

## The Montreal Cognitive Assessment (MoCA) in neuro-oncology: A pilot study of feasibility and utility in telehealth and in-person clinical assessments

Varna Jammula<sup>✉</sup>, James L. Rogers, Elizabeth Vera, Alexa Christ, Heather E. Leeper, Alvina Acquaye, Nicole Briceno, Anna Choi, Ewa Grajkowska, Jason E. Levine, Matthew Lindsley, Jennifer Reyes, Kayla N. Roche, Michael Timmer, Lisa Boris, Eric Burton, Nicole Lollo, Marissa Panzer, Matthew A. Smith-Cohn, Marta Penas-Prado, Valentina Pillai, Brett J. Theeler, Jing Wu, Mark R. Gilbert, and Terri S. Armstrong<sup>✉</sup>

*Neuro-Oncology Branch, National Cancer Institute, National Institutes of Health, Bethesda, Maryland, USA (V.J., J.L.R., E.V., A.C., H.E.L., A.A., N.B., A.C., E.G., M.L., J.R., K.R., M.T., L.B., E.B., N.L., M.P., M.A.S.-C., M.P.-P., V.P., J.W., M.R.G., T.S.A.); Office of Information Technology, Center for Cancer Research, National Cancer Institute, National Institutes of Health, Bethesda, Maryland, USA (J.L.); Department of Neurology, Uniformed Services University of the Health Sciences, Bethesda, Maryland, USA (B.J.T.)*

**Corresponding Author:** Varna Jammula, BS, Neuro-Oncology Branch, National Cancer Institute, National Institutes of Health, 9030 Old Georgetown Road, Room 214, Bethesda, MD 20814, USA ([jammulavr@nih.gov](mailto:jammulavr@nih.gov)).

### Abstract

**Background.** Cognitive impairments are a common burden for patients with primary CNS tumors. Neuropsychological assessment batteries can be too lengthy, which limits their use as an objective measure of cognition during routine care. The purpose of this study was to evaluate the feasibility and utility of the brief Montreal Cognitive Assessment (MoCA) in routine in-person and telehealth visits (as a result of the global COVID-19 pandemic) with neuro-oncology patients.

**Methods.** Seventy-one adults with primary CNS tumors completed MoCA testing in person ( $n = 47$ ) and via telehealth ( $n = 24$ ). Correlation analysis and patient-reported outcomes (PROs), including symptom burden and interference, perceived cognition, general health status, and anxiety and depression, were included in this study. Feasibility was assessed through a provider satisfaction questionnaire.

**Results.** Patients were primarily White (83%), college-educated (71%) males (54%) with high-grade tumors (66%). The average total score on the MoCA administered in person was 25 (range: 6-30), with 34% classified as abnormal, and the average total score via telehealth was 26 (range: 12-30), with 29% classified as abnormal. Providers reported satisfaction in using the MoCA during routine clinical care, both in person and via telehealth. Lower MoCA scores correlated with worse symptom severity, KPS, age, education, and previous treatment.

**Conclusions.** The MoCA was feasible in clinical and telehealth settings, and its relationship to clinical characteristics and PROs highlights the need for both objective and patient-reported measures of cognition to understand the overall cognitive profile of a patient with a CNS tumor.

### Keywords

CNS tumors | cognitive dysfunction | neurocognitive testing | telehealth

Cognitive dysfunction (CD) is one of the most common symptoms experienced by primary brain tumor (PBT) patients and is associated with the disease and as a

consequence of treatment, often including surgical resection, radiation therapy, and chemotherapy.<sup>1-3</sup> In a recent systematic review of literature on neurocognitive function

in patients with diffuse glioma, 63% of patients had an impairment in at least one cognitive domain.<sup>4</sup> Similarly, Tucha et al reported that 71% of patients had impairments in 3 or more cognitive areas.<sup>5</sup> Furthermore, deficits in the cognitive domains of executive functioning, attention, memory, and processing speed have shown to be detrimental to a patient's quality of life, even after treatment is ceased.<sup>3,6</sup> Previous research suggests that assessing CD in this population is important as it may provide insight into overall survival, progression-free survival, and direct tumor management.<sup>7,8</sup> Spinal cord tumors are rare, and there are limited reports describing cognitive function in these patients. However, there is evidence of cognitive impairment in those with spinal cord injury, specifically in the cognitive domains of memory, attention, and processing speed.<sup>9,10</sup> Craig et al reported that about 30% of the adult spinal cord injury population have severe cognitive impairments.<sup>11</sup> When considering the similarities between the mechanisms of spinal cord injuries and spinal cord tumors,<sup>12</sup> these findings highlight the need to explore cognitive deficits in the primary CNS tumor population.

Both patient-reported and objective measures of CD have been developed to assess and improve the evaluation of patients reporting or clinically suspected to have cognitive deficits. Several patient-reported measures are commonly used to assess PBT patients including the HealthMeasures Quality of Life in Neurological Disorders (Neuro-QOL) Cognitive Function tool<sup>13</sup> and the MD Anderson Symptom Inventory-Brain Tumor module (MDASI-BT).<sup>14</sup> Previous studies have identified limitations to solely relying on patient-reported measures of cognition as patients may under or overreport perceived cognitive impairments.<sup>15</sup> Objective cognitive functioning measures include neurocognitive assessments, which allow health care providers to identify deficits within specific cognitive domains and avoid issues inherent with patient self-report data. While narrow in scope, cognitive screening tests are brief and used by clinicians as a tool to monitor progression of CD or identify impairment in at-risk individuals.<sup>16</sup> The Mini-Mental State Examination (MMSE) is the most used screening tool in PBT clinical trials and assesses orientation, attention, memory, language, and visuospatial skills.<sup>17</sup> However, the MMSE has limited value in detecting CD in visuospatial and executive function and has minimal sensitivity in the brain tumor population.<sup>18,19</sup> Other validated performance-based measures commonly used in brain tumor research include the Mattis Dementia Rating Scale, Neuropsychiatric Inventory, Hopkins Verbal Learning Test-Revised, Trail Making Test, Controlled Oral Word Association Test, Digit Span, Digit Symbol, Hand Dynamometer, and the Grooved Pegboard Test.<sup>17</sup> Neurocognitive batteries include a combination of these objective tests and provide a comprehensive picture of a patient's cognitive function across several domains, which can aid in diagnosis.<sup>16</sup> Assessing cognition among PBT patients can be challenging when considering the length and sensitivity of these various tests while also trying to administer an assessment battery that addresses all relevant cognitive domains. The time needed to complete test administration training and the extensive time needed for the patients to complete the tests make them difficult to administer and limit their frequent use during routine clinical

assessments. In addition, not having a standardized approach to cognitive testing and screening in routine clinical assessments limits the ability to quantify these important cognitive symptoms.

The Montreal Cognitive Assessment (MoCA) is a brief screening tool created to identify mild cognitive impairment (MCI) and has better sensitivity than the MMSE.<sup>20</sup> While it was originally developed for patients with MCI and Alzheimer's disease, the MoCA detected cognitive impairment better than the MMSE in patients with brain metastases. In a study by Olson et al, over half of the patients that were classified as normal by the MMSE were found to be cognitively impaired by the MoCA.<sup>18</sup> However, when comparing the MoCA to a more comprehensive neuropsychological battery in a PBT population, the MoCA has poorer sensitivity to detecting cognitive deficits.<sup>21</sup> This study by Robinson et al had some limitations in its small sample size and a patient population of mostly highly educated male adults. The use and sensitivity of the MoCA in the PBT population continues to be a question of interest, and few studies have explored its validity and feasibility among neuro-oncology patients. Due to the global COVID-19 pandemic, our practice, like many others, incorporated telehealth assessments into routine clinical care. Few studies have investigated the administration of the MoCA remotely,<sup>22-25</sup> and they have found the remote administration to be feasible and valid.<sup>23,24</sup> However, no studies have explored its feasibility specifically within the neuro-oncology population. Therefore, the present study seeks to evaluate the feasibility and utility of the MoCA in routine assessment in telehealth and in-person clinical care of neuro-oncology patients. This study also describes associations between MoCA scores and subjective measures of cognition, symptom burden, and general health status.

## Materials and Methods

### Participants

Patients with primary CNS tumors enrolled in the Neuro-Oncology Branch Natural History Study (NOB-NHS; NCT02851706) and being followed throughout their disease course were included in this cross-sectional study. The Neuro-Oncology Branch sees adult patients with primary CNS tumors referred for consultation or clinical therapeutic trial participation. The most common tumors seen are glioblastoma, oligodendroglioma, and ependymoma (which more commonly occurs in the spine) The NHS is an IRB-approved observational protocol that follows patients diagnosed with primary CNS tumors longitudinally throughout their disease course. Informed consent was obtained from all patients enrolled in the study. Importantly, all patients seen for clinical assessment and care are required to be on a clinical study (ClinicalTrials.gov Identifier: NCT00009035). This study allows for the evaluation of tools for clinical care and describes the impact of the disease and treatment on the patient. The evaluation of the MoCA as a tool in routine assessments was added to this study, and patients were enrolled January-March of 2020 (assessments performed as part of routine

assessment in the outpatient clinic) and March-May of 2021 (assessments performed as part of telehealth assessments, due to the global COVID-19 pandemic). All patients provided informed consent, and their demographic, clinical, and tumor-related information were collected at the time of study entry to the NOB-NHS. The present study includes both objective cognitive testing and subjective patient-reported outcomes (PROs), which are routinely assessed as a part of clinical care. PROs were obtained electronically and could have been completed up to 1 week prior to each clinical evaluation. All clinical providers (neuro-oncologists and nurse practitioners) completed training and certification through the official MoCA website.<sup>26</sup>

### Montreal Cognitive Assessment Administration

The MoCA is a brief cognitive screening tool used as an objective measure of cognitive function in 8 domains (attention and concentration, executive function, memory, language, visuoconstructional skills, conceptual thinking, calculation, and orientation).<sup>20</sup> In the outpatient clinic, clinical providers, including physicians and nurse practitioners, were given a hard (paper) copy of the MoCA along with an instruction manual prior to each patient. MoCA test versions were altered on a monthly basis, and each test scored by a clinician was reliability checked and re-scored by another trained individual (V.J.). Any discrepancies between the original score and reliability checked score were adjudicated between the 2 individuals until agreement on a final score was reached. This testing was done as a part of routine clinical assessment, replacing other cognitive assessments by the clinical providers.

A standard operating procedure (SOP) for MoCA use in telehealth was developed with guidance from the official MoCA website<sup>26</sup> and literature on the remote use of the MoCA,<sup>22-24</sup> with modification to allow for ease of administration. MoCAs were administered prior to clinical visits via Microsoft Teams (Microsoft Corporation, Redmond, WA, USA) by 2 clinical research team members (V.J. and J.L.R.). These assessment visits were scheduled prior to patient's telehealth clinical visits with their provider. Depending on patient and staff availability, assessment visits occurred either on the same or different days within the week, ensuring that results would be available before the patient's telehealth visit with their physician.

The telehealth MoCA SOP included the following: each MoCA visit began with a PowerPoint (Microsoft Corporation) slide presentation and the test initiation time was noted on the administrator's printed copy of the test. In the first slide, the test administrator introduced himself/herself, explained the purpose of the testing, and stated the name and location of the NCI Neuro-Oncology Branch Clinic (Bethesda, MD, USA). The second slide displayed an image of the Trail Making Test item of the assessment. Patients were asked to verbally state where the arrow would go next based on the pattern described. Slides 3 and 4 included images of the cube or chair copy (depending on the version) and the clock drawing items, respectively. Patients were asked to copy the figure and draw a clock with the correct time as instructed on a blank piece of paper, which they were asked to provide. At the conclusion

of testing, patients were asked to show their drawings to the camera for the administrator to screenshot and score.

The remaining PowerPoint slides included images of each animal in the naming section, which patients were asked to state aloud individually. Other modifications from the original in-person version of the MoCA occurred in the vigilance test of attention and the orientation sections. In the test of attention, patients were asked to clap or raise their hands rather than tap their hands. In the orientation portion, the questions for "place" and "city" were replaced with the name and location of the NCI Neuro-Oncology Branch clinic. At the end of testing, the time was recorded again by the administrator, who then documented the total time to complete the MoCA. Patients were also asked an open-ended question about their satisfaction with completing the MoCA via a telehealth visit. Similar to the in-person MoCA, the telehealth MoCA was scored by the test administrator and reliability checked by another individual (either V.J. or J.L.R.). Any discrepancies between the original score and reliability checked scores were adjudicated between the 2 individuals until agreement on a final score was reached. Test versions were changed every month.

### Patient-Reported Outcomes

The Neuro-QOL Item Bank v2.0-Cognitive Function-Short Form<sup>13</sup> was used to assess patient-perceived cognitive function. The MDASI-BT and MD Anderson Symptom Inventory-Spine Tumor module (MDASI-SP),<sup>27</sup> depending on primary lesion location, were used to assess patient-reported symptom burden and interference. Overall symptom severity (average of symptom items), interference (average of 6 interference items), and for those completing the MDASI-BT, the Cognitive Factor<sup>14</sup> was used as a self-reported measure of cognitive symptom burden within the past 24 hours, specifically in difficulty remembering, understanding, speaking, and concentrating. The EQ-5D-3L was used as a self-report of general health status within the 5 dimensions of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression.<sup>28</sup> The Patient-Reported Outcomes Measurement Information System (PROMIS) was used as a self-report of anxiety and depression through the PROMIS Item Bank v1.0-Emotional Distress-Anxiety Short Form and v1.0-Emotional Distress-Depression Short Form.<sup>29</sup> Patients with a set of MoCA and PROs from the same clinical evaluation were included in the analysis of associations between the MoCA and PROs. A higher score on the MDASI-BT and MDASI-SP indicates worse symptom burden and interference severity. A higher index score on the EQ-5D-3L suggests a better perception of health, and similarly, a higher score on the Neuro-QOL indicates better patient-perceived cognitive function.

### Feasibility Measures

All providers were asked to complete a series of multiple-choice and open-ended questions regarding their thoughts on the use of the MoCA both in clinic and via

**Table 1.** Montreal Cognitive Assessment (MoCA) Feasibility Questionnaire for Clinical Providers**In-person MoCA Feasibility Questions**

1. Did you include the MoCA in your neurologic assessment of every patient?
2. Were the results of the MoCA assessment performed by your team discussed prior to you seeing the patient?
3. If you did not include the MoCA in your assessment, what stopped you from using it during your evaluation?
4. Did you find the MoCA difficult to incorporate into your assessment?
5. Estimate the amount of time it took you to administer the MoCA in each evaluation
6. In your opinion, were you able to accurately assess the patient's level of cognition with the MoCA?
7. Did you use the results of the MoCA when determining the course of treatment for the patient?
8. Additional comments?

**Telehealth MoCA Feasibility Questions**

1. Were the MoCA results from the virtual assessment visits discussed with your patients during their telehealth or clinic visits?
2. Did you find administration of the MoCA in a separate visit helpful for your clinical practice and telehealth visit with your patients?
3. In your opinion, were you able to accurately assess your patients' cognition using the MoCA results obtained during remote assessment visits?
4. Did you use the remote MoCA results when determining the course of treatment for any of your patients?
5. Additional comments?

telehealth. [Table 1](#) outlines the list of questions that were included in these feasibility questionnaires.

### Statistical Analyses

Descriptive statistics were used to characterize the sample and summarize MoCA and PRO scores from in-person clinic and telehealth visits. For patients that had both telehealth and in-clinic MoCA scores ( $n = 7$ ), only the telehealth assessment score was used in the analyses. Neuro-QOL T-scores  $<40$  were considered moderate to severe CD<sup>13</sup> and MoCA total scores  $\leq 25$  were considered abnormal.<sup>20</sup> The 5 dimensions of the EQ-5D-3L were dichotomized into "some problems" and "no problems." A Karnofsky performance status (KPS) score  $\geq 90$  was categorized as "good" while a KPS score  $\leq 80$  was categorized as "poor." Tumor grade was dichotomized into low grade (WHO grades I/II) and high grade (WHO grades III/IV). Patients were grouped based on tumor location: brain, brain and spine, or spine. Any tumor location that involved the frontal lobe, either alone or in combination with another location, was categorized as "frontal," and all other tumors were categorized as "elsewhere." Race and ethnicity were dichotomized into a White/Hispanic group and a White/non-Hispanic group, with Asians, Blacks, and Native Hawaiian/Pacific Islanders grouped together with White/Hispanics. The "college" education group included patients with "some college" education and patients who received a bachelor's degree.

Spearman's correlations were performed on the associations between the MoCA scores and PROs, age, and KPS. Mann-Whitney *U* tests were performed for between-group differences for continuous variables and Fisher's exact tests for associations among categorical variables. Due to a small sample size, patients with a tumor in the brain and spine and patients with a tumor in the brain were grouped together for the statistical tests performed. All statistical analyses were performed in IBM SPSS Statistics (IBM Corp. Released 2019, IBM SPSS Statistics for Windows, Version 26.0, IBM Corp., Armonk, NY, USA).

## Results

### Patient Demographics and MoCA Scoring

The present study included 71 patients with an average age of 43 years (range: 19-75). The majority of patients were male (54%), college-educated (71%), and White (83%). The most common tumor diagnosis was glioblastoma (20%), with the majority of patients having received radiation therapy (78%). Most patients also had a good KPS (57%) and were not currently on treatment (79%). See [Table 2](#) for additional demographic and clinical information.

The median total score on the MoCA was 27 (range: 6-30), with 32% ( $n = 23$ ) classified as abnormal ([Table 3](#)). Most patients had a tumor located in the brain or brain and spine region (82%), with a median score of 26 on the MoCA compared to spine patients (18%) with a median score of 28. The median age within the brain or brain and spine tumor group was 41, with 44% of patients with abnormal

**Table 2.** Patient Demographic and Clinical Characteristics, N = 71

Age	Mean (SD), Range	43 (13)	19-75
		n	%
Diagnosis	Anaplastic astrocytoma	10	14
	Anaplastic ependymoma	7	10
	Anaplastic hemangiopericytoma	1	1
	Anaplastic oligodendroglioma	6	8
	Anaplastic pleomorphic xanthoastrocytoma	2	3
	Astrocytoma	5	7
	Diffuse midline glioma	2	3
	Dysembryoplastic neuroepithelial tumor	1	1
	Ependymoma	7	10
	Glioblastoma	14	20
	Gliosarcoma	1	1
	High-grade neuroepithelial tumor	1	1
	Medulloblastoma	2	3
	Myxopapillary ependymoma	4	6
	Oligodendroglioma	1	1
	Papillary tumor of pineal region	1	1
	Pilocytic astrocytoma	3	4
	Pleomorphic xanthoastrocytoma	1	1
	No tissue diagnosis	2	3
Number of treatments	0	27	38
	1	24	34
	≥2	20	28
Current treatment phase	Active treatment	15	21
	Surveillance	56	79
Number of surgeries	0	2	3
	1	39	55
	2	19	27
	≥3	11	15
Original surgery extent	Biopsy	17	24
	Subtotal resection	29	41
	Gross total resection	18	25
	Resection NOS	5	7
Number of recurrences	0	41	58
	1	12	17
	≥2	18	25
Tumor location	Brain	52	73
	Brain + spine	6	8
	Spine	13	18

**Abbreviations:** NOS, not otherwise specified; SD, standard deviation.

MoCA scores being older than 41. The median age within the spine tumor only group was 45, with 29% of patients with abnormal scores being younger than 45 and no patients with abnormal scores over the median age. See [Table 4](#) for additional demographic, clinical, and MoCA score information based on tumor location in the brain vs spine.

### MoCA in Routine In-Person Assessment

The MoCA was administered in person to 47 patients, and the median MoCA score for this group overall was 26 (range: 6-30), with 34% of patients having a score classified as abnormal. All 9 providers who used the MoCA in clinical care completed the feasibility questionnaire on the use of the

**Table 3.** Montreal Cognitive Assessment (MoCA) Test Details by Visit Type

	N	Clinic Visit		Telehealth Visit		Total	
		47	5	24	4	71	5
MoCA time	Mean (SD), range	—	—	13:29 (03:25)	9:20-22:05	13:29 (03:25)	9:20-22:05
MoCA score	Mean, SD	25	5	26	4	25	5
	Median, range	26	6-30	27	12-30	27	6-30
		n	%	n	%	n	%
MoCA result <sup>a</sup>	Normal	31	66	17	71	48	68
	Abnormal	16	34	7	29	23	32
Sex	Female	23	49	10	42	33	46
	Male	24	51	14	58	38	54
Ethnoracial group	White/Hispanic <sup>b</sup>	8	17	4	17	12	17
	White/non-Hispanic	35	75	20	83	55	78
Education	High school	6	13	2	8	8	11
	College	27	57	14	58	41	58
	Graduate/professional	12	26	7	29	19	27
KPS	100	11	23	9	38	20	28
	90	15	32	6	25	21	30
	80	11	23	4	17	15	21
	70	9	19	0	0	9	13
	60	1	2	1	4	2	3
	50	0	0	1	4	1	1
Recurrence	No	27	57	14	58	41	58
	Yes	20	43	10	42	30	42
Tumor grade	Low	15	32	7	29	22	31
	High	31	66	16	67	47	66
Radiation	No	12	26	4	17	16	22
	Yes	35	74	20	83	55	78
Levetiracetam use	No	27	57	17	71	44	62
	Yes	20	43	7	29	27	38
Dexamethasone use	No	43	91	22	92	65	91
	Yes	4	9	2	8	6	9
Sites	Single	35	75	15	63	50	70
	Multiple	11	23	9	38	20	28
Tumor side	Right	22	47	13	54	35	49
	Left	10	21	3	13	13	18
	Posterior fossa	1	2	2	8	3	4
	Brainstem/midline	2	4	1	4	3	4
	Left + right	2	4	1	4	3	4
	N/A	9	19	4	17	13	18
Frontal lobe involvement	Frontal	15	32	10	42	25	35
	Elsewhere	31	66	14	58	45	63

**Abbreviations:** KPS, Karnofsky performance status; SD, standard deviation.

<sup>a</sup>Abnormal = MoCA score  $\leq$ 25.

<sup>b</sup>includes Asian, Black/African American, Native Hawaiian/Pacific Islander, and Hispanic/Latino.

MoCA as part of routine in-person clinical assessments, and 6 out of 9 providers stated the MoCA was used during the neurologic evaluation of each patient. Additionally, 6 out of

9 providers reported that the MoCA results were discussed during the clinical case presentations prior to the attending physician seeing their patient. Those who did not discuss the

**Table 4.** Associations Among Patient Characteristics and MoCA Scores Based on Tumor Location Groups, N = 71

	Brain, Brain + Spine				Spine			
	n	%	Median MoCA Score	% With Abnormal MoCA	n	%	Median MoCA Score	% With Abnormal MoCA
Total	58	100	26	36	13	100	28	15
Sex								
Female	26	45	26	35	7	54	29	14
Male	32	55	27	38	6	46	28	17
Ethnoracial group								
White/Hispanic <sup>b</sup>	10	17	27	40	2	15	29	0
White/non-Hispanic	44	76	26	34	11	85	28	18
Missing	4	7	24	50	0	0		0
Education								
High school	7	12	23	71	1	8	29	0
College	49	88	27	33	11	92	28	18
KPS group								
Poor (<=80)	24	41	26	46	3	23	28	33
Good (>=90)	31	53	27	29	10	77	29	10
Recurrence								
No	31	53	27	26	10	77	28	20
Yes	27	47	26	48	3	23	29	0
Tumor grade								
Low grade (I/II)	11	19	27	27	11	85	27	18
High grade (III/IV)	45	78	26	40	2	15	30	0
Radiation								
No	11	19	26	18	6	46	28	20
Yes	47	81	26	40	7	54	29	13
Levetiracetam use								
No	31	53	26	36	13	100	27	15
Yes	27	47	26	37	0	0		0
Dexamethasone use								
No	53	91	26	36	12	92	28	8
Yes	5	9	26	40	1	8	16	100
Sites								
Single	41	71	27	32				
Multiple	16	28	26	44				
Missing	1	2	24	100				
Tumor side								
Right	35	60	26	40				
Left	13	22	27	31				
Left + right	3	5	25	67				
Posterior fossa	3	5	28	0				
Brainstem/midline	3	5	27	0				
Missing	1	2	24	100				
Frontal lobe involvement								
Frontal	25	43	26	40				
Elsewhere	32	55	27	31				
Missing	1	2	24	100				

**Abbreviations:** KPS, Karnofsky performance status; MoCA, Montreal Cognitive Assessment.

<sup>a</sup>Abnormal = MoCA score <25.

<sup>b</sup>Includes Asian, Black/African American, Native Hawaiian/Pacific Islander, and Hispanic/Latino.

MoCA results reported that their patient's scores did not indicate cognitive issues. The majority (78%) of providers did not find it difficult to incorporate the MoCA into their routine clinical assessment of the patient, with an estimated administration time of 5-20 minutes depending on the individual patient. The majority (67%) felt that cognition was accurately assessed, and 89% of providers stated that the results of the MoCA were useful when considering treatment and discussing follow-up plans. In the open-ended question of the feasibility questionnaire, 3 out of 9 providers reported the difficulties faced when assessing patients in clinic. One provider stated that they felt the assessment took too long to complete in clinic, while 2 providers reported that some of their patients were having too much difficulty completing the MoCA. In these instances, the patients did not complete the MoCA and their results were not recorded for analysis in this study.

### MoCA in Telehealth Assessment

The MoCA was administered via telehealth to 24 patients, and the median MoCA score for this group overall was 27 (range: 12-30), with 29% having scores considered abnormal. On average, the MoCA was completed in 13 minutes (range: 9-22). Overall, patients had positive feedback and reported satisfaction and with administration of the MoCA via telehealth, specifically stating that having "time spent away from home" and traveling to the clinic previously for in-person assessments contributed to fatigue when taking the MoCA. They also felt more comfortable in their own home or chosen environment rather than the more "stressful environment" of the clinic. However, test administrators reported that some patients were noticeably distracted by family members or children in their home while taking the assessment.

Eight out of 11 providers whose patients underwent MoCA testing responded to the feasibility questionnaire on the use of the MoCA via telehealth, and 3 providers did not complete the questionnaire due to scheduling conflicts that

resulted in a lack of MoCA assessments in their patients. Of the 8 providers who completed the questionnaire, the majority (63%) stated they discussed the results of the remote MoCA with their patients during their visit and found the administration of the MoCA in a separate visit helpful (75%) in their clinical practice. The majority (63%) felt cognition was accurately assessed. Use in determining treatment course could not be assessed, as the majority (88%) stated patients either did not have a treatment decision as part of the visit or did not have cognitive impairment. Difficulties found when assessing patients remotely included 6 instances of technical difficulties (Wi-Fi connectivity and electronic device camera not working), distractions in the home environment, and the use of a smart tablet during the drawing section, which can alter the patient's drawing to appear more precise. All but one attempted assessment was completed.

### Associations Between the MoCA and Sample Characteristics

Spearman rho correlations among MoCA total scores and sample characteristics are shown in Table 5, and correlations among MoCA total scores and PROs are shown in Table 6.

There was a difference in MoCA scores between patients with spine tumors and patients with brain or brain and spine tumors ( $P = .01$ ), with patients with brain tumors scoring lower on the MoCA, consistent with more cognitive difficulties. Further associations in those with spine tumors could not be undertaken due to the small sample size.

Among patients with brain or brain and spine tumors, KPS was positively correlated with total MoCA scores ( $r = 0.35$ ,  $P = .009$ ), with a higher KPS associated with a higher MoCA score. However, this did not remain statistically significant when KPS was dichotomized into "good" and "poor." Among the 3 levels of education, a difference in MoCA scores was noted ( $P = .03$ ), with high school

**Table 5.** Associations Among MoCA Median Score and Severity and Patient and Clinical Characteristics Among Brain, Brain + Spine Tumor Patients, N = 71

		Median MoCA Score	% With Abnormal MoCA <sup>a</sup>	Statistic	Sig.
KPS <sup>b</sup>				0.35	0.009
Education <sup>c,d</sup>	High school	23	71	7.0, 4.3	0.030, 0.042
	College	26	35		
	Graduate/professional	28	27		
Age <sup>b</sup>				0.27	0.042
Radiation <sup>d</sup>	None prior		18	1.9	0.296
	Prior		40		
Treatment <sup>d</sup>	None prior		13	4.6	0.059
	Prior		44		

**Abbreviations:** KPS, Karnofsky performance status; MoCA, Montreal Cognitive Assessment.

<sup>a</sup>Abnormal = MoCA score  $\leq 25$ ;

<sup>b</sup>Correlation;

<sup>c</sup>Kruskal-Wallis test;

<sup>d</sup>Fisher's exact test.



**Table 6.** Spearman Rho Correlation Coefficients Among MoCA Total Score and PROs

		MoCA Total Score	
		Brain, Brain + Spine	Spine
n		58	13
Overall symptom burden		−0.226	−0.492
Symptom factors	Affective symptom factor	−0.160	Disease-related symptom factor −0.257
	Cognitive symptom factor	−0.271 <sup>a</sup>	Autonomic function symptom factor −0.676 <sup>a</sup>
	Neurologic symptom factor	−0.178	Constitutional/treatment symptom factor −0.479
	Treatment-related symptom factor	−0.244	Emotional symptom factor −0.265
	General disease symptom factor	−0.321 <sup>a</sup>	
	GI symptom factor	0.010	
Overall symptom interference		−0.168	−0.344
Symptom interference subscales	Activity-related interference	−0.104	−0.331
	Mood-related interference	−0.244	−0.415
EQ-5D-3L Index score		0.219	0.192
PROMIS Anxiety T-score		−0.118	−0.380
PROMIS Depression T-score		−0.068	−0.169
Neuro-QOL Cognition Function T-score		0.206	0.450

**Abbreviations:** GI, gastrointestinal; MoCA, Montreal Cognitive Assessment; Neuro-QOL, HealthMeasures Quality of Life in Neurological Disorders; PROMIS, Patient-Reported Outcomes Measurement Information System; PROs, Patient-reported outcomes.

<sup>a</sup> $P < .05$ .

graduates scoring lower (ie, having greater cognitive impairment) than graduate/professional school graduates. More older patients ( $P = .042$ ) and patients with prior treatment ( $P = .059$ ) had abnormal MoCA scores than younger patients or those who underwent surgery alone (44% vs 29% and 44% vs 13%, respectively).

### Association Between MoCA scores and PROs

In patients with brain or brain and spine tumors, MoCA scores were negatively correlated with the MDASI-BT cognitive ( $r = -0.27$ ,  $P = .040$ ) and general disease symptom factors ( $r = -0.32$ ,  $P = .010$ ), which included change in vision. Among patients with spine tumors ( $n = 13$ ), MoCA scores were negatively correlated with the autonomic symptom factor ( $r = -0.68$ ,  $P = .01$ ), which included alterations in bowel and bladder function and sexual dysfunction. Lower MoCA scores paired with worse symptom severity. There were no associations with overall symptom severity, interference, perceived cognition as measured by the Neuro-QOL cognition, general health status as measured by the EQ-5D, or mood disturbance as measured by the PROMIS Anxiety and PROMIS Depression.

## Discussion

The present study describes the feasibility and utility of the MoCA in clinical care of patients living with primary CNS tumors. Associations between objective MoCA scores, patient characteristics, and PROs were also outlined. Over a third of patients who were assessed in the clinic or by telehealth had abnormal MoCA scores. The majority of clinicians found the test to be easy to incorporate into their clinical practice and felt it accurately assessed cognitive function both in face-to-face and telehealth settings. Providers often discussed the MoCA results with other providers and their patients. Some providers reported issues with the length of the assessment during clinic visits, and a few expected technical difficulties involving Wi-Fi and other connectivity issues arose while administering the MoCA remotely.

Patients were also satisfied with taking the MoCA remotely, stating that they preferred the less stressful environment of their home and not having fatigue as a result of travel to the clinic, which may have impacted the results of their MoCA. Test administrators reported distractions by family members or children in the patient's home

environment; this may have not only affected the patient's performance, specifically on the attention portions of the MoCA, but also the average time it took to complete, as reported in this study. A few patients also used a smart tablet rather than a paper and pencil for the visuospatial and executive function portions of the MoCA, which may have altered their drawings to appear more precise. Future studies and providers administering the MoCA via telehealth should consider emphasizing the importance of completing the assessment in a quiet room and using a pencil and paper.

Previous studies have found the MoCA to be a valid measure of CD, specifically in patients with MCI or neurodegenerative disease.<sup>30,31</sup> When comparing the MoCA to the MMSE and a neuropsychological assessment battery, Lam and colleagues<sup>31</sup> and Hoops and colleagues<sup>30</sup> found that MoCA scores aligned with scores on the comprehensive battery, and their sensitivity was superior to that of MMSE scores. The feasibility of the MoCA reported in the present study aligns with findings of previous feasibility studies in the neuro-oncology population by Olson et al<sup>18</sup> and Renovanz et al.<sup>32</sup> The validity and feasibility of the MoCA support its use in place of intensive assessment batteries or as a red flag for later completion of more extensive testing<sup>33</sup> may save time and relieve patient burden. Furthermore, the MoCA may be useful as a screening tool for determining the added value of performing more detailed assessments, and future studies should continue to investigate this.

Overall, there are a limited number of studies that have reported on administering the MoCA remotely, with no studies identified by the authors focusing specifically in the neuro-oncology population. These studies<sup>22-24</sup> found that remote MoCA testing is feasible, similar to the findings of this pilot study. MoCA scores resulting from telehealth administration were higher than scores resulting from in-person administration in our study. The differences in assessment methods and the demographic of patients seen over telehealth may have contributed to the descriptive differences between in-person and telehealth assessment groups. Previously, Chapman et al reported that there were no differences in MoCA performance between stroke survivors who had taken the MoCA both in person and via teleconference.<sup>22</sup> While this finding provides supporting evidence of the reliability of the remote MoCA in the stroke patient population, future studies are needed to further evaluate the test-retest reliability of the MoCA specifically in the neuro-oncology population.

Lower KPS, prior treatment, a high school education, and older age were each associated with lower scores on the MoCA. Interestingly, a small subset (15%) of those with spine tumors also had abnormal cognitive test scores. Comprehensive neuropsychological assessments have shown similar associations to education and age within the brain tumor population.<sup>34</sup> One important concept to consider is cognitive reserve, which is a theory that explains the differences between cognitive outcomes of a disease and brain pathology. More specifically, cognitive reserve refers to factors that help the brain compensate for brain damage, and education is known to be a common proxy by playing a protective role in disease outcomes.<sup>35</sup> The findings in the present study regarding the relationship between education status and MoCA scores further

support this concept. Although this was a cross-sectional study, analyzing the effects of education on MoCA scores longitudinally may provide more insight into cognitive reserve in this patient population. A recent study has found that patients with isocitrate dehydrogenase (*IDH*)-wildtype gliomas may have worse cognitive decline than those with *IDH*-mutant gliomas,<sup>36</sup> and other studies suggest an association between *APOE* alleles and cognitive function among brain tumor patients.<sup>37</sup> This suggests further genomic analysis in addition to neurocognitive testing may be necessary to understand the patient's overall cognitive profile and provide appropriate treatment.

Importantly, when considering the associations identified among MoCA scores, patient characteristics, and PROs, it is important to consider the unique nature of brain and spine neoplasms. In neuro-oncology, cognition is physiologically impacted by both the tumor treatment and the disease itself.<sup>38</sup> Similar to other disease populations, neuro-oncology patients with co-morbid conditions that impact cognition also struggle with worse cognitive impairment. Future studies on the use of the objective measures of cognition, such as the MoCA, should consider controlling for these factors to highlight the value of such assessments in neuro-oncology.

Within tumor location groups, there were correlations between MoCA scores and self-reported severity of cognitive symptoms on the MDASI-BT, general disease, and autonomic symptom factors. Associations with other self-report measures, most notably Neuro-QOL, were not found in this study. This may be because the cognitive functions that patients perceive they are having difficulties with, as reported in the Neuro-QOL, are not tested by the MoCA (ie, reading comprehension, multi-tasking, planning, etc.). In addition, we agree with other reports<sup>32</sup> that future research should consider the relevance of the abnormal ( $\leq 25$ ) MoCA score cutoff in neuro-oncology by exploring associations with deficits on objective neurocognitive testing and changes in patient-reported function over time. Importantly, the MoCA was originally designed for use in patients with Alzheimer's disease,<sup>20</sup> and thus a different threshold score may be more appropriate in patients with CNS tumors. Additionally, future prospective studies with larger and more pathologically heterogeneous sample sizes are needed to truly appreciate the role of the MoCA in neuro-oncology. Ultimately, the MoCA is only one tool in the neuro-oncologist's armamentarium and must be considered in the context of other clinical indications of cognitive functioning.

## Limitations

There are several key limitations to the present study worth considering when evaluating the results of this pilot study. First, the sample size accrued for this study was small, specifically in the group of patients who underwent the MoCA via telehealth. This limitation reduced the study's statistical power and may have affected the ability to detect statistically significant associations between MoCA scores and patient characteristics and PROs. Additionally, due to the nature of this study, only univariate associations could be investigated. Second, the MoCA scoring guidelines used in the present study were developed based on research in other patient populations.

Therefore, it is important to continue to evaluate the use of the MoCA in patients with brain tumors to ensure these guidelines allow for an accurate assessment of cognition in this patient population. Third, the method of administering the executive/visuospatial portion of the MoCA, specifically the Trail Making Test, via telehealth was recommended by the official MoCA website<sup>26</sup>; however, its validity is not well studied. The results of this portion of the test may not have accurately assessed executive/visuospatial function, and future studies should continue to evaluate the validity of telehealth administration.

The present study also included a sample being cared for at a large, quaternary referral center and thus might not reflect the population of neuro-oncology patients seen in the community setting. In addition, patients who were seen via telehealth were not undergoing treatment at the time of MoCA administration, which may have resulted in a selection bias for patients who were less likely to have cognitive deficits. Finally, the study lacks a longitudinal analysis of the use of MoCA scores and associations to patient characteristics and PROs. Assessing cognition over longer periods of time may provide greater insight into the causal relationships between MoCA scores, patient characteristics, and PROs, which can, in turn, help clinicians to target CD and improve patient outcomes.

## Conclusions and Implications

In summary, the present study indicates that the use of the MoCA is feasible in both telehealth and in-person clinical settings for patients with CNS tumors. The findings suggest that KPS, age, education, and previous treatment are factors that may impact cognitive outcomes of patients with CNS tumors. Future studies should continue to evaluate the relation of these factors to cognitive outcomes of disease in neuro-oncology, establish validation of the proposed cutoff score, and continue to assess the feasibility of use in routine care.

There were few associations found between MoCA scores and PROs in either tumor location group. A possible explanation is that the MoCA tests different areas of cognitive function than PROs, underscoring the importance of including both objective and subjective measures of cognition during routine clinical care. Additionally, since the MoCA may not be sensitive enough to assess for CD in brain tumor patients,<sup>32</sup> identifying a more appropriate “abnormal” cutoff score might be key in accurately determining one’s level of cognitive functioning.

Providers also noted that some patients, specifically those with severe deficits, took significantly longer to complete the MoCA than other neuro-oncology patients. For these patients, the MoCA may be too difficult, and using another form of a brief neurocognitive assessment may be appropriate. Therefore, having a caregiver present during the assessment, especially when administered remotely, may be helpful. Future studies need to evaluate whether the MoCA remains accurate in assessing cognition in patients of this population with severe deficits. Additional studies exploring use in a larger sample and longitudinally over time are underway and will be shared in a subsequent report.

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## References

- Correa D. Neurocognitive function in brain tumors. *Curr Neurol Neurosci Rep.* 2010;10(3):232–239.
- Chang E, Wefel J, Hess K, et al. Neurocognition in patients with brain metastases treated with radiosurgery or radiosurgery plus whole-brain irradiation: a randomised controlled trial. *Lancet Oncol.* 2009;10(11):1037–1044.
- Lawrie T, Gillespie D, Dowswell T, et al. Long-term neurocognitive and other side effects of radiotherapy, with or without chemotherapy, for glioma. *Cochrane Database of Syst Rev.* 2019;8(8):CD013047.
- van Kessel E, Baumfalk A, Zandvoort M, Robe P, Snijders T. Tumor-related neurocognitive dysfunction in patients with diffuse glioma: a systematic review of neurocognitive functioning prior to anti-tumor treatment. *J Neurooncol.* 2017;134(1):9–18.
- Tucha O, Smely C, Preier M, Lange K. Cognitive deficits before treatment among patients with brain tumors. *Neurosurgery.* 2000;47(2):324–334.
- Classen L, Amidi A, Wu L, et al. Long-term cognitive dysfunction after radiation therapy for primary brain tumors. *Acta Oncol.* 2019;58(5):745–752.
- Wefel J, Cloughesy T, Zazzali J, et al. Neurocognitive function in patients with recurrent glioblastoma treated with bevacizumab. *Neuro Oncol.* 2011;13(6):660–668.
- Zarino B, Cristofori A, Fornara G, et al. Long-term follow up of neuropsychological functions in patients with high grade gliomas: can cognitive status predict patient’s outcome after surgery. *Acta Neurochir.* 2020;162(4):803–812.
- Distel D, Amodeo M, Joshi S, Abramoff B. Cognitive dysfunction in persons with chronic spinal cord injuries. *Phys Med Rehabil Clin N Am.* 2020;31(3):345–368.
- Chen Y, Liang L, Cao S, et al. Serum CCL21 as a potential biomarker for cognitive impairment in spinal cord injury. *Biomed Res Int.* 2020;2020:1–5.
- Craig A, Guest R, Tran Y, Middleton J. Cognitive impairment and mood states after spinal cord injury. *J Neurotrauma.* 2017;34(6):1156–1163.
- Ge L, Arul K, Mesfin A. Spinal cord injury from spinal tumors: prevalence, management, and outcomes. *World Neurosurg.* 2019;122:e1551–e1556.
- Cella D, Lai J-S, Nowinski C, et al. Neuro-QOL: brief measures of health-related quality of life for clinical research in neurology. *Neurology.* 2012;78(23):1860–1867.
- Armstrong T, Mendoza T, Gring I, et al. Validation of the M.D. Anderson Symptom Inventory Brain Tumor Module (MDASI-BT). *J Neurooncol.* 2006;80(1):27–35.
- Pranckeviciene A, Deltuva V, Tamasauskas A, Bunevicius A. Association between psychological distress, subjective cognitive complaints and

- objective neuropsychological functioning in brain tumor patients. *Clin Neurol Neurosurg*. 2017;163:18–23.
16. Roebuck-Spencer T, Glen T, Puente A, et al. Cognitive screening tests versus comprehensive neuropsychological test batteries: a National Academy of Neuropsychology education paper. *Arch Clin Neuropsychol*. 2017;32(4):491–498.
  17. Martino M, Santini B, Cappelletti G, et al. The quality of measurement properties of neurocognitive assessment in brain tumor clinical trials over the last 30 years: a COSMIN checklist-based approach. *Neurol Sci*. 2020;41(11):3105–3121.
  18. Olson R, Chhanabhai T, McKenzie M. Feasibility study of the Montreal Cognitive Assessment (MoCA) in patients with brain metastases. *Support Care Cancer*. 2008;16(11):1273–1278.
  19. Meyers C, Wefel J. The use of mini-mental state examination to assess cognitive functioning in cancer trials: no ifs, ands, buts, or sensitivity. *J Clin Oncol*. 2003;21(19):3557–3558.
  20. Nasreddine Z, Philips N, Bedirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. 2005;53(4):695–699.
  21. Robinson G, Biggs V, Walker D. Cognitive screening in brain tumors: short but sensitive enough? *Front Oncol*. 2015;5(60):1–7.
  22. Chapman J, Cadilhac D, Gardner B, et al. Comparing face-to-face and videoconference completion of the Montreal Cognitive Assessment (MoCA) in community-based survivors of stroke. *J Telemed Telecare*. 2021;27(8):484–492.
  23. Iiboshi K, Yoshida K, Yamaoka Y, et al. A validation study of the remotely administered Montreal Cognitive Assessment tool in the elderly Japanese population. *Telemed J E Health*. 2020;26(7):920–928.
  24. Abdolahi A, Bull M, Darwin K, et al. A feasibility study of conducting the Montreal Cognitive Assessment remotely in individuals with movement disorders. *Health Informatics J*. 2016;22(2):304–311.
  25. Gagnon C, Olmand M, Dupuy E, et al. Videoconference version of the Montreal Cognitive Assessment: normative data for Quebec-French people aged 50 years and older. *Aging Clin Exp Res*. 2022:1–7.
  26. Nasreddine Z. MoCA Test. 2021. <https://www.mocatest.org/>. February 1, 2021.
  27. Armstrong T, Gning I, Mendoza T, et al. Reliability and validity of the M. D. Anderson Symptom Inventory-Spine Tumor Module. *J Neurosurg Spine*. 2010;12(4):421–430.
  28. Group E. EuroQol—a new facility for the measurement of health-related quality of life. *Health Policy*. 1990;16(3):199–208.
  29. Pilkonis P, Choi S, Reise S, et al. Item banks for measuring emotional distress from the Patient-Reported Outcomes Measurement Information System (PROMIS®): depression, anxiety, and anger. *Assessment*. 2011;18(3):263–283.
  30. Hoops S, Nazem S, Siderowf A, et al. Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology*. 2009;73(21):1738–1745.
  31. Lam B, Middleton L, Masellis M, et al. Criterion and convergent validity of the Montreal Cognitive Assessment with screening and standardized neuropsychological testing. *J Am Geriatr Soc*. 2013;61(12):2181–2185.
  32. Renovanz M, Reitzug L, Messing L, et al. Patient reported feasibility and acceptance of Montreal Cognitive Assessment (MoCA) screening pre- and postoperatively in brain tumour patients. *J Clin Neurosci*. 2018;53:79–84.
  33. Hewins W, Zienius K, Rogers J, et al. The effects of brain tumours upon medical decision-making capacity. *Curr Oncol Rep*. 2019;21(6):55.
  34. Noll K, King A, Dirven L, et al. Neurocognition and health-related quality of life among patients with brain tumors. *Hematol Oncol Clin North Am*. 2022;36(1):269–282.
  35. Jammula V, Leeper H, Gilbert M, Cooper D, Armstrong T. Effects of cognitive reserve on cognition in individuals with central nervous system disease. *Cogn Behav Neurol*. 2021;34(4):245–258.
  36. Zhang Z, Jin Z, Yang X, et al. Pre-operative neurocognitive function was more susceptible to decline in isocitrate dehydrogenase wild-type subgroups of lower-grade glioma patients. *Front Neurol*. 2020;11:591615.
  37. Correa D, Satagopan J, Baser R, et al. APOE polymorphisms and cognitive functions in patients with brain tumors. *Neurology*. 2014;83(4):320–327.
  38. Armstrong T, Bolanos-Vera E, Acquaye A, et al. The symptom burden of primary brain tumors: evidence for a core set of tumor- and treatment-related symptoms. *Neuro Oncol*. 2016;18(2):252–260.