Article published online: 2022-08-16

Original Article

Evaluation of Cognitive Functions in Traumatic Brain Injury Patients Using Mini Mental State Examination and Clock Drawing Test

Abstract

Background: Traumatic brain injuries (TBIs) are the leading cause of morbidity, mortality, disability, and socioeconomic losses globally, but of more concern, in India and other developing countries. The Mini mental state examination (MMSE) and clock drawing test (CDT) are the two mostly adapted methods for cognitive impairment screening. Therefore, it is necessary to establish a robust evaluation system exclusively for post-TBI cognitive impairment. **Materials and Methods:** One hundred and thirty-four cases treated previously at the health facility for TBIs were evaluated for cognitive functions during the follow-up period ranging from 3 weeks to 6 months in the out-patient department. All cases underwent mini-mental score examination (MMSE) and CDT to assess their cognitive performances. The data were analyzed statistically using Chi-square and ANOVA tests of significance. **Results:** Statistically significant association ($P < 0.001$) between the cognitive status of patients on the basis of overall MMSE score and the site of brain injury was observed. It was noted that 76 (56.7%) of the cases had cognitive impairment (MMSE score <24) with majority 44 (32.8%) patients having frontal lobe injuries, followed by 14 (10.1%) having brain injuries in the temporal lobe. On the other hand, using CDT score, it was observed that 102 (76.1%) of the cases had cognitive impairment (CDT score <5) with the majority 49 (36.6%) cases having frontal lobe injury followed by 19 (14.2%) having brain injury in the parietal lobe. **Conclusion:** The CDT was able to access cognitive function disruption in those patients, in whom the mini-mental score examination was not able to assess the same, and this difference in detection capabilities of both the tests was statistically found significant.

Keywords: *Clock drawing test, cognitive functions, Mini-Mental State Examination test, traumatic brain injury*

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Introduction

Traumatic brain injuries (TBIs) are the leading cause of morbidity, mortality, disability and socioeconomic losses globally, but of more concern in India and other developing countries. It is estimated that nearly 1.5–2 million persons are injured and 1 million succumb to death every year in India. Road traffic injuries are the leading cause (60%) of TBIs followed by falls (20%–25%) and violence (10%). Apart from many other causes of traumatic injuries, alcohol abuse/consumption is known to be present among 15%–20% of TBIs at the time of injury.[1] Subsequent to the brain injury resulting in trauma, cognitive deficits that can follow TBI include impaired attention, disrupted insight, judgement and thought, reduced processing speed, distractibility, and deficits in executive functions such as abstract reasoning, planning problem, solving, and multitasking.[2] Memory loss, the most common cognitive impairment among head-injured people, occurs in 20%–79% of people with closed head trauma, depending on severity.[3]

Clinically, cognitive impairment caused by TBI is different in mechanisms, clinical manifestations, risk factors, and outcomes.[4] Therefore, it is necessary to establish a robust evaluation system exclusive for post-TBI cognitive impairment because it may act as a decisive test for post-TBI cases enabling them fit/unfit for public jobs/sensitive jobs and services. There are a number of neuropsychological and extensive bedside tests available to evaluate executive cognitive function, but most of them are time-consuming. The mini-mental status examination (MMSE)

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Access this article online

Website: www.asianjns.org

DOI: 10.4103/ajns.AJNS_331_20

Quick Response Code:

How to cite this article: Singh A, Kumar R, Singh NP, Yadav R, Kumar A. Evaluation of cognitive functions in traumatic brain injury patients using mini mental state examination and clock drawing test. Asian J Neurosurg 2021;16:99-105.

Submitted: 05-Jul-2020 **Revised:** 05-Aug-2020
Accepted: 20-Oct-2020 **Published:** 23-Feb-2021

and clock drawing test (CDT) are the two mostly adapted methods for cognitive impairment screening.

The potential of CDT as a screening tool for cognitive impairment has long been a matter of great interest. This is a cognitive test with a number of scoring variations, most of which are fairly easy and simple to perform and assess.[5] Clock drawing involves comprehension, perception, memory, gross motor function, visuospatial organization, concentration, numerical knowledge, concept of time, and inhibition of distracting stimuli. Although it appears simple, drawing of a clock correlates to a complex goal-directed behavior in an abstract environment.[6] It was originally used to assess visuo-constructive abilities, but abnormal clock drawing occurs in other cognitive impairments also. The test can be performed on patients who have verbal understanding, memory and spatially coded knowledge in addition to constructive skills.[7] Education, age, and mood can influence the test results; subjects of low education, advanced age, and depression performing more poorly.[8,9]

Routine tests of cognition such as Mini-Mental State Examination (MMSE), developed by Folstein, is a thirty-point questionnaire that is used extensively in clinical and research setting to measure cognitive impairment.[10] It is also used to estimate the severity and progression of cognitive impairment and to follow the course of cognitive changes in an individual over time, thus, making it an effective way to document an individual's response to treatment.[11] At the same time, it often fails to identify executive dysfunction even if severe.

This study was undertaken to determine the uses and efficiency of CDT to identify cognitive dysfunction and to assess its utility along with MMSE in identifying potential executive cognitive dysfunction in the TBI patients during follow-up in a clinical setting.[12,13]

Materials and Methods

Patient selection

The study was carried out in the physiology department with the collaboration of the neurosciences department at a tertiary level health-care facility of northern India. A total of 134 patients were recruited for the study with effect from October 2018 to May 2019. These cases were treated previously at the health facility for TBIs and were evaluated for cognitive functions during the follow-up, ranging from 3 weeks to 6 months, in the out-patient department. All these cases were evaluated by a faculty of Neurosurgery first and then were subjected for the cognitive battery of tests once found suitable for these evaluations. Prior ethical clearance was obtained from the institutional ethical clearance committee, and informed consent was taken from patients. Cases who met the inclusion criteria were recruited in this study. Most of these were admitted in the indoor patient department of neurosurgery department following TBI and were discharged after their appropriate case management.

Inclusion and exclusion criteria

Cases in the age group of 18 years and above who were treated and discharged previously from the health facility for TBIs and attending the out-patient department for follow-up after a time-duration ranging from 3 weeks to 6 months, were included in the study. Patients who had a history of any neurodegenerative illness, alcohol or substance abuse, cognitive dysfunctions before the trauma, mental deterioration due to fulminant infection or neurological disorders, patients with repeated trauma or any chronic illness and uncooperative cases and those not providing their informed written consent for participating in the study were excluded from the study. Illiterate patients who were unable to follow verbal as well as written commands and those patients with altered sensorium who could not be assessed by neurocognitive battery of tests were also excluded from the study.

Battery of tests used for cognitive assessment

The Mini-mental state examination (MMSE) and CDT was used to measure cognitive impairment in all TBI patients. The MMSE test, a thirty-point questionnaire, included questions and problems of a number of higher mental skills like orientation, attention, calculation, recall, language, repetition, and complex commands. On the other hand, the CDT was a five points score scale which included questions related with the clock drawing skills, namely, inclusion of every number, correct order of number, drawing correct time, drawing of two clock hands, and correct numbers placed in the four quadrants of the clock as CDT sub-tests. The subjects were presented with a white paper and the instructions to draw a clock. There was no time limit. Free draw method was used for CDT, in which subjects were instructed to draw a clock with the clock hands at a fixed time, often ten past eleven.

Interpretations of MMSE and clock drawing test

For MMSE, any score of 24 or more (out of maximum 30) indicated a normal cognition, while cognitive impairment categories and scores were mild (19–23 points), moderate (10–18 points), and severe (≤9 points).[14] Even a maximum score of 30 points attained by a patient does not rule out cognitive impairment as the presence of physical problems can also interfere with the interpretation if not properly noted; for example, a patient may be physically unable to hear or read instructions properly or may have a motor deficit that affects writing and drawing skills, but his higher functions may be intact enabling the patients to perform the cognitive functions efficiently.

For CDT, a total score of five was considered as normal cognition while test score <5 pointed toward cognitive impairment.

The clinical and radiological assessment data were utilized for the categorization of the type and site of TBIs which was collected from discharge summary and case files of each patient in consultation with treating surgeons from the medical record department of the university.

Statistical analysis

The data, thus collected, were analyzed using Statistical Product and Service Solutions (spss software) IBM statistics, version 25, Chicago, USA. The association between the presence of cognitive impairment and site of brain injuries by using both the study tools (MMSE and CDT) was analyzed using Chi-square test, while ANOVA was used to compare the mean scores of MMSE, CDT, Glasgow Coma Scale (GCS), and age. A value of $P < 0.05$ was considered statistically significant.

Results

Table 1 shows the association of various studied variables and the site of brain injury. The site of injury was broadly categorized into frontal, temporal, parietal, occipital, and multiple lobe injury/diffused axonal injury. Majority of TBI patients had frontal lobe injury 50 (37.3%) and among them, most 40 (80.0%) were between 21 and 60 years of age. Association between age and site of brain injury was not found to be statistically significant ($\chi^2 = 18.62$, $P = 0.098$).

Gender wise distribution showed that 86 (64.2%) males and 48 (35.8%) female as study participants. Frontal lobe injury was predominant in both the gender with males accounting for 29 (21.6%) and females accounting for 21 (15.2%). Association between gender and site of injury was found statistically not significant ($\chi^2 = 3.05$, $P = 0.550$).

Although 102 (76.1%) of the patients were educated, only up to high school, the insignificant association between the site of brain injury and educational status of patients ($P = 0.072$) was observed.

According to GCS status, 106 (71.9%) patients had mild illness GCS (13–15) of which majority 38 (28.4%) had frontal lobe injury followed by parietal lobe injury 22 (16.4%). Association between the site of injury and GCS scale status was not statistically significant ($P = 0.326$).

Based on scores obtained by patients in mini-mental score examination, it was observed that 62 (46.3%) cases had normal cognitive functions while 38 (28.4%), 24 (17.9%), 10 (7.5%) had mild, moderate, and severe cognitive impairment, respectively. There was a statistically significant association between the site of injury in patients and the level of cognitive impairment based on MMSE score ($P < 0.001$). It can be fairly predicted that the frontal lobe is the most common site for cognitive compromises.

Table 2 depicts that there was a statistically significant association ($P < 0.001$) between the cognitive status of patients on the basis of overall MMSE score and the site of brain injury. 76 (56.7%) of the cases had cognitive impairment (MMSE score <24) with majority 44 (32.8%) patients having frontal lobe injuries followed by 14 (10.1%) having brain injuries in the temporal lobe. On evaluating the cognitive status and the site of injury according to all the eight individual components of MMSE, it was observed that orientation to time ($\chi^2 = 40.7$, $P < 0.001$), orientation to place ($\chi^2 = 42.05$, $P < 0.001$), attention and calculation ($\chi^2 = 42.03$, $P < 0.001$), repetition of words ($\chi^2 = 17.3$, $P = 0.002$), recall of words ($\chi^2 = 11.81$, $P = 0.02$), and complex command ($\chi^2 = 25.75$, $P < 0.001$)

Table 1: Association of various variables and site of brain injury

Variable name	Sub-groups	Site of brain injury					Total, *n* (%)	χ^2 and *P*
		Frontal lobe, *n* (%)	Temporal lobe, *n* (%)	Parietal lobe, *n* (%)	Occipital lobe, *n* (%)	Multiple lobe injury/DAI, *n* (%)		
Age groups (years)	≤20	3 (2.2)	6 (4.5)	6 (4.5)	4 (3.0)	3 (2.2)	22 (16.4)	18.62, 0.098
	21-40	19 (14.2)	11 (8.2)	14 (10.4)	8 (6.0)	6 (4.5)	58 (43.3)	
	41-60	21 (15.7)	5 (3.7)	3 (2.2)	6 (4.5)	7 (5.2)	42 (33.3)	
	61-80	7 (5.2)	0 (0.0)	3 (2.2)	2 (1.5)	0 (0.0)	12 (9.0)	
Gender	Male	29 (21.6)	14 (10.4)	17 (12.7)	16 (11.9)	10 (7.5)	86 (64.2)	3.05, 0.550
	Female	21 (15.7)	8 (6.0)	9 (6.7)	4 (3.0)	6 (4.5)	48 (35.8)	
Education	Primary	21 (15.7)	7 (5.2)	6 (4.5)	5 (3.7)	3 (2.2)	42 (31.4)	29.88, 0.072
	High school	25 (18.7)	5 (3.7)	10 (7.5)	10 (7.5)	10 (7.5)	60 (44.7)	
	Intermediate	0	1 (0.7)	1 (0.7)	1 (0.7)	1 (0.7)	4 (3.0)	
	Graduate	4 (3.0)	9 (6.7)	9 (6.7)	4 (3.0)	2 (1.5)	28 (20.9)	
Glasgow coma scale score	Mild (13-15)	38 (28.4)	15 (11.2)	22 (16.4)	16 (11.9)	15 (11.2)	106 (71.9)	9.202, 0.326
	Moderate (9-12)	12 (9.0)	7 (5.2)	4 (3.0)	2 (1.5)	1 (0.7)	24 (17.9)	
MMSE grading	Normal	6 (4.5)	8 (6.0)	18 (13.4)	20 (14.6)	14 (10.4)	62 (46.3)	88.78, <0.001
	Mild	17 (12.7)	10 (7.5)	7 (5.2)	0	0	38 (28.4)	
	Moderate	21 (15.7)	2 (1.5)	1 (0.7)	0	0	24 (17.9)	
	Severe	6 (4.5)	2 (1.5)	0	0	2 (1.5)	10 (7.5)	

MMSE – Mini mental state examination; DAI – Diffuse axonal injury

Table 2: Association between various components of mini mental state examination and site of brain injury

Variable name	Sub-groups	Site of brain injury					Total, *n* (%)	χ^2 and *P*
		Frontal lobe, *n* (%)	Temporal lobe, *n* (%)	Parietal lobe, *n* (%)	Occipital lobe, *n* (%)	Multiple lobe injury/ DAI, *n* (%)		
Cognition status (total MMSE score)	Normal cognition (score=24-30)	6 (4.5)	8 (6.0)	16 (11.9)	20 (13.9)	14 (10.4)	58 (43.3)	81.07,
	Cognitive impairment (score <24)	44 (32.8)	14 (10.1)	10 (7.5)	0 (0.0)	2 (1.5)	76 (56.7)	<0.001
Orientation to time (maximum score 5)	Normal cognition (score=5)	6 (4.5)	10 (7.5)	21 (15.7)	13 (9.7)	10 (7.5)	60 (44.8)	40.7,
	Cognitive impairment (score <5)	44 (32.8)	12 (9.0)	5 (3.7)	7 (5.2)	6 (4.5)	74 (55.2)	<0.001
Orientation to place (maximum score 5)	Normal cognition (score=5)	18 (13.4)	17 (12.7)	23 (17.2)	20 (14.9)	14 (10.4)	92 (68.7)	42.05,
	Cognitive impairment (score <5)	32 (23.9)	5 (3.7)	3 (2.2)	0 (0.0)	2 (1.5)	42 (31.3)	<0.001
Registration of words (maximum score 3)	Normal cognition (score=3)	47 (35.1)	21 (15.7)	22 (16.4)	20 (14.9)	14 (10.4)	124 (92.5)	4.99,
	Cognitive impairment (score <3)	3 (2.2)	1 (0.7)	4 (3.0)	0 (0.0)	2 (1.5)	10 (7.5)	0.29
Attention and calculation (maximum score 5)	Normal cognition (score=5)	2 (1.5)	10 (7.5)	13 (9.7)	14 (10.4)	11 (8.2)	50 (37.3)	42.03,
	Cognitive impairment (score <5)	48 (35.8)	12 (9.0)	13 (9.7)	6 (4.5)	5 (3.7)	84 (62.7)	<0.001
Recall of words (maximum score 3)	Normal cognition (score=3)	6 (4.5)	4 (3.0)	11 (8.2)	8 (6.0)	5 (3.7)	34 (25.4)	11.81,
	Cognitive impairment (score <3)	44 (32.8)	18 (13.4)	15 (11.2)	12 (9.0)	11 (8.2)	100 (74.6)	0.02
Language (maximum score 2)	Normal cognition (score=2)	43 (32.1)	21 (15.7)	23 (17.2)	18 (13.4)	15 (11.2)	120 (89.6)	1.83,
	Cognitive impairment (score <2)	7 (5.2)	1 (0.7)	3 (2.2)	2 (1.5)	1 (0.7)	14 (10.4)	0.767
Repetition of words (maximum score 1)	Normal cognition (score=1)	16 (11.9)	0 (0.0)	4 (3.0)	0 (0.0)	2 (1.5)	22 (16.4)	17.3,
	Cognitive impairment (score=0)	34 (25.4)	22 (16.4)	22 (16.4)	20 (14.9)	14 (10.4)	112 (83.6)	0.002
Complex command (maximum score 6)	Normal cognition (score=6)	1 (0.7)	3 (2.2)	9 (6.7)	10 (7.5)	5 (3.7)	28 (20.9)	25.75,
	Cognitive impairment (score <6)	49 (36.6)	19 (14.2)	17 (12.7)	10 (7.5)	11 (8.2)	106 (79.1)	<0.001

MMSE – Mini mental state examination; DAI – Diffuse axonal injury

were found to have statistically significant association between them. Other components such as registration of words (χ^2 = 4.99, *P* = 0.29) and language (χ^2 = 1.83, *P* = 0.767) were not significantly associated with brain injury site.

Table 3 depicts that there was statistically significant association (χ^2 = 35.77, *P* < 0.001) between the cognitive status of patients on the basis of overall CDT score and the site of brain injury. It was observed that 102 (76.1%) of the cases had cognitive impairment (CDT score <5) with the majority among them, 49 (36.6%) cases, having frontal lobe injury followed by 19 (14.2%) having brain injury in the parietal lobe.

On evaluating the cognitive status and the site of brain injury according to all the five individual components of CDT, it was observed that inclusion of every number in the clock (χ^2 = 31.28 *P* < 0.001), correctly ordered number on the clock (χ^2 = 46.21, *P* < 0.001), drawing correct time on the clock (χ^2 = 54.42, *P* < 0.001), correctly drawing of two clock hands (χ^2 = 38.86, *P* < 0.001), and correct number placed in the four quadrants of the clock (χ^2 = 36.01, *P* < 0.001) had statistically significant association between them.

Table 4 depicts that the mean age, mean MMSE score, CDT score of patients is significantly associated with the site of brain injury and their *P* values are *P* = 0.047, *P* < 0.001, *P* < 0.001, respectively, but mean GCS score is not significantly associated with the site of injury (*P* = 0.26).

Table 5 reveals that according to the MMSE score results, 76 (56.7%) of the TBI patients had cognitive impairment while CDT detected 102 (76.1%) as having cognitive impairment. There was a statistically significant association between the cognition status and test used for its detection (χ^2 = 11.31, *P* = 0.001).

Discussion

The present study has revealed that older adults and middle-aged patients who met with TBI (mainly frontal lobe injury) exhibited poor cognitive performance. Similar observations were also reported by Gruber *et al*,.[15] Bruns and Hauser,[16] Paula *et al*.[17] and Crowe *et al*.[18] in their studies.

It was observed that the cognitive impairment detected by both MMSE and CDT tests was mainly seen in the frontal lobe injury followed by parietal and temporal lobe TBIs patients. Similar findings were reported by Gershberg and Shimamura,[19] in their study and discussed that cognitive impairment in these patients occurs due to damage to prefrontal cortex which disrupts a variety of cognitive functions, including planning, problem solving, and temporal organization.

On evaluating the cognitive status and the site of injury according to all the eight individual components of MMSE, it was observed in the present study that orientation to time, orientation to place, attention and calculation, repetition of words, recall of words, and complex command were significantly associated with site of brain injury. Patients with frontal lobe brain injury have reported highest risk of cognitive impairment by both MMSE (32.8%) and CDT (36.6%) therefore verifying the role of frontal

Table 3: Association between various components of clock drawing test and site of brain injury

Variable name	Sub-groups	Site of brain injury					Total, *n* (%)	χ^2 and *P*
		Frontal lobe, *n* (%)	Temporal lobe, *n* (%)	Parietal lobe, *n* (%)	Occipital lobe, *n* (%)	Multiple lobe injury/ DAI, *n* (%)		
CDT score status	Normal cognition (score=5)	1 (0.7)	4 (3.0)	7 (5.2)	13 (9.7)	7 (5.2)	32 (23.9)	35.77,
	Cognitive impairment (score <5)	49 (36.6)	18 (13.4)	19 (14.20	7 (5.2)	9 (6.7)	102 (76.1)	<0.001
Inclusion of every number in clock	Normal cognition (score=1)	7 (5.2)	9 (6.7)	14 (10.4)	15 (11.2)	11 (8.2)	56 (14.8)	31.28,
	Cognitive impairment (score=0)	43 (32.1)	13 (9.7)	12 (9.0)	5 (3.7)	5 (3.7)	78 (58.2)	<0.001
Correctly ordered number on clock	Normal cognition (score=1)	3 (2.2)	9 (6.7)	15 (11.2)	16 (11.9)	11 (8.2)	54 (40.3)	46.21,
	Cognitive impairment (score=0)	47 (35.1)	13 (9.7)	11 (8.2)	4 (3.0)	5 (3.7)	80 (59.7)	<0.001
Drawing correct time on clock	Normal cognition (score=1)	5 (3.7)	11 (8.2)	15 (11.2)	20 (14.9)	11 (8.2)	62 (43.6)	54.42,
	Cognitive impairment (score=0)	35 (33.6)	11 (8.2)	11 (8.2)	0 (0.0)	5 (3.7)	72 (53.7)	<0.001
Drawing of two clock hands	Normal cognition (score=1)	17 (12.7)	17 (12.7)	20 (14.9)	20 (14.9)	14 (10.4)	88 (65.7)	38.86,
	Cognitive impairment (score=0)	33 (24.6)	5 (3.7)	6 (4.5)	0 (0.0)	2 (1.5)	46 (34.3)	<0.001
Correct number placed in the four quadrants of clock	Normal cognition (score=1)	4 (3.0)	5 (3.7)	6 (4.5)	15 (11.2)	8 (6.0)	48 (28.4)	36.01,
	Cognitive impairment (score=0)	46 (34.3)	17 (12.7)	20 (14.9)	5 (3.7)	8 (6.0)	96 (71.6)	<0.001

CDT – Clock drawing test; DAI – Diffuse axonal injury

Table 4: Association of mean scores of age, Glasgow Coma Scale, mini-mental status examination and clock drawing test and site of brain injury

Variable name	Site of brain injury					Total	ANOVA test *F*, *P*
	Frontal lobe	Temporal lobe	Parietal lobe	Occipital lobe	Multiple lobe injury/DAI		
Age (years), mean±SD	41.8±15.8	31.1±12.6	33.5±17.0	37.0±15.1	35.2±12.9	36.9±15.5	2.5, 0.047
GCS score, mean±SD	14.2±1.5	13.5±2.3	14.3±2.0	3.7±2.4	14.7±0.9	14.1±1.9	1.3, 0.26
MMSE score, mean±SD	16.5±5.4	23.5±2.6	25.5±2.8	27.4±1.5	24.5±8.1	21.9±6.4	29.9, <0.001
CDT score, mean±SD	0.66±1.2	2.3±1.7	2.9±2.0	4.2±1.2	3.4±1.9	2.2±2.0	25.7, <0.001

CDT – Clock drawing test; MMSE – Mini mental state examination; GCS – Glasgow Coma Scale; SD – Standard deviation

Table 5: Comparison between mini-mental status examination and clock drawing test results for cognitive status of traumatic brain injurie patients

Cognition status	MMSE (*n*=134), *n* (%)	CDT (*n*=134), *n* (%)	χ^2 and *P*
Cognitive impairment	76 (56.7)	102 (76.1)	11.31,
Normal cognition	58 (43.3)	32 (23.9)	0.001

CDT – Clock drawing test; MMSE – Mini mental state examination

lobes in cognitive function impairment. Few studies have also shown strong evidence that frontal damage disrupts performance on the test of recognition and free recall.[20,21]

Despite the common advantages such as simple application, exclusive coverage of cognitive domains and broad clinical application, two scales differ largely in their contents: MMSE emphasizes evaluation of speech and orientation[22] and the content is highly verbal, lacking sufficient items to adequately measure visuospatial and/or constructional praxis. Hence, its utility in detecting cognitive impairment caused by focal lesions is uncertain. On the other hand, in drawing the clock as done in CDT, different cortical systems work simultaneously, including the frontal, parietal, and temporal lobes.[23,24] Thus, different cognitive abilities can be measured, by CDT such as selective and sustained attention, auditory comprehension, verbal working memory, numerical knowledge, visual memory and reconstruction, visuospatial skills, on-demand motor execution (praxis), and executive function. It is apparent from current study that parietal lobe dysfunctions are mainly detected by CDT and not by MMSE. However, CDT detects frontal, parietal dysfunctions and occipital lobe also, in contrary to MMSE which detects mainly frontal and temporal dysfunctions.

It was observed in the present study that 10.1% of temporal lobe injury patient had lower cognitive impairment by MMSE and by CDT score it was observed in 13.4% patients. Findings of many researchers confirm that the temporal lobe plays a significant role in both retrograde and anterograde memory as it is well-known for its function in memory storage, language recognition, and processing of audio-visual sensory input. The role of medial temporal lobes and hippocampus as memory center has been widely described, and researches have shown that focal lesions in the hippocampus result in limited impairment of memory function, whereas extensive lesions that include the hippocampus and the medial temporal cortex result in severe impairment.[21,25]

Another finding of the present study was that 7.5% of parietal lobe injury patients have shown lower scores for MMSE <24 indicating cognitive disruption for orientation, attention, repetition of words and complex command, while 14.2% of parietal lobe injury patient had low CDT score <5 with cognitive function impairment in the inclusion of every number on clock, correct order of number, drawing correct time, drawing of two clock hands, and correct number placed in the four quadrants, as CDT subtests. Scientists have found in their studies that parietal lobe injury is associated with verbal short-term memory loss due to damage to the supramarginal gyrus. It usually includes right-left confusion, difficulty with writing (agraphia) and difficulty with mathematics (acalculia), language (aphasia) and the inability to perceive objects. Right side damage can also cause difficulty in making things (constructional apraxia), denial of deficits (anosognosia), and drawing ability.[26]

It was also noted that 7.2% of occipital lobe injury patients showed significantly lower CDT score while they had normal MMSE score, thus focusing on the visual memory disruption associated with the occipital lobe injury. Occipital lobe receives incoming information, which is processed and immediately sent to the hippocampus, where it is formed into short-term memory. Thus, hampering of visual perception due to occipital brain injury leads to impairment of various subsets of CDT.

The results indicate that the ability to detect cognitive impairment of CDT in TBI patients was better than MMSE and this difference was found to be statistically significant ($P = 0.001$). In all the groups of TBI, it was seen that many patients had normal MMSE scores and abnormal CDT scores; while, in contrast, it was very rare for patients to have normal CDT score but abnormal MMSE score. When the MMSE score was abnormal and suspicion of cognitive impairment was high, abnormal CDT reinforced the diagnosis of cognitive impairment. MMSE mainly focused on recall, speech, orientation with less focus on visuo-constructive function. In comparison, CDT had wider coverage and well balanced with every subtest.

Conclusion

1. The CDT was able to access cognitive function disruption in those patients in whom the mini mental score examination was not able to assess the same and this difference in detection capabilities of both the tests was statistically found significant. The study may help in fetching the practicability and preference of one of these two tests, based on their merits, if any
2. CDT can detect the dysfunctions of frontal, parietal, temporal, and occipital lobes in contrary to MMSE. However, this test cannot be used in illiterate subjects
3. CDT was found as a multidimensional test which covers visuospatial and visuo-constructive skills, the symbolic and graphomotor representation, the auditory language skills, attention, semantic memory, conceptual abilities, and the executive function, which includes organization, planning, and parallel processing. On the other hand, MMSE was found good in assessing attention, language, memory, orientation, and visuospatial proficiency. It is clearly understood by using these two tools that some points of cognition were covered by MMSE but CDT covered all the higher cognitive functions
4. It was concluded that CDT is better tool to assess cognitive impairment in TBI because it is simple to perform and less time consuming, quick to apply, well accepted by patients, easy to score and relatively independent of language, education, and culture of the patients
5. MMSE detects mainly temporal and frontal dysfunctions, takes 30 min to perform test, time-consuming and language is main hurdle while CDT is fast screening tool (takes approximately 5 min), easy to administer, well tolerated, free of cost, may be useful in developing countries.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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