Few data have hitherto been reported on the use of MoCA in memory clinic populations (Nasreddine *et al.*, 2005; Smith *et al.*, 2007; Damian *et al.*, 2011), and some of these studies have selected patients based on diagnosis (Alzheimer's disease (AD,) MCI, +/− normal controls), a method alien to the workings of most clinics where patient diagnoses are unknown at the time of testing, clinical heterogeneity is high, and there are no normal controls. For this reason, pragmatic studies of newly developed cognitive screening tests in relatively unselected clinic populations are necessary. Such studies have shown that cut-offs

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appropriate to index studies may need to be revised in the clinic setting (Larner, 2007; 2009; Hancock and Larner, 2011).

Combining screening tests to try to improve diagnostic utility in the memory clinic has been attempted on occasion (Flicker *et al.*, 1997; Hancock and Larner, 2009). Since MoCA is acknowledged to be a highly sensitive but not very specific test, whereas the MMSE is highly specific but not very sensitive, combining MoCA with the MMSE might be anticipated to improve overall diagnostic utility. Nasreddine *et al.* (2005) advocated sequential use of the MMSE and MoCA in patients with cognitive complaints and functional impairment if MMSE score was normal (≥26/30).

A study was therefore undertaken to examine the screening utility of MoCA in an unselected cognitive disorders clinic population. The study aims were to ascertain whether MoCA was useful in the diagnosis of dementia and MCI in a memory clinic population, and whether its diagnostic utility is improved by combining MoCA with the MMSE.

Methods

Consecutive new patient referrals were recruited prospectively (September 2009–March 2011) from a Cognitive Function Clinic based in a regional neuroscience center. Standard clinical diagnostic criteria (DSM-IV) were used for the diagnosis of dementia (American Psychiatric Association, 2000) and for MCI (Petersen *et al.*, 1999), as in previous studies (Hancock and Larner, 2009; 2011). MoCA administration was performed independent of, but on the same day as, patient clinical and neuropsychological assessment (the latter included some or all of the following elements: Wechsler Adult Intelligence Scale Revised, National Adult Reading Test, Wechsler Memory Scale-III, Graded Naming Test, Rey-Osterreith Complex Figure, Stroop color-word test, and verbal fluency tests). The MoCA result was not used in the diagnostic judgment of dementia/MCI (i.e. cognitive impairment) vs. no cognitive impairment in order to minimize review bias (Gifford and Cummings, 1999). DSM-IV criteria were operationalized pragmatically as the demonstration of multiple cognitive deficits that included memory impairment, sufficiently severe to cause impairment in occupational or social functioning; Petersen MCI criteria were operationalized as the demonstration of cognitive impairment in one or more domain insufficient to mandate a diagnosis of dementia with essentially normal functional activities.

As this was a pragmatic study, patients were not selected according to diagnosis but simply as they presented to the clinic. Dementia subtypes were not specifically examined in this study.

Standard summary measures of diagnostic utility were generated (sensitivity, specificity, positive and negative predictive values (PPV, NPV), diagnostic odds ratio (DOR), likelihood ratios, ROC curve) with 95% confidence intervals (CI). Utility indices were calculated as per Mitchell *et al.* (2009). Correlations and the test of agreement (κ statistic; Cohen, 1960) were calculated between MoCA and MMSE. The STARD guidelines on reporting diagnostic test accuracy were observed (Bossuyt *et al.*, 2003).

Diagnostic utility measures were also derived for combined use of MoCA and MMSE using the cut-points (≥26/30) defined in the index study of Nasreddine *et al.* (2005). Tests were applied both in series (i.e. both tests required to be positive before a diagnosis of cognitive impairment made: the "And" rule) or in parallel (either test positive sufficient for a diagnosis of cognitive impairment to be made: the "Or" rule) (Flicker *et al.*, 1997; Hancock and Larner, 2009).

As administration of MoCA and MMSE was already routine in this clinic, the study was an audit of established practice, so institutional ethical review and specific consent procedures were not indicated.

Results

One-hundred-and-fifty patients were assessed (M : F ratio = 93 : 57, 62% male; age range 20–87 years, median 61 years). Of these, 36 (24%) were judged to have dementia by DSM-IV criteria, 29 (19%) had MCI by Petersen criteria, and 85 (57%) had no dementia.

MoCA proved easy to use, being completed in all cases. MoCA scores ranged from 5/30 to 30/30 (Figure 1a), whereas MMSE scores ranged from 11/30 to 30/30 (Figure 1b). There were weak negative correlations between age and MoCA score ($r = -0.38$; $t = 4.94$, $df = 148$, $p < 0.001$) and between age and MMSE score ($r = -0.26$; $t = 3.27$, $df = 146$, $p < 0.001$). MoCA and MMSE scores were highly correlated ($r = 0.85$; $t = 19.2$, $df = 146$, $p < 0.001$) but the test of diagnostic agreement was not so marked ($\kappa = 0.39$, 95% CI 0.26-0.53; where $\kappa = 1$ is perfect agreement between tests and $\kappa = 0$ is agreement purely due to chance alone).

In the cognitively impaired group the mean (+/−SD) MoCA score was 18.3 +/− 4.5, and in the non-impaired group it was 25.2 +/− 3.2. The mean MoCA scores differed significantly between the two groups ($t = 12.0$, $df = 148$, $p < 0.001$). Mean MoCA scores in the dementia and MCI groups

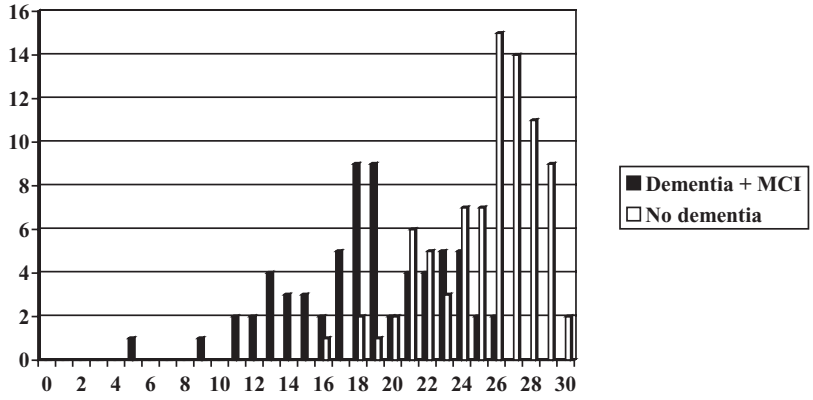

Figure 1a. MoCA scores vs diagnosis.

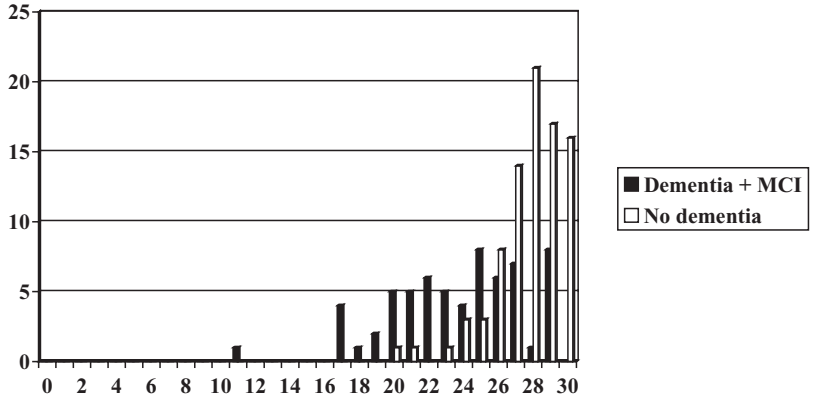

Figure 1b. MMSE scores vs. diagnosis.

were 16.6 +/− 4.4 and 20.4 +/− 3.8 respectively and differed significantly between the two groups ($t = 3.19$, $df = 63$, $p < 0.01$).

In the cognitively impaired group the mean MMSE score was 23.6 +/− 3.8, and in the non-impaired group 27.7 +/− 2.1. The mean MMSE scores differed significantly between the two groups ($t = 6.62$, $df = 148$, $p < 0.001$). Mean MMSE scores in the dementia and MCI groups were 22.2 +/− 3.9 and 25.3 +/− 3.1 respectively and differed significantly between the two groups ($t = 2.02$, $df = 63$, $p < 0.05$).

At the specified MoCA and MMSE cut-offs of ≥26/30 used in the index paper for the diagnosis of dementia and MCI (Nasreddine *et al.*, 2005), MoCA was very sensitive (0.97) but with only modest specificity (0.60) whereas MMSE was very specific (0.89) but not very sensitive (0.65) (Table 1). In other words, MoCA identified almost all the clinically diagnosed cases of dementia and MCI (63/65) but with a large number of false positives (34), whereas the MMSE missed a significant proportion of the dementia and MCI cases (22 false negatives = 35% of cases) but with many fewer false positives (9). Comparing just the MCI cases (n = 29) against cognitively unimpaired cases, a key differential in the identification of early cognitive impairment, results were little different (sensitivity = 0.93; specificity = 0.60), accounted for by two cases of MCI with MoCA score of 26/30. Screening utility between dementia and MCI was not calculated because of the relatively small numbers (36 vs 29) and because this differential is perhaps less crucial than MCI vs. no cognitive impairment in terms of clinical relevance.

The overall accuracy of MoCA was examined at all cut-off values. The best sensitivity for a diagnosis of dementia or MCI was 1.00 at cut-offs ≥27/30 (with specificity no better than 0.42); the best specificity achieved was 1.00 at a cut-off of <16/30 (with sensitivity = 0.25). Optimal MoCA cutoff, defined by the maximal test accuracy for the differential diagnosis of dementia or MCI/not dementia (= 0.81) was ≥20/30. When compared to the specified cut-off (Table 1) at this MoCA cut-off there was improved specificity (0.95) and PPV (0.91) but poorer sensitivity (0.63) and NPV (0.77).

Areas under the ROC curves, measures of diagnostic accuracy, were 0.91 (95% CI = 0.86–0.95) for MoCA, and 0.83 (95% CI = 0.77–0.90) for MMSE (Figure 2; note that an AUC of 0.5,

Table 1. Diagnostic parameters for MoCA and MMSE (with 95% Confidence intervals)

	MOCA CUT-OFF ≥26/30	MMSE CUT-OFF ≥26/30
Overall test accuracy	0.76 (0.69–0.83)	0.79 (0.72–0.86)
Sensitivity	0.97 (0.93–1.00)	0.65 (0.53–0.77)
Specificity	0.60 (0.50–0.70)	0.89 (0.83–0.96)
Youden index (Y)	0.57	0.54
Positive predictive value (PPV)	0.65 (0.55–0.74)	0.82 (0.71–0.93)
Negative predictive value (NPV)	0.96 (0.91–1.00)	0.78 (0.69–0.86)
Predictive summary index	0.61	0.60
Diagnostic odds ratio (DOR)	47.3 (36.3–61.5)	15.7 (8.3–30.0)
Positive likelihood ratio (LR+)	2.42 (1.86–3.15) = small	6.15 (3.23–11.7) = moderate
Negative likelihood ratio (LR−)	0.05 (0.04–0.07) = large	0.39 (0.21–0.74) = small
Utility index (UI+)	0.63 (= adequate)	0.53 (= adequate)
Utility index (UI−)	0.58 (= adequate)	0.69 (= good)
Area under ROC curve	0.91 (0.86–0.95)	0.83 (0.77–0.90)

Table 2. Diagnostic parameters combining MoCA and MMSE in series ("AND") and in parallel ("OR") (with 95% confidence intervals)

	SERIES MOCA (≥26/30) "AND MMSE (≥26/30)	PARALLEL MOCA (≥26/30) "OR MMSE (≥26/30)
Overall test accuracy	0.80 (0.74–0.87)	0.75 (0.67–0.83)
Sensitivity	0.65 (0.53–0.77)	0.97 (0.92–1.00)
Specificity	0.92 (0.86–0.98)	0.59 (0.48–0.69)
Youden index (Y)	0.57	0.56
Positive predictive value (PPV)	0.85 (0.75–0.95)	0.64 (0.54–0.73)
Negative predictive value (NPV)	0.78 (0.70–0.86)	0.96 (0.91–1.00)
Predictive summary index	0.63	0.60
Diagnostic odds ratio (DOR)	20.8 (9.97–43.2)	43.6 (33.7–56.4)
Positive likelihood ratio (LR+)	7.90 (3.79–16.5) = moderate	2.35 (1.82–3.04) = small
Negative likelihood ratio (LR−)	0.38 (0.18–0.79) = small	0.05 (0.04–0.07) = large
Utility index (UI+)	0.56 (= adequate)	0.62 (= adequate)
Utility index (UI−)	0.72 (= good)	0.57 (= adequate)

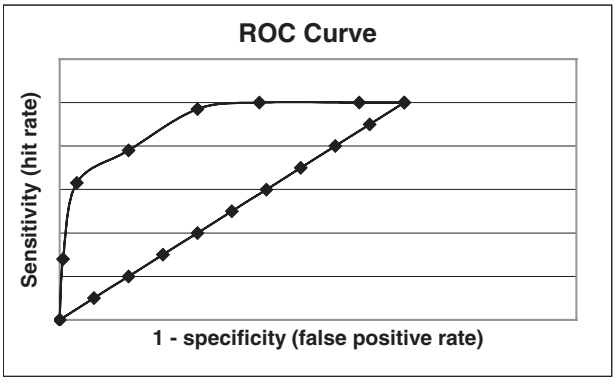

Figure 2. ROC curve for MoCA.

a straight line, indicates a test providing no added information; an AUC of 1 indicates a test providing perfect discrimination; and an AUC of > 0.75 is thought desirable for diagnostic tests).

In patients who were administered both MoCA and MMSE (n = 148), combining the tests in series ("And" rule; Table 2, left-hand column) gave results almost identical to those using MMSE alone (Table 1, right-hand column), whilst combining tests in parallel ("Or" rule; Table 2, right-hand column) gave results almost identical to those using MoCA alone (Table 1, left-hand column). In other words, MoCA "and" MMSE missed a significant proportion of the dementia and MCI cases (22 false negatives, or 35% of cases) but with few false positives (7), whereas MoCA "or" MMSE identified almost all the cases of dementia and MCI but with a large number of false positives (35).

Discussion

Study limitations included the selective nature of the population, inevitable in any hospital-based study, although less selective than in some previous MoCA studies (consecutive rather than by diagnosis), and the numbers studied. Diagnoses were clinical,

without pathological confirmation or long-term follow-up. Dementia severity was not measured as the purpose of the study was to examine allcomers to the clinic irrespective of severity, thus reflecting day-to-day clinical practice. Nevertheless, the study confirmed the high sensitivity of MoCA for identifying cases of cognitive impairment (dementia and MCI), as previously reported in diagnostically selected populations (Nasreddine *et al.*, 2005; Smith *et al.*, 2007). The values for sensitivity (0.97), specificity (0.60) and area under the ROC curve (0.91) were very similar to those observed in the largest series reported to date (n = 135; 0.98, 0.52, 0.90, respectively; Damian *et al.*, 2011), despite the differences in case mix and the prevalence of cognitive impairment in the cohorts (43% vs. 28%).

MoCA compared favorably with the diagnostic parameters of other cognitive screening instruments examined in previous cohorts from this clinic, such as the Addenbrooke's Cognitive Examination (ACE; Larner, 2007) and the Addenbrooke's Cognitive Examination-Revised (ACE-R; Larner, 2009), despite dementia prevalence being higher in these cohorts and utility for MCI diagnosis not being examined. Certainly MoCA performed better than MMSE and its derivative Mini-Mental Parkinson (MMP) for MCI diagnosis (Larner, in press).

As in previous pragmatic studies examining cognitive screening instruments (Larner, 2007; 2009; Hancock and Larner, 2011), a lower cut-off ($\geq$20/30) than that suggested in the index paper ($\geq$26/30; Nasreddine *et al.*, 2005) was found to give greater overall test accuracy (0.81 vs 0.76) with improved test specificity (0.95 vs 0.60) for some loss in sensitivity (0.63 vs 0.97). Other studies have also suggested the possibility of using different MoCA cut-offs: in a study of community-dwelling older adults, Luis *et al.* (2009) suggested 23/30 might be superior, while Damian *et al.* (2011) found that a threshold score of 24 would have superior predictive value in a memory disorders clinic where the prior probability of cognitive impairment is high. This study endorses the latter finding, and may be explained in part by the absence of normal controls as used in the index study (Nasreddine *et al.*, 2005).

Combining screening tests may sometimes improve overall diagnostic utility (e.g Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) and MMSE, Flicker *et al.*, 1997; IQCODE and ACE-R, IQCODE and MMSE, Hancock and Larner, 2009). Despite their apparent complementarity in terms of high sensitivity (MoCA) and high specificity (MMSE), combining the MoCA and MMSE in this study was found to add no diagnostic gain. This finding is concordant with an item analysis of the MoCA and MMSE (Damian *et al.*, 2011), which indicated that not all subtests were of equal predictive value and that a selection of MoCA and MMSE items with high predictive value might engender a more useful hybrid test.

The recommendation of Nasreddine *et al.* (2005) that patients with cognitive complaints but without functional impairment be administered MoCA first, because MMSE is likely to produce a normal score, finds some support in the results of the current study.

Conflict of interest

None.

Acknowledgment

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References

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, text revison (DSM-IV-TR). Washington, DC: American Psychiatric Association.

Bossuyt, P. M. *et al.* (2003). The STARD statement for reporting studies of diagnostic accuracy: explanation and elaboration. *Clinical Chemistry*, 49, 7–18.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20, 37–46.

Damian, A. M. *et al.* (2011). The Montreal Cognitive Assessment and the Mini-Mental State Examination as screening instruments for cognitive impairment: item analyses and threshold scores. *Dementia and Geriatric Cognitive Disorders*, 31, 126–131.

Dong, Y. *et al.* (2010). The Montreal Cognitive Assessment (MoCA) is superior to the Mini-Mental State Examination (MMSE) for the detection of vascular cognitive impairment after acute stroke. *Journal of the Neurological Sciences*, 299, 15–18.

Flicker, L., Logiudice, D., Carlin, J. B. and Ames, D. (1997). The predictive value of dementia screening instruments in clinical populations. *International Journal of Geriatric Psychiatry*, 12, 203–209.

Folstein, M. F., Folstein, S. E. and McHugh, P. R. (1975). "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12, 189–198.

Gagnon, J. F., Postuma, R. B., Joncas, S., Desjardins, C. and Latreille, V. (2010). The Montreal Cognitive Assessment: a screening tool for mild cognitive impairment in REM sleep behaviour disorder. *Movement Disorders*, 25, 936–940.

Gifford, D. R. and Cummings, J. L. (1999). Evaluating dementia screening tests: methodologic standards to rate their performance. *Neurology*, 52, 224–227.

Gill, D. J., Freshman, A., Blender, J. A. and Ravina, B. (2008). The Montreal Cognitive Assessment as a screening tool for cognitive impairment in Parkinson's disease. *Movement Disorders*, 23, 1043–1046.

Hancock, P. and Larner, A. J. (2009). Diagnostic utility of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) and its combination with the Addenbrooke's Cognitive Examination-Revised (ACE-R) in a memory clinic-based population. *International Psychogeriatrics*, 21, 526–530.

Hancock, P. and Larner, A. J. (2011). Test Your Memory (TYM) test: diagnostic utility in a memory clinic population. *International Journal of Geriatric Psychiatry*, 26, 976–980.

Larner, A. J. (2007). Addenbrooke's Cognitive Examination (ACE) for the diagnosis and differential diagnosis of dementia. *Clinical Neurology and Neurosurgery*, 109, 491–494.

Larner, A. J. (2009). ACE-R: cross-sectional and longitudinal use for cognitive assessment. In A. Fisher and I. Hanin (eds.), *New Trends in Alzheimer and Parkinson Related Disorders: ADPD 2009*. Collection of selected free papers from the 9th International Conference on Alzheimer's and Parkinson's disease AD/PD. Prague, Czech Republic, 11–15 March (pp.103–107) Bologna: Medimond International Proceedings.

Larner, A. J. (in press). Mini-Mental Parkinson (MMP) as a dementia screening test: comparison with the Mini-Mental State Examination (MMSE). *Current Aging Science*, 4.

Luis, C. A., Keegan, A. P. and Mullan, M. (2009). Cross validation of the Montreal Cognitive Assessment in community dwelling older adults residing in the Southeastern US. *International Journal of Geriatric Psychiatry*, 24, 197–201.

Mitchell, A. J., McGlinchey, J. B., Young, D., Chelminski, I. and Zimmerman, M. (2009). Accuracy of specific symptoms in the diagnosis of major depressive disorder in psychiatric out-patients: data from the MIDAS project. *Psychological Medicine*, 39, 1107–1116.

Nasreddine, Z. S. *et al.* (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53, 695–699.

Nazem, S. *et al.* (2009). Montreal Cognitive Assessment performance in patients with Parkinson's disease with "normal" global cognition according to Mini-Mental State Examination score. *Journal of the American Geriatrics Society*, 57, 304–308.

Olson, R. A., Chhanabhai, T. and McKenzie, M. (2008). Feasibility study of the Montreal Cognitive Assessment (MoCA) in patients with brain metastases. *Supportive Care in Cancer*, 16, 1273–1278.

Pendlebury, S. T., Cuthbertson, F. C., Welch, S. J., Mehta, Z. and Rothwell, P. M. (2010). Underestimation of cognitive impairment by Mini-Mental State Examination versus the Montreal Cognitive Assessment in patients with transient ischemic attack and stroke: a population-based study. *Stroke*, 41, 1290–1293.

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G. and Kokmen, E. (1999). Mild cognitive impairment: clinical characterization and outcome. *Archives of Neurology*, 56, 303–308.

Smith, T., Gildeh, N. and Holmes, C. (2007). The Montreal Cognitive Assessment: validity and utility in a memory clinic setting. *Canadian Journal of Psychiatry*, 52, 329–332.

Videnovic, A., Bernard, B., Fan, W., Jaglin, J., Leurgans, S. and Shannon, K. M. (2010). The Montreal Cognitive Assessment as a screening tool for cognitive dysfunction in Huntington's disease. *Movement Disorders*, 25, 401–404.

Wong, A. *et al.* (2009). The validity, reliability and clinical utility of the Hong Kong Montreal Cognitive Assessment (HK-MoCA) in patients with cerebral small vessel disease. *Dementia and Geriatric Cognitive Disorders*, 28, 81–87.

Zadikoff, C. *et al.* (2008). A comparison of the mini mental state exam to the Montreal Cognitive Assessment in identifying cognitive deficits in Parkinson's disease. *Movement Disorders*, 23, 297–299.