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# Neuropsychological Profile of Traumatic Brain Injury Patients with Medicolegal Cases: A Pilot Study

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## Abstract

**Introduction** Traumatic brain injury (TBI) is a global health problem and is a silent epidemic of the modern times. Studies indicate litigation is a prominent factor that accounts for poor outcome and prolonged recovery from mild TBI. Depression is the most frequently diagnosed psychiatric disorder after TBI. Postconcussion symptoms, litigation, and suboptimal effort could contribute to the neuropsychological functioning of TBI patients medicolegal cases (MLCs). With increase in TBI and medicolegal cases, there is a requirement for comprehensive neuropsychological assessment.

**Method** The aim of the study was to evaluate the cognitive functions, postconcussion, and depressive symptoms in TBI patients with MLC and without MLCs (non-MLC). Patients were also assessed on electrophysiological parameters. An observational cross-sectional design was adopted, the sample size was 30 TBI patients in total, 15 (MLC) and 15 (non-MLC), and 11 patients from each group for electrophysiological assessment. The patients were in the age range of 18 to 50 years.

**Results** The MLC group had poor performance compared with the non-MLC group on both neuropsychological and electrophysiological measures. There was evidence of significant difference in verbal working memory, verbal learning, and memory and visuoconstructive ability. In the MLC group, postconcussion and depressive scores were negatively correlated with visuospatial span.

**Conclusion** Findings from this study indicate differences in the neuropsychological performance and electroencephalographic measures in between MLC and non-MLC groups. The results could be indicative of persistent cognitive problems associated with TBI for patients pursuing litigation. Poor performance could also be attributed to suboptimal level of effort. However, being a preliminary study with a small sample size, the findings need to be treated with caution.

**Keywords**
- traumatic brain injury
- cognition
- EEG
- medicolegal case
- postconcussion syndrome
- neuropsychology
- cognitive impairment

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## Introduction

Traumatic brain injury (TBI) is a global public health crisis typically caused by contact and inertial forces acting on the brain. TBI can have a physical, cognitive, emotional, and psychosocial impact across the lifespan of an individual. An epidemiological study undertaken by Gururaj[1] at National Institute of Mental Health and Neurosciences (NIMHANS) in the period March 2000 to March 2003 revealed that in India nearly two million people sustain brain injuries, 0.2 million lose their lives, and nearly a million need rehabilitation services in a year. Patients with mild TBI (mTBI) most often have impairments in immediate memory, attention, speed, and executive functions. In TBI patients, depression is the most common comorbid psychiatric disorder. TBI is associated with adverse outcomes such as decreased social activity, unemployment, reduced quality of life, and suicide.[2] Research shows that symptom reporting in the TBI group was significantly associated with age, gender, preinjury alcohol abuse, preinjury psychiatric history, and severity of injury.[3–9] A meta-analytic review of neuropsychological studies of mTBI at varied stages postinjury found that speed of processing, working memory, attention, memory and executive function were most sensitive to dysfunction in individuals, with memory being predominantly affected in the acute phase, and showing resolution with time.[10] A cross-sectional study of 13,332 individuals from the Brain Health Registry with history of repetitive head injury (RHI) or TBI showed evidence of worsening neuropsychiatric and cognitive functioning in later life.[11] Litigation is the process of taking legal action in the case of injury, it involves ascertaining the circumstances, impact, and responsibility regarding an injury obtained, in the court of law, and is referred to as a medicolegal case (MLC). Most individuals with mTBI have complete recovery; however, some may experience persistent symptoms that appear inconsistently with the severity of the injury. Often symptoms may be ascribed to malingering, exaggeration, or poor effort on cognitive testing. Studies examined the influence of poor effort on symptoms and neurocognitive performance following TBI on patients receiving financial compensation and found that they performed poorly on attention and executive functioning indexes. Hiploylee et al[12] compared litigants with nonlitigants in a sample of 285 patients with concussion. The extent and degree of sequelae depended on the severity and location of the injury and was mitigated by premorbid and postinjury factors such as pain, work status, litigation status, and support. Subrahmanyam and Agrawal[13] in 2012 studied the medicolegal issues faced by TBI patients in India. They explored the consequences of TBI and the medicolegal requirements for such cases. Yattoo et al[14] studied the factors that impact the outcome of TBI in a tertiary care hospital; they found that factors such as early recognition, resuscitation, and triage, imaging, and aggressive surgical management improved that outcome of severe head injury. Individuals seeking financial compensation are four times more likely to give poor effort on neuropsychological testing, with studies reporting 40% base rate of poor effort/test invalidity in personal injury cases.[15] The presence of an ongoing MLC is a significant factor and should be taken into account when evaluating cognitive impairment following TBI.[16] Studies suggest that effort and symptom could influence performance in TBI.[17–25] There is a dearth of studies on the neuropsychological profile of TBI patients with MLCs in India. The neuropsychological assessment and interpretation is primarily driven by normative data, behavioral observation, and clinical interviews. With the increase in TBI and associated MLCs, the need for accurate neuropsychological assessment and reporting is critical. The focus of this study was to profile neurocognitive functions using a battery of neuropsychological tests coupled with an electrophysiological measure (electroencephalography, EEG). The aim of the study was to identify the neuropsychological profile of TBI patients to compare the neuropsychological performance of patients with and without MLCs and evaluate associated postconcussion and depression symptoms.

## Methodology

The objective of the study was to assess attention, processing speed, verbal and visual working memory, visuoconstructive ability, verbal learning and memory, visual learning and memory, postconcussive symptoms and depressive symptoms as well as electrophysiological parameters in TBI patients and to compare the performance of those with and without an MLC. An observational, cross-sectional, single assessment design was adopted. The subjects were recruited from the neurosurgery outpatient services during the period July 2016 to March 2017. Convenience sampling technique was used. The sample size for the study was 30, 15 TBI patients with litigation (MLC group) and 15 TBI patients without litigation (non-MLC group), and 11 subjects from each group consented for participating in the electrophysiological assessment. The inclusion criteria were as follows: age range of 18 to 50 years, right-handed individuals, ability to read and write with corrected vision/hearing, and history of head injury within a period of 3 months to 2 years prior to recruitment. Those with history of posttraumatic epilepsy, major psychiatric disorders, or neurological disorder and neurosurgical condition other than head injury, clinical evidence of mental retardation, surgery, substance dependence, severe sensorimotor, or language deficits were excluded from the study.

### Materials

The sociodemographic and clinical proforma was developed by the researcher. Cognitive tests were selected from the NIMHANS Neuropsychological Battery.[26] The Digit Symbol Substitution Test (DSST)[27] a test of mental speed was used to assess the visuomotor coordination, motor persistence, sustained attention, and response speed. The color trail test (CT 1 and CT 2)[28] was used to assess focused attention, perceptual tracking, and mental flexibility. Verbal working memory was assessed using the n-back test[29] and visuospatial span was measured using the spatial span test.[30] Rey's Auditory Verbal Learning Test (AVLT)[31] was used to assess verbal learning and memory. Complex figure test (CFT)[32] assessed the visual constructive ability, visual learning, and memory. The Rey 15-item memorization test[33,34] was used to establish possible suboptimal performance that could imply possible malingering. The Rivermead Post Concussion Symptom Questionnaire (RPQ)[35] was used to measure postconcussion symptoms and Beck Depression Inventory (BDI)[36] was used to measure depressive symptoms. The EEG was performed with the contingent continuous performance task, as an attention task (CONCPT),[37] and the Halstead finger tapping task was used as a motor task.[38] For the electrophysiological measure, the EEG/ERP (event-related potentials) was recorded using the Neuroscan from eight discrete along with one ground and two reference channels using the standard 10 to 20 montage, and electrode impedances were kept at less than 15 Kilo Ohms at each site. The recording consisted of two parts eyes closed (3 minutes) and task phase. The motor speed, attention, and memory tasks developed on the Neuroscan Stim software (version 2.2) were utilized. Data was analyzed using software for EEG analysis for both active and eyes closed.

### Procedure

Recruitment was initiated after obtaining approval from the Internal Ethics Committee of the Department of Clinical Psychology. The patients were informed about the nature of the study. Those who met the inclusion criteria were recruited after obtaining a written informed consent. The overall duration for assessment was ~5 to 6 hours. Neuropsychological tests were paper pencil tests and required a maximum of 3 to 4 hours. The EEG evaluation required ~2 hours. The participants were given adequate rest periods to reduce the effects of fatigue.

## Results

The results obtained were analyzed using descriptive statistics such as means and standard deviation for continuous variables, frequencies, and percentages for qualitative variables. The neuropsychological and electrophysiological assessment data was analyzed using nonparametric tests, since the distributions for neuropsychological and electrophysiological assessment were not normal. $p$-Value < 0.05 was considered to be statistically significant.

### Sociodemographic Variables

The sociodemographic findings (►**Table 1**) of both MLC and non-MLC TBI patients are given below. The mean age of the MLC group was 33.13(±9.37) years and the mean age of the non-MLC group was 32.93 (±8.66) years. There was no significant difference between the two groups with respect to age. The mean number of years of education was 10.73 (±2.81) years in the MLC group and 13.07 (±4.07) in the non-MLC group. The number of years of education in both groups was comparable, and there was no significant difference ($p$ =0.264). The male: female ratio was 13:2 in both groups. There was no statistical difference between both groups with regard to marital status ($p$ = 0.489). In terms of employment, 33.3% patients were employed in the MLC group and 73.3% were employed in the non-MLC group. There was no statistical difference between both groups with regard to employment ($p$ = 0.066). Majority of patients from both groups were from the middle socioeconomic status (53.3% MLC group; 46.7% non-MLC group). Socioeconomic status did not differ significantly between groups. The severity was determined with the scores of Glasgow Coma Scale (GCS) (score of 13–15 was mTBI, 9–12 moderate TBI, and 3–8 severe TBI). From the medical records and GCS scores of the patients, it was found that 84% of the patients had mild traumatic injury.

**Table 1** Sociodemographic variables of MLC and non-MLC groups

| Sociodemographic variables | | MLC ($n$ = 15) | | Non-MLC ($n$ = 15) | | $p$-Value |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | |
| Age (y) | | 33.13 | 9.37 | 8.66 | 32.93 | 0.952 |
| Education (y) | | 10.73 | 2.815 | 4.079 | 13.07 | 0.0769 |
| Sociodemographic Variables | | MLC ($n$ = 15) | | Non-MLC ($n$ = 15) | | $p$-Value |
| | | $n$ | % | $n$ | % | |
| Education | School | 11 | 73.3 | 7 | 46.7 | 0.264 |
| | College | 4 | 26.7 | 8 | 53.3 | |
| Employment | Employed | 5 | 33.3 | 11 | 73.3 | 0.066 |
| | Unemployed | 10 | 66.7 | 4 | 26.7 | |
| Marital status | Married | 6 | 40 | 9 | 60 | 0.489 |
| | Unmarried | 6 | 40 | 5 | 33.3 | |
| | Separated | 3 | 20 | 1 | 6.7 | |

Abbreviations: MLC, medicolegal case; SD, standard deviation.

## Neuropsychological Profile

Neuropsychological functions from various cognitive domains were assessed and analyzed using the two tailed Mann–Whitney U test. ►**Table 2** shows the neuropsychological deficits of all the participants. On the AVLT, 70% of patients had deficits in verbal learning and memory (66.66% immediate recall; 70% delayed recall), and on the complex figure test 56.66% had deficits in delayed recall for visual material. About 50% of patients had deficits in mental speed (53.33% on DSST), 40% of the patients had deficits in visual recall (43.33% CFT immediate recall) and focused attention (46.66% CT 1; 40% CT 2), 30% of the sample had deficits in verbal working memory (36.6% on 1 back hit; 30% on 2 back hit), and 26.6% showed deficits on the visual working memory task.

A comparison of the neuropsychological functions of both groups was made (►**Table 3**). Results showed a significant difference between MLC and non-MLC patients on verbal working memory in terms of correct responses and errors (n-back 2, Hits{ $p = 0.041$}, Errors {$p = 0.044$}). On the test of visuospatial construction, there was evidence of significant difference between both groups (CFT copy $p = 0.029$). The MLC group performed significantly poorer on the test of verbal learning and memory, particularly in the recognition trial (hits and misses, $p = 0.047$) The performance of both MLC and non-MLC groups was comparable on the tests of mental speed, focused attention, visuospatial working memory, and visual learning and memory ($p > 0.05$).

**Table 2** Neuropsychological deficits in TBI patients ($n = 30$)

| Cognitive domains | Test variables | No. of patients with deficits | Percentage |
|---|---|---|---|
| Mental speed | Digit Symbol Substitution (time taken) | 16 | 53.33 |
| Focused attention | CT 1 (time taken) | 14 | 46.66 |
| | CT 2 (time taken) | 12 | 40 |
| Verbal working memory | 1 back hits | 11 | 36.66 |
| | 2 back hits | 9 | 30 |
| Visual working memory | Visuospatial span | 8 | 26.66 |
| Verbal learning and memory | AVLT (total words recalled) | 21 | 70 |
| | AVLT-IR | 20 | 66.66 |
| | AVLT-DR | 21 | 70 |
| Visuospatial construction | CFT-copy | 19 | 63.33 |
| Visual learning and memory | CFT-IR | 13 | 43.33 |
| | CFT-DR | 17 | 56.66 |

Abbreviations: AVLT-DR, Auditory Verbal Learning Test delayed recall; AVLT-IR, Auditory Verbal Learning Test immediate recall; CFT-DR, complex figure test delayed recall; CFT-IR, complex figure test immediate recall; CT, colors trail test; TBI, traumatic brain injury.

## Postconcussion and Depressive Symptoms

The data from the self-report measures of RPQ and BDI indicated that both groups were relatively asymptomatic. The postconcussion and depressive symptoms were comparable and there was no statistically significant difference between both MLC and non-MLC groups (►**Table 4**). A two-tailed Spearman rank correlation was computed for the neuropsychological functions with BDI and RPQ for both groups (►**Table 5**). In the MLC group, results obtained indicated that the visuospatial span was negatively correlated with symptoms of postconcussion and

**Table 3** Comparison of the neuropsychological profile of MLC and non-MLC groups

| Tests | Median MLC group $n = 15$ | Median non-MLC group $n = 15$ | Mann–Whitney U test | Sig. |
|---|---|---|---|---|
| Digit Symbol Substitution | 526 (680–322) | 310 (405–201) | 72 | 0.093 |
| Color trail-1 | 104 (154–90) | 85 (139–55) | 79.5 | 0.171 |
| Color trail-2 | 235 (339–150) | 142 (196–120) | 74.5 | 0.115 |
| n-back 1 hit | 7 (9–6) | 8 (9–7) | 85.5 | 0.247 |
| n-back 1 error | 1 (3–0) | 1 (2–1) | 100.5 | 0.609 |
| n-back 2 hit | 4 (6–4) | 8 (8–6) | 64 | 0.041 |
| n-back 2 error | 5 (6–4) | 3 (5–1) | 64.5 | 0.044 |
| Spatial span | 14 (16–8) | 14 (16–10) | 107 | 0.818 |
| AVLT recognition hits | 11 (14–10) | 14 (15–14) | 65.5 | 0.047 |
| AVLT misses | 4 (5–1) | 1 (4–0) | 65.5 | 0.047 |
| CFT-copy | 26 (31–20) | 34 (35–29) | 60 | 0.029 |
| CFT-immediate recall | 14 (18–8) | 20 (30–12) | 76.5 | 0.134 |
| CFT-delayed recall | 11 (15–9) | 22 (28–10) | 71 | 0.085 |

Abbreviations: AVLT, Auditory Verbal Learning Test; CFT, complex figure test; MLC, medicolegal case.

**Table 4** Postconcussion and depression scores of MLC and non-MLC groups

| Tests | Group | Mean | SD | *p*-Value |
|---|---|---|---|---|
| RPQ | MLC | 7.20 | 6.87 | 0.472 |
| | Non-MLC | 9.13 | 7.68 | |
| BDI | MLC | 9.33 | 10.14 | 0.873 |
| | Non-MLC | 9.87 | 8.16 | |

Abbreviations: BDI, Beck Depression Inventory; MLC, medicolegal case; RPQ, Rivermead Post Concussion Symptom Questionnaire.

depression. In the non-MLC group, it was found that on the test of verbal learning and memory, total recall, and immediate recall of words was negatively correlated with depressive symptoms and postconcussion symptoms.

### Electrophysiological Parameters

Relative power distribution of different frequency bands was analyzed. The relative contribution of each frequency band was expressed in terms of the percentage of power contributed (►**Table 6**). Results for the Rey 15 memorization test indicated that there was significant difference in α band in electrode TP8 between MLC and non-MLC groups. Performance of non-MLC patients was better when compared with MLC patients. The latency related to P300 indicated that the non-MLC group as compared with the MLC group had significantly shorter latencies at three left frontal electrodes. There was no significant difference in amplitude between two groups (►**Table 7**). Results from the EEG indicated significant difference in β, theta, and α band between the two groups on the finger (right) tapping test. Latency related to P300 indicated that there were significantly shorter latencies in the non-MLC group at F3 on the continuous performance test.

## Discussion

The sociodemographic variables of education, socioeconomic status, and marital status of both MLC and non-MLC groups were comparable. The neuropsychological data revealed that the majority of TBI patients had deficits in verbal learning and memory, visual recall, and mental speed. In addition, there were deficits in attention, verbal, and visual working memory. Frencham et al[10] in a meta-analytic review found that speed of processing, working memory, attention, and executive functions were the most sensitive indicators of impairment in mTBI. Attentional and processing speed deficits are commonly reported after TBI that is supported by several studies.[39–44] TBI patients have difficulty in organizing new information that impedes the encoding and retrieval process. Research has shown that TBI has a greater effect on verbal and visual memory. Temporal lobes, medial temporal regions, and orbitofrontal regions are vulnerable to the effects of TBI that disrupts memory formation and retention functions.[44–46]

The comparison of neuropsychological functions of the MLC and non-MLC groups showed comparable performance in mental speed, attention, visuospatial span, visual learning, and memory. However, there was a significant difference in verbal working memory, verbal learning and memory, and visuospatial construction. On the verbal working memory task, the total number of correct responses were lower and the number of errors were higher for the MLC group. In view of the sample size, nonparametric testing was used to compare the data for both groups, and the generalizability of the findings is restricted. Studies show that working memory deficits are common and are sensitive to brain damage. The frontal lobe that is responsible for executive functions and working memory is particularly vulnerable to the TBIs due to coup and contre-coup insults to the brain.[10,29,47] With respect to verbal learning and memory the MLC group showed significantly lower learning and recall

**Table 5** Correlation between neuropsychological functions with BDI and RPQ

| Neuropsychological Tests | RPQ ($r_s$) | BDI ($r_s$) | RPQ ($r_s$) | BDI ($r_s$) |
|---|---|---|---|---|
| | MLC group | | Non-MLC group | |
| Digit Symbol | 0.102 | −0.059 | 0.224 | 0.258 |
| Color trail 1 | 0.237 | 0.110 | 0.183 | 0.299 |
| Color trail 2 | 0.162 | 0.002 | −0.013 | 0.081 |
| Spatial Span | −0.578* | −0.569* | 0.001 | −0.168 |
| AVLT total correct | 0.155 | 0.298 | −0.570* | −0.538* |
| AVLT-IR | −0.063 | 0.109 | −0.589* | −0.610* |
| AVLT-DR | 0.044 | 0.214 | −0.247 | −0.268 |
| CFT Copy | −0.101 | 0.068 | −0.269 | −0.359 |
| CFT-IR | −0.027 | 0.198 | −0.306 | −0.323 |
| CFT-DR | −0.291 | −0.122 | −0.287 | −0.332 |

Abbreviations: AVLT-DR, Auditory Verbal Learning Test-delayed recall; AVLT-IR, Auditory Verbal Learning Test-immediate recall; BDI, Beck Depression Inventory; CFT-IR, complex figure test immediate recall, CFT-DR, complex figure test delayed recall; MLC, medicolegal case; RPQ, Rivermead Post Concussion Symptom Questionnaire; $r_s$, Spearman's Correlation coefficient.
*Negatively corelated.

**Table 6** Comparison of relative power on the Rey 15 memorization test

| Electrode | Frequency band | Median MLC group $n = 11$ | Median non-MLC group $n = 11$ | Mann–Whitney U test | Sig. |
|---|---|---|---|---|---|
| T7 | Delta | 1.447 | 1.498 | 47 | 0.375 |
| | Theta | 3.367 | 3.064 | 59 | 0.922 |
| | Alpha | 3.062 | 2.952 | 57 | 0.818 |
| | Beta | 2.070 | 2.879 | 31 | 0.053 |
| TP7 | Delta | 1.385 | 1.483 | 60 | 0.948 |
| | Theta | 3.843 | 0.664 | 42 | 0.224 |
| | Alpha | 4.473 | 3.528 | 57 | 0.818 |
| | Beta | 2.749 | 3.362 | 46 | 0.341 |
| TP8 | Delta | 1.616 | 1.228 | 41 | 0.200 |
| | Theta | 4.106 | 0.764 | 45 | 0.309 |
| | Alpha | 3.765 | 6.991 | 30 | 0.045 |
| | Beta | 2.301 | 2.195 | 55 | 0.718 |

Abbreviation: MLC, medicolegal case.

**Table 7** Comparison of amplitude and latency for P300 on continuous performance test

| Electrode | | Median MLC group, $n = 11$ | Median non-MLC group, $n = 11$ | Mann–Whitney U test | Sig. |
|---|---|---|---|---|---|
| F3 | Latency | 511 | 389 | 30 | 0.042 |
| | Amplitude | 5.387 | 5.057 | 59 | 0.922 |
| F4 | Latency | 535 | 373 | 39 | 0.158 |
| | Amplitude | 3.843 | 0.664 | 54 | 0.670 |

Abbreviation: MLC, medicolegal case.

of words. When compared with the non-MLC group, the MLC group had significant errors on the recognition task of the AVLT, pointing to underutilization of recognition cues in verbal recall. Research has shown that TBI patients tend to have a difficulty in consolidation of new information; they have less proactive interference and impaired acquisition. However, they do not differ in the benefit experienced from semantic or recognition retrieval cues.[45,48,49] The weaker performance on the recognition task could also be an indicator of poor effort, as recognition clues should ideally help in retrieval. Forced choice tests or recognition tasks are often used for detecting malingering or decreased effort in patients.[50] On the visuospatial construction test, the MLC group had significantly poor performance as compared with non-MLC group. Mild traumatic injury has a significant effect on verbal and visual memory domains initially. But typically 3 months postinjury most patients show improvement across cognitive domains. In the current study, factors such as severity of injury, location of injury, or time since injury have not been considered while comparing the neuropsychological functions of the MLC and non-MLC group. Neuropsychological functioning and recovery post-TBI vary across individuals and domains; for instance, in moderate-to-severe TBI, recovery may take several years. Time since injury is also a significant moderator of neuropsychological functioning post-TBI.[10,51] Research indicates that the initial effect of mTBI on neuropsychological functioning tends to dissipate quickly. On the other hand, memory complaints may occur due to poor effort, in view of ongoing litigation or financial incentives. In addition to the above-mentioned functions, across all neuropsychological domains there was an observed difference in the performance of the MLC group, wherein their performance levels were lower than the non-MLC group.

An evaluation of the postconcussion and depressive symptoms showed that both groups did not have significant symptoms on either parameter. This finding is consistent with results reported by [46] which suggest fairly low mean frequency scores for both patients with mTBI and patients with minor injuries. Dikmen et al[52] in a longitudinal study of cognition and posttraumatic symptoms found that most neuropsychological and functional problems decreased by year 1; however, three or more posttraumatic symptoms persisted for about half of the individuals. Another longitudinal study of postconcussion syndrome patients concluded that postconcussion syndrome may be permanent if recovery has not occurred by 3 years. The symptoms occur in a predictable order, and additional symptoms reduce recovery rate by 20%. Correlation of neuropsychological functions with postconcussion symptoms and depression was done to explore the relationship between cognitive functioning and self-reported symptoms. There was significant correlation between some neuropsychological functions with BDI and RPQ in both groups. There was negative correlation between visuospatial working memory and symptoms of postconcussion and depressive symptoms in the MLC group. It was found that a higher spatial span was correlated with lesser postconcussion and depressive symptoms on both RPQ and BDI. Working memory functions are most commonly associated with postconcussion symptoms, after head trauma.[53,54] Several studies highlight the presence of working memory impairments in patients with depressive symptoms.[2,55] In the non-MLC group, there was correlation between total learning and immediate recall with postconcussion and depressive symptoms. Reddy et al[43] in a study found that both verbal and visual learning and memory were negatively correlated with postconcussion symptoms. The present study also showed a negative correlation between verbal learning and memory and depression. Kizilbash et al[56] found that depressive symptoms had an adverse effect on immediate recall of new information and the total amount of acquisition. The findings suggest that cognitive functions such as impaired working memory, verbal learning, and recall are related to individual reports of postconcussion symptoms and mood symptoms.

An evaluation of the electrophysiological parameters and neuropsychological functions showed that the finger tapping test (right hand) indicated no significant difference in β, theta, and α band frequencies between two groups. However, there was an observed difference between the groups. Performance of MLC patients was better than non-MLC patients for both right hand and left hand on finger tapping test. The cerebellum is known to be involved in event-based timing of repetitive movements. Cerebellar damage might cause deficit in finger tapping and disrupted timing of discontinuous movements.[57] The anterior cingulate cortex within the prefrontal cortex is increasingly considered as a brain region activated during tasks requiring conflict-monitoring and allocation of attention.[58] On the continuous performance test, P300 results indicated that the non-MLC group had significantly shorter latencies than the MLC group This was not due to inability to perform fast movements, since the MLC group of both finger movements was much higher than the non-MLC group. Obtained results for 15 memory test indicated that there was significant difference in the α band for both groups. Performance of non-MLC patients was better as compared with MLC patients. Several studies have found that effort and symptoms can influence neuropsychological performance and functioning post-TBI.[17–25] Litigation status may mediate the profile of neuropsychological performance, symptoms, and even recovery following TBI.[16]

## Conclusion

TBI creates a medical, social, and economic burden on the world at large. There are multiple sequelae of head injury including postconcussion symptoms, depression symptoms, and cognitive deficits. Cognitive functions are a vital part of both basic and instrumental activities of daily living, and are critical to recovery and adaptive functioning. In the current study, clinical evaluation of the TBI patients suggested that at the time of assessment, all subjects were able to comprehend test instructions and there was no evidence of any developmental or comorbid psychiatric, or neurological disorders. The TBI patients consisted of an MLC group that was seeking compensation (incentive) for the injury and a non-MLC group that did not pursue litigation. The MLC group performed weaker across cognitive domains when compared with the non-MLC group. The findings of the study showed evidence of cognitive deficits in TBI patients. In addition, those pursuing MLCs performed significantly poorer on tests of verbal working memory, verbal learning and memory, and visuospatial construction. Self-report measures of postconcussion and depression symptoms did not indicate significant problems. However, there was correlation between postconcussion measures, depression measures, and working memory. There was also evidence of variations in the electrophysiological measures on tests of attention and memory for the MLC group. It may be inferred that TBI patients follow a heterogeneous and protracted recovery pattern; some patients could be experiencing cognitive challenges in the form of working memory impairments, processing speed, learning, and memory difficulties. These impairments may be the reason for pursuing legal action. Alternatively, litigation itself may be a factor affecting the recovery process. The poor performance of the MLC group on the recognition tasks could be indicative of suboptimal effort, which could be an underlying factor affecting the neuropsychological profile of TBI patients with MLCs.

The limitations of the study include small sample size, participants not matched for age, gender, duration of illness, education, employment, marital status, and socioeconomic status. Consideration factors such as severity, location of injury, imaging data would have yielded more comprehensive results. The neuropsychological data was comprehensive; however, the tasks and analysis of EEG were limited to only three tests. For the EEG, the present study focused on frontal and temporal regions; however, inclusion of other regions would have been valuable. The use of symptom validity tests would have aided in determining the presence of malingering. In view of the above limitations, generalization of the results will be restricted. Future studies in this area should include larger samples, matched for parameters of age, gender, education, and brain injury parameters so that findings may be generalized with more confidence. The study evaluated symptoms and performance through behavioral, cognitive, and electrophysiological measures. The implication of this study is the presence of significant difference in neuropsychological functions in TBI patients with and without MLCs, and the possibility of suboptimal effort. This study emphasizes the need for comprehensive neuropsychological assessment, symptom validity and effort testing while assessing patients with MLC and TBI. This being one of the first studies to evaluate the neuropsychological and electrophysiological parameters in TBI with MLCs in India could further contribute to the development of forensic neuropsychological assessment practices.

**Conflict of Interest**
None declared.

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