

## Correlation of neuropsychological deficits with findings on MRI AND NEUROPET in patients with MTBI

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### Abstract

**Background & Objective:** Spectrums of post-traumatic symptoms are frequent among mild traumatic brain injury (MTBI) patients. They account for symptoms in 40-80% of patients during 3-4months and 15-30% of patients 6 months post-injury. There are no studies in India to support the literature of the same. The current prospective study evaluates neuropsychological deficits (NPD) and explores the value of MRI and NEUROPET in patients with MTBI. **Methods:** Fifteen MTBI patients presenting with initial GCS score of 13-15 were recruited initially 1-2 weeks post injury. All patients were followed up twice, after 1-2 and 6-7months. The patients were evaluated with MRI, Neuropet, neuropsychological test (PGIBBD – PGI brain battery of dysfunction), post-traumatic symptoms. All test variables were analyzed using repeated measure of analysis with 0.05 significant levels. **Results:** Sustained-attention was first to improve. Memory and executive domains improved partially until 2months and then after complete recovery. But few facets of learning/memory did not improve even at 6months. The post traumatic symptoms decreased since baseline from 76% to 52% at 3-4months and further to 28% at 6-7 months. The results of present study provide information that MRI lesions found in MTBI patients were predictive of neuropsychological deficits (NPD) if scan was done as early as within 1 week post injury. FDG F18 Neuropet in the present study has demonstrated hypometabolic lesions not seen on MRI and these lesions were correlating to neuropsychological deficits which were persistent 6 mths post injury in respective patients. **Interpretations & Conclusion:** The study reports course of changes in cognition, traumatic symptoms, since the time of injury till 6-7months. The results summarize that majority of post-traumatic symptoms recovers after MTBI without any intrusions, but residuals are not uncommon. Structural lesions on MRI may not always be present but when present may influence the degree or severity of the symptoms in patients with MTBI. Introduction of FDG PET as an early diagnostic modality in patients with neuropsychological disturbances after MTBI might be beneficial as the patients will be opted for relevant pharmacological and cognitive behavioural interventions.

**Keywords:** mild traumatic brain injury; neuropsychological test scores; post traumatic symptoms;

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### Introduction

Traumatic Brain Injuries (TBIs) are a major public health problem in India. Rapid increase in economic growth in our country coupled with rise in population, motorization and industrialization has contributed to significant increase in TBI both in number and percentages. Mild TBI (MTBI) accounts for nearly 80 - 90% of total brain injuries and the requirement of neurosurgical intervention is <1% [1-3].

The MTBI group of patients manifests symptoms in multi spectrum like cognitive, somatic, psychosocial, behavioral, and emotional. These manifestations are more evident during acute stages in about 30 - 80% of patients and resolves within a few days to weeks among majority of them, and in some sub group about 20 - 26% of patient the symptoms persist for longer duration [4-6]. The MTBI patient group manifesting with post traumatic symptoms may or may not have any abnormal lesions on conventional imaging. These patients are only treated for troubling somatic symptoms. Overtime the post traumatic symptom resolves without any intrusions. The natural course of post traumatic symptoms recovery is well documented in many developed countries.

In India neurological disability is 3<sup>rd</sup> epidemic among which brain injury is a major cause [7]. However, despite the increase in TBI burden with plenty of resources, the research in post traumatic

symptoms recovery of MTBI area is known less, emphasizing the need for detailed research.

The purpose of the current prospective study is to assess neuropsychological deficits in patients with MTBI, to find correlation between MR image findings and PCS and explore the value of Neuropet in MTBI patients.

### Definition

MTBI is defined as an injury which produces a period of unconsciousness for <30 minutes and /or brief retrograde amnesia, A GCS of 13-15, no focal neurological deficit, No intracranial complications.

Although majority of MTBI experience transient symptoms, a significant minority will have persistent and disabling conditions termed as post concussion syndrome (PCS) preventing them from returning to premorbid lifestyle.

Neuropsychological testing in patients with PCS assesses the deficits more precisely and also helps to some extent in treatment planning and prognostication.

Many studies have shown MRI to be more sensitive than CT especially in detection of non hemorrhagic contusion, DAI and show some correlation between these MRI lesions and the deficits on neuropsychological tests.

Modalities like SPECT and PET may detect areas of hypoperfusion and decreased metabolic activity (glucose uptake) in patients with MTBI and might prove to be more sensitive than other imaging modalities in the initial diagnostic evaluation of patients with MTBI [8].

**Why this study?**

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Most of the studies done previously were retrospective and PET scan was done more than two weeks post injury thus negating its usefulness as initial diagnostic tool.

**Aims and Objectives**

- To assess neuropsychological deficits in patients following MTBI.
- To find correlation between MR image findings and PCS (post concussion syndrome)

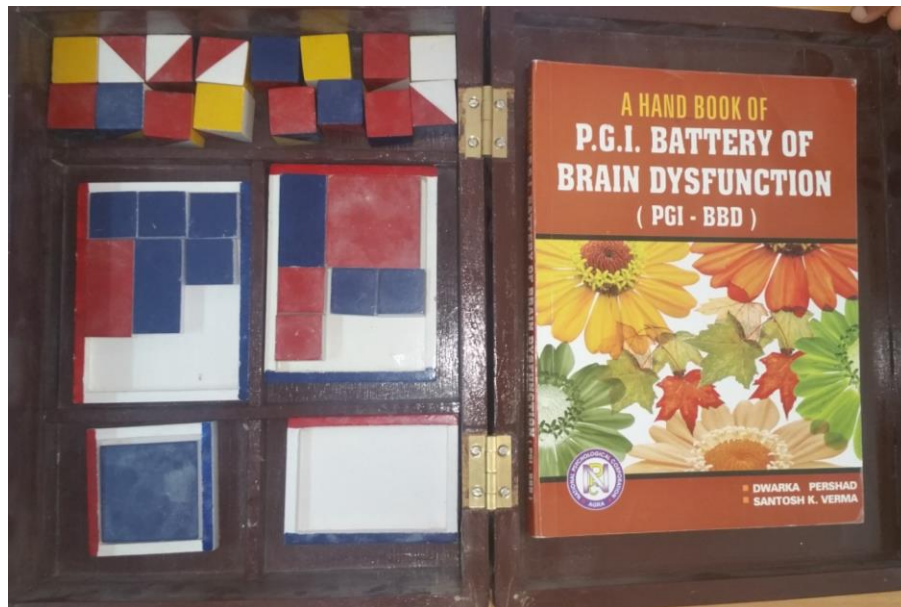
- To explore the value of FDG -PET scan in MTBI.

**Materials and methods**

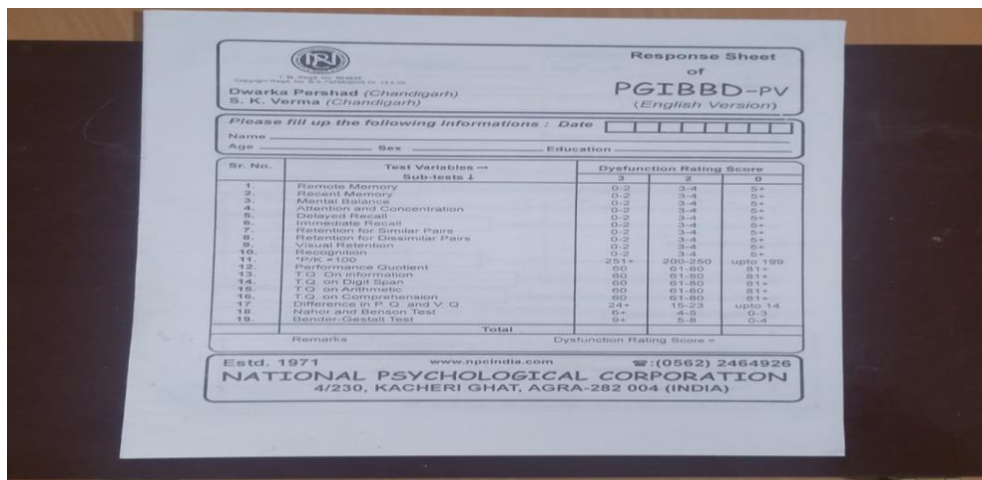
This is a prospective, cohort study which includes 15 consecutive patients with MTBI.

Informed written consent is obtained from all the patients recruited in the study.

Duration of the study: 1 year with follow up of individual patients at 1-2, 6-7 months by neuropsychological assessment (PGIBBD).



**Fig 1: PGIBBD (PGI Brain Battery Of Dysfunction)**



**Fig 2: PGIBBD – Dysfunction rating score**

**Inclusion criteria**

- ✓ History of MTBI, defined as an injury which produced a period of unconsciousness for 30 minutes or less and/or retrograde amnesia less than 24 hrs, a Glasgow score of 13 to 15,
- ✓ Age group between 15-60 years,
- ✓ No focal neurological deficit,
- ✓ No intracranial complications.

**Exclusion criteria**

- Head injuries with GCS <13
- Head injuries with other extracranial injuries
- Age < 15 and > 60 years (pediatric and old age population)

- Patients who have undergone any neurosurgical procedure, or required hospital admission or prior to head injury.
- Patients with neurological, neurosurgical, psychiatric illnesses were also excluded.
- Pregnant and lactating women, patients with cardiac pacemakers and ferromagnetic materials in their bodies were also excluded.

All the patients included in the study underwent clinical examination, CT, MRI, and F18 FDG-PET scan within 1-2 wks of injury and follow up at 1-2, 6-7 months by neuropsychological assessment.

**Analysis**

The data was following normal distribution and variances was equal on comparing with post period values with the basal values ( $p > 0.05$ ), therefore parametric test was considered. The mean scores of all NPTs was taken for first and second time interval for any significant changes ( $p < 0.05$ ) using repeated measures of analysis.

**Results**

A total of 15 patients (10 men) underwent baseline neuropsychological assessment with all patients follow up on 1-2 and 6-7 months. Road traffic accident (RTA) was major cause of injury contributing to 11 (73%), followed by falls 3 (20%) and assault 1(6%) with mean age of  $31 \pm 4.91$  years and mean education of  $12.44 \pm 2.66$  years.

The mean duration for first assessment is 45.88days; second assessment is 210.18days. All patients had loss of consciousness (LOC) with mean duration of  $11.24 \pm 10.19$  minutes;  $< 5$  minutes was seen in 8 (53%), 6-15 minutes was seen in 4 (26%), and 16-30

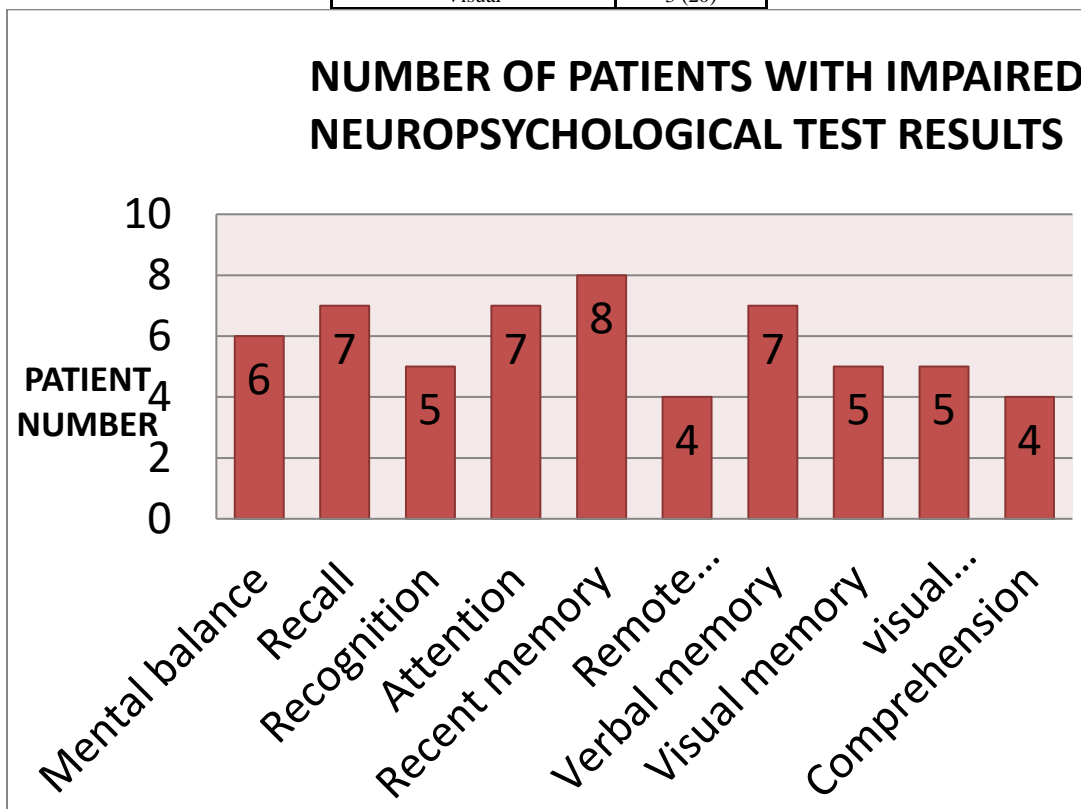
minutes was seen in 3 (20%); 12 (80%) patients had 1-2 episode of vomiting; 40% (6) patients had post traumatic amnesia lasting for 6-24 hours; only 2 (13%) patients had seizures less than 36 hours since injury.

The results on cognitive scores at baseline imply that the initial neuropsychological test scores were lower than that of normal population scores. Over time their improvement are as follows; Sustained attention improved completely during 2 weeks to 3 months. Visuo spatial memory (spatial span) and Visuo constructive ability (CFT), immediate and delayed recall improved partially from baseline till 3 months, complete recovery from 3 – 6 months. Patients with traumatic amnesia and seizures also improved.

During 2-3 weeks 76%, 3-4 months 52% and 6-7 months 28% of MTBI patients manifest with post traumatic symptoms. Common symptoms that were present from baseline till 6-7 months are headache, behavioural disturbance , sleep disturbance, irritability, poor concentration, longer time to think.

**Table 1: Presenting Complaints of the patients**

Presenting complaints of the patients - (Rivermaide PCS questionnaire)	
Symptom	Number(%)
Head ache	12 (80)
Behavioural disturbances	11 (73.3)
Sleep disturbances	9 (60)
Attention deficit	7 (46.6)
Giddiness	4 (26.6)
Visual	3 (20)



**Fig 3: Number of patients with Impaired Neuropsychological test results**

**Table 2: MRI lesions with seen in MTBI**

MRI lesions seen in MTBI			
Location	Frontal (13)	Temporal (12)	Parietal (8)

Right	6	7	4
Left	2	4	2
Bilateral	5	1	2

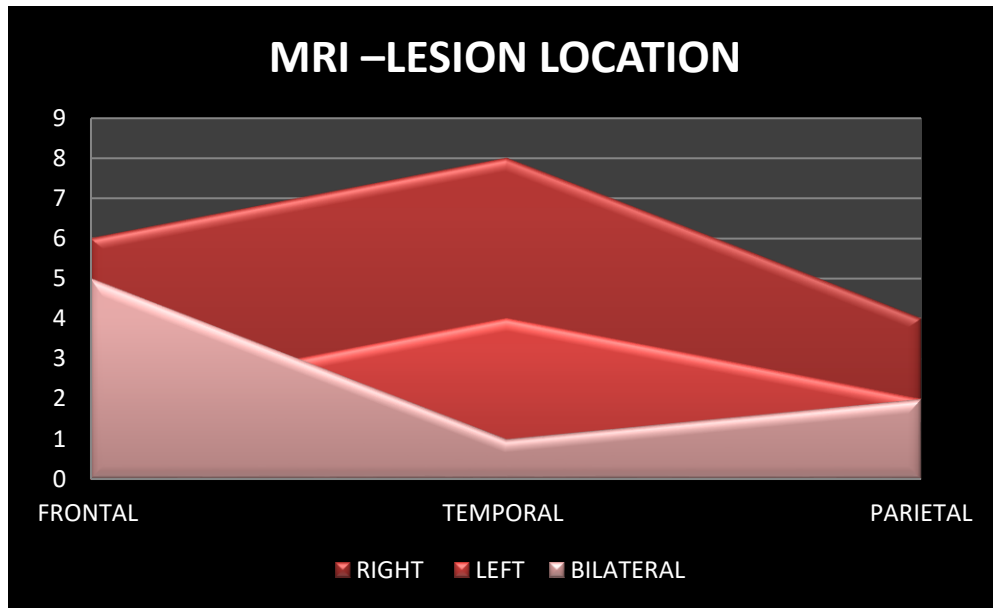


Fig 4: MRI-Lession Location

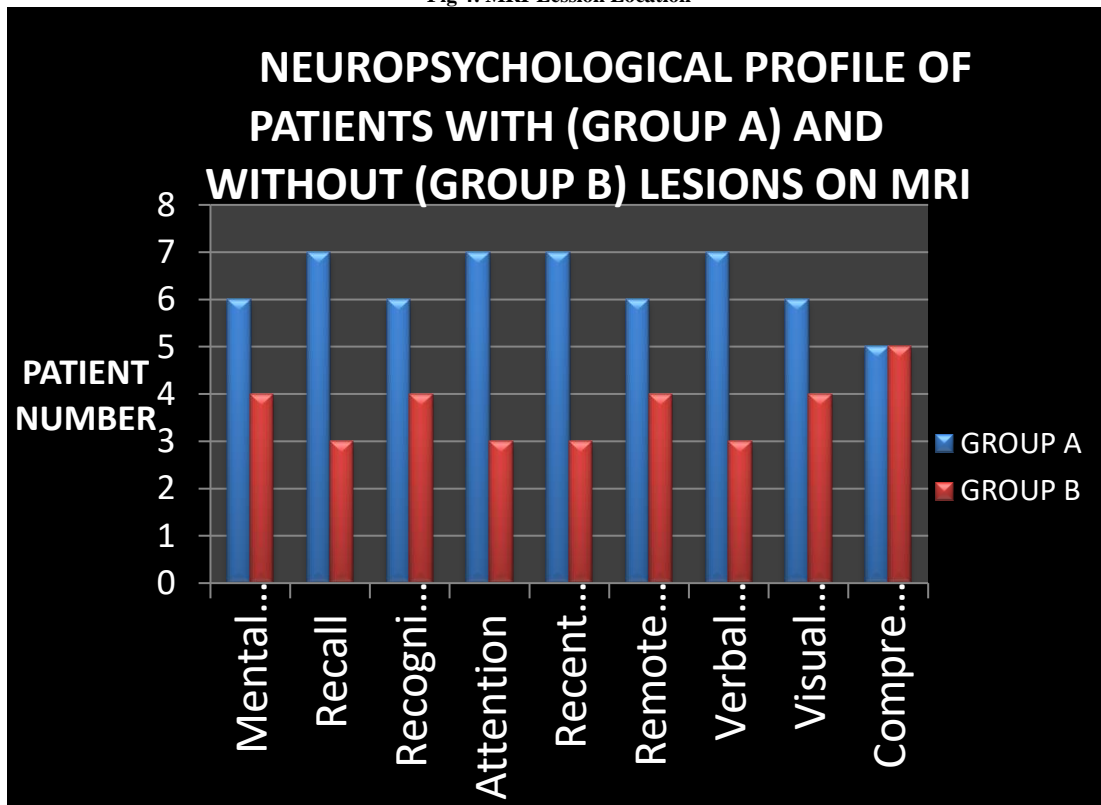


Fig 5: Neuropsychological profile of Patients

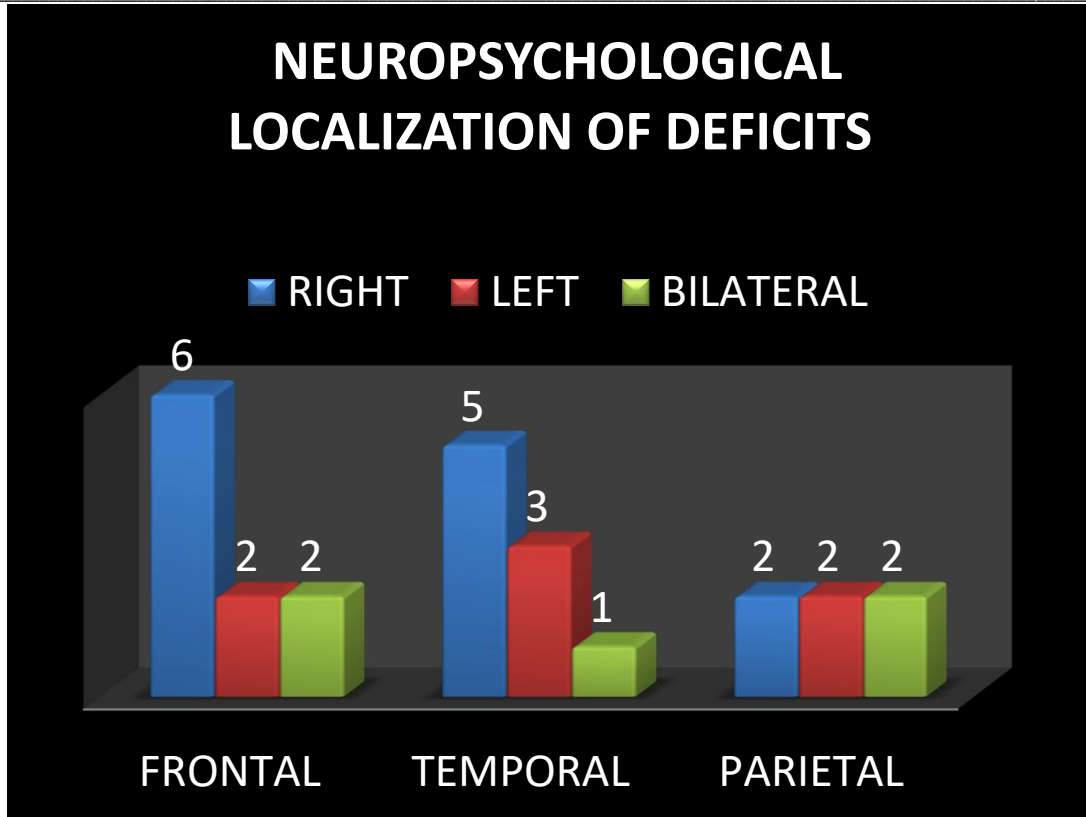


Fig 6: Neuropsychological Localization of deficits

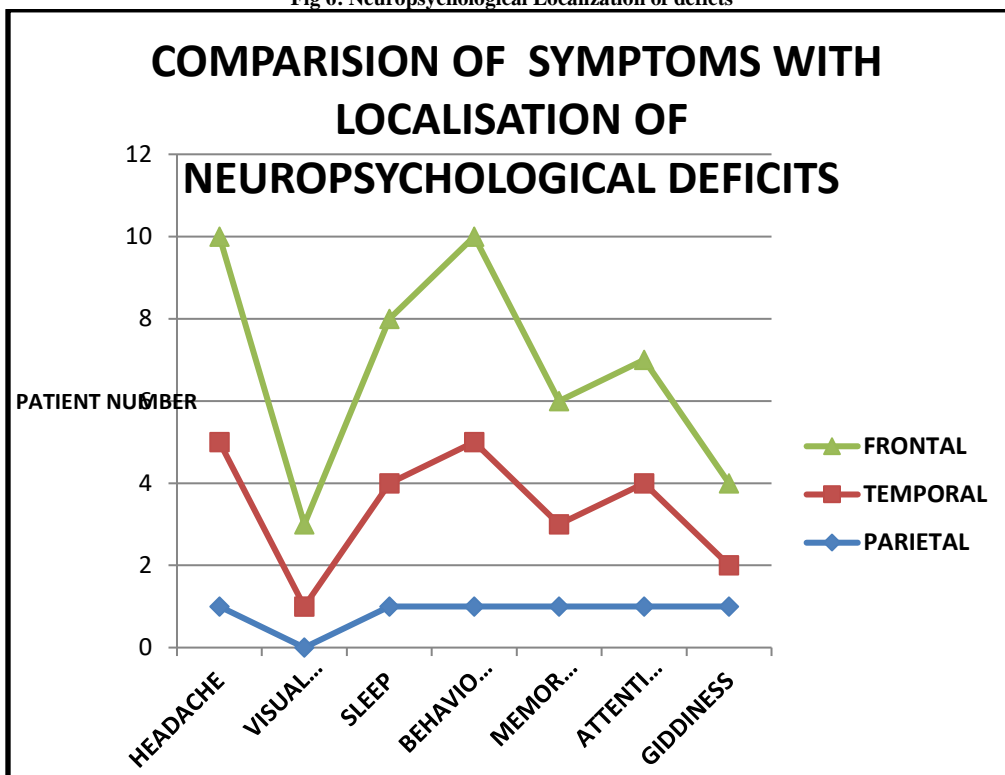


Fig 7: Comparison of symptoms with localization of Neuropsychological Deficits

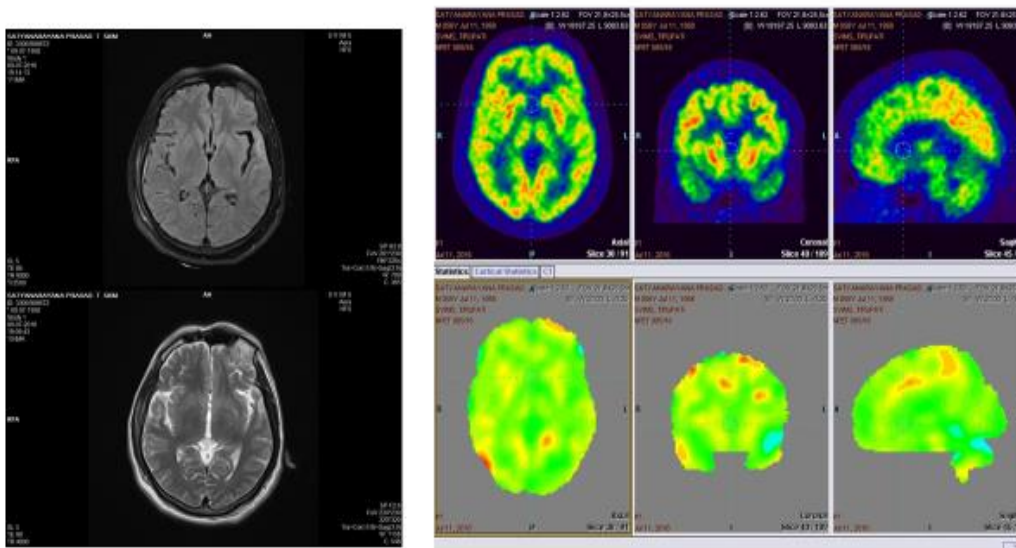
Table 3: Neuropsychological Deficit localization in patients with Frontal Lesion on MRI

Neuropsychological deficit localization in patients with frontal lesions on MRI			
Frontal MRI lesions	Frontal Neuropsychological Deficit Localization		
	Present	Absent	Total
Present	9	4	13
Absent	0	2	2
Total	9	6	15

**Table 4: Neuropsychological deficit localization in patients with Temporal Lesions on MRI**

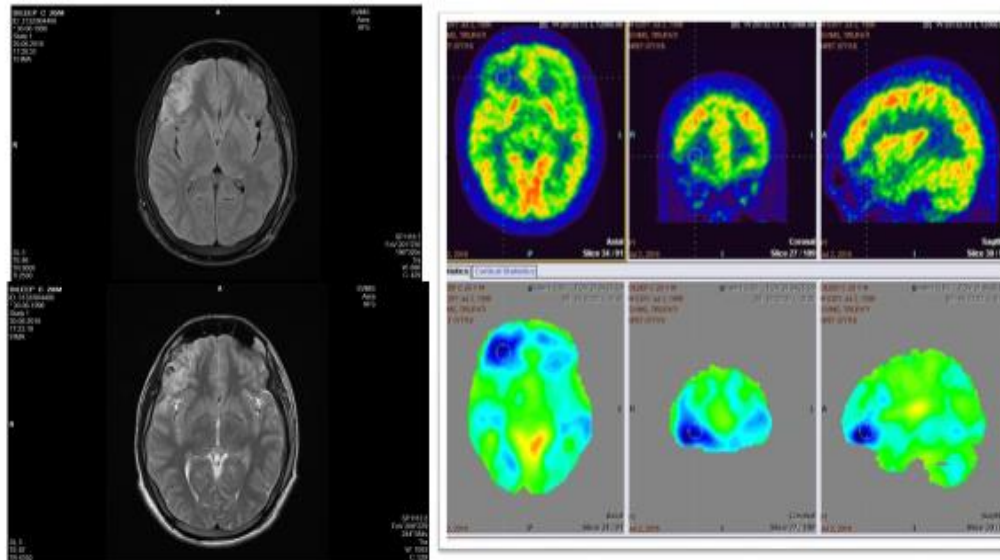
Neuropsychological deficit localization in patients with temporal lesions on MRI			
Temporal MRI lesions	Temporal neuropsychological deficit localization		
	Present	Absent	Total
Present	5	7	12
Absent	2	1	3
Total	7	8	15

### HYPERMETABOLISM IN B/L F,T,BG



**Fig 8: MRI vs NEUROPET [Hyper metabolism in Bilateral frontal, temporal, Basal ganglia regions]**





**Fig 9: Hypermetabolism in B/L F, T, BG, Post central gyrus**

### Discussion

- In this prospective study 9 out of 15 patients with PCS following MTBI had deficits on neuropsychological tests.
- Most of the symptoms were associated with frontal/temporal dysfunction on neuropsychological testing.
- The mean age of 31+ 4.9 years reflects the relatively young and productive age profile of the patients.
- Neuropsychological deficits (NPD) were seen as soon as 1 month post injury. These observations suggest that PCS can manifest early and may persist thereafter.
- The commonest symptoms reported by patients in this study were headache, memory, sleep disturbances, and behavioural changes similar to the observations in studies conducted by Hughes et al[9]. The most frequent neuropsychological localization was frontal and temporal which was similar to study conducted by Hughes et al[9].
- The study reports improvement in neuropsychological test scores, post traumatic symptoms after brain injury, however the recovery of these symptoms range from partial to complete.
- The study summarize that the attention is the first cognitive function that improves earlier followed by executive function that get better slowly and the memory is the last higher mental function that its improvement starts after few days and resolves then after. During 2-3 weeks of post injury nearly three-fourth of patients had post traumatic symptoms, which later on 3-4 months reduced to half of total patients. And during 6-7 months 28% of patients had persistent symptoms.
- For comparison of variables with seizures and amnesia our sample size is too small, but on observational basis the present study that specifically focused on GCS 15 reports that patients with amnesia and seizures also recovered similar to patients without any neurological symptoms during injury. Even though the recovery is expected to be good in this group the persistence of post traumatic symptoms percentages is slightly more than literature (GCS of 13, 14 and 15).
- In present study all patients had normal CT findings (uncomplicated) reports improvement in attention, executive function and memory domains in descending order by 6-7 months.
- There are reports of sports related studies on concussion injury which evaluated neuropsychological functioning from very acute period (less than 24 hours) till one month post injury with serial evaluation in between. The results reveal that majority of

cognitive impairment resolves in 5 to 10 days durations[10,11]. Forty MTBI patients injured by various modes were evaluated during 48 hours and one month. Patients with LOC presented with improvements in directed attention scores and distractibility, but had not reached to normal values by one month[12].

- A study conducted cognitive test one month post injury. The results showed that regardless of traumatic amnesia at presentation cognitive scores were virtually at normative levels at 1 month[13]. In the present study also one-fourth of patients with amnesia improved in cognitive domains similar to other patients who had no amnesia, but the duration required for improvement were longer.
- A study performed cognitive testing at 24 hours and 3 months post injury in MTBI patients. They found cognitive impairment was reported by 44% of the patients on the first day and by 26% at 3 months post-injury[14].
- The current study reports that sustained attention improved completely in 3-4 months after injury. The response speed, visuospatial (spatial span) and constructive ability (CFT) improved partially. The current study supports the literature that few aspects of cognitive domains recover partially and some completely between baselines to 3-4 months post injury.
- Twenty to thirty percent of MTBI patients manifest with irritability and concentration problem at one month of post injury. The MTBI patients did things more slowly, fatiguing quickly, and had poor balance compared with controls at three months[15]. Forgetfulness, and sleep disturbance were most commonly reported at 3 months[15]. Headache, fatigue, and sleep disturbance were most commonly reported at 6 months[15]. The post traumatic symptoms reported in literature are 84 - 67.3% at 1<sup>st</sup> week, 29 - 41% at 3<sup>rd</sup> month and 14 - 26.4% at 6<sup>th</sup> month[4,5] The present study results accounts that headache, sleep disturbance, irritability, decrease response time, poor concentration are the post traumatic symptoms that have persisted from baseline till 6-7months, although the mentioned symptoms subsided overtime.
- The current study reports post traumatic symptoms decline in MTBI patients from 76% at baseline to 52% at 3-4 months and further to 28% at 6-7 months. Possible reason in the study sample for higher percent of post traumatic symptoms are

- Patients perceptions of their illness that their symptoms have serious negative consequences on their lives may be a risk factor for their persistence of traumatic symptoms[16].
- MTBI due to motor vehicle collisions, falls and assault have a higher chances of persistent symptoms that may be related to traumatic experience itself, where the trauma is often unexpected, may cause emotionally charged, or associated with multiple factors[17].
- Of the 59 children studied by vander et al. one year after head injury , MRI lesions were seen in 66%[18]. In the present study MRI lesions were seen in more than 60 % of patients.
- Vander et al studied MRI in 67 patients within one to three months and again within 6 to 12 months after injury[18]. The lesion location was predominantly in the frontal and temporal regions in comparison to the present study.
- Frontal lesions seen in MRI done in the early period after head injury were found to be predictive of cognitive outcome in the study by vander *et al*[18]. The results of present study also provide similar information that MRI lesions found in MTBI patients were predictive of neuropsychological deficits (NPD) if scan was done as early as within 1 week post injury.
- In the present study FDG F18 NeuroPET has demonstrated hypometabolic lesions not seen on MRI and these lesions were correlating to neuropsychological deficits which were persistent 6 months post injury in respective patients.

### Conclusions

In summary, the longitudinal view of cognitive impairment, post traumatic symptoms suggest significant improvement between 14 and 120 days. Further improvement is seen up to next 3 months (210 days) after injury without any intervention. But the improvement is not complete and there are residual symptoms seen in the entire spectrum. However, the present study result replicates the literature reports and adds Indian data regarding natural course of post traumatic symptoms in MTBI group.

Structural lesions on MRI may not always be present but when present may influence the degree or severity of the symptoms in patients with MTBI.

FDG -PET scan forms an important diagnostic tool in early identification of lesion not found on CT/MRI in patients suffering from neuropsychological disturbances.

Introduction of FDG PET as an early diagnostic modality in patients with neuropsychological disturbances after MTBI might be beneficial as the patients will be opted for relevant pharmacological and cognitive behavioural interventions.

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