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Post traumatic amnesia as a predictor for development and recovery of visual field defects following mild traumatic brain injury (mTBI)

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ABSTRACT

Introduction: Mild traumatic brain injury can trigger long term visual dysfunction in the form of visual field defects which can disrupt the normal lifestyle of any individual and other rehabilitation efforts resulting in social and professional distress. Post traumatic amnesia is one of the predictors of severity in mTBI.

The purpose of this study was two fold (i)To find out the association between post traumatic amnesia and visual field defects following mild traumatic brain injury. (ii) The implication of post traumatic amnesia on the development and recovery of visual field defects post mTBI.

Materials and Methods: Hospital based prospective, analytical, observational study. A total of 260 patients with the diagnosis of mTBI were studied. Diagnosis of mTBI was based on the WHO Operational criteria for clinical identification of mTBI.

Visual field index (VFI) was taken to estimate the extent of visual field damage because it is a global index which expresses the amount of visual field loss as a percentage relative to the sensitivity of a reference group of healthy observers.

The Galveston orientation and amnesia test (GOAT) was applied to assess post traumatic amnesia. The study period was from July 2017 to March 2019. Each patient with mTBI was examined for Visual field defects at 1 month, 6 months and 1 year post injury.

Results: The main observation of this study were (i) It is important to look for visual field defects even in mild traumatic brain injury for atleast 6 months post injury because during this period the appearance of visual field defect peaked. (ii) There is a strong possibility of developing visual field defects among the group of patients who presented with the history of post traumatic amnesia following mild traumatic brain injury (P=0.0001) (iii) If a patient with mild traumatic brain injury suffers from visual field defects, possibility of his/her symptoms persisting beyond 12 months increases significantly if there is history of post traumatic amnesia (P=0.0001).

Conclusion: Mild traumatic brain injury can trigger long term visual dysfunction in the form of Visual field defects. Our results will help in providing information regarding development, progress and outcome of visual field defects following mild traumatic brain injury.

1. Introduction

Traumatic brain injury is a major cause of death and disability with an estimated incidence of 10 million cases per year.[1] The vast majority are so-called mild traumatic brain injuries (mTBI) and are at least tenfold more prevalent than the more severe injuries.[2] While the likelihood of a favourable recovery from mTBI within a few months is high,[3–5] a proportion of patients experience long-standing cognitive, emotional, and/ or somatic symptoms that interfere with work, school, and/or family responsibilities.[6]

Visual symptoms associated with moderate and severe traumatic brain injury are usually profound and have historically overshadowed the impact of mTBI . Even mTBI

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can significantly affect visual functions. This is due to the fact that about 70% of the brain's sensory processing is visual related. [7,8]

The most common visual deficits associated with mTBI are occulomotor dysfunction (accommodative, version, vergence) and their associated reading problems, photosensitivity and visual field defects. [8–10]

Although Visual Field defects are expected in more severe forms of acquired brain injury (moderate TBI, severe TBI, CVA), a study among warfighters showed VF defects are common in mTBI. 62% of mTBI patients had visual field defects as detected by a Humphrey matrix FDT Perimeter. The most common VF defect seen was nonspecific scatter defects 48%. [11]

Visual field defects lead to impairments in activities of daily life such as reading, writing, driving or overall orientation and may therefore have severe impact on patients well being and quality of life. [12] Thus it becomes imperative to look for visual field defects even in mild traumatic brain injury.

It is important for the health care provider to understand the relevance of visual field testing in different stages of post mTBI recovery particularly since VF deficit can negatively affect other rehabilitation efforts and overall quality of life. [9]

Post traumatic amnesia is defined as the period of time from last memory before trauma until the return of normal continuous memory when the individual is continuously oriented and demonstrates consistent recall. [13]

The risk of neuro-cranial complications after a brain injury in which patients did not experience loss of consciousness or post traumatic amnesia is only a quarter of the risk of individual that do experience loss of consciousness or post traumatic amnesia. Duration of post traumatic amnesia is one of the best predictors of severity of brain injury. [14,15]

There is almost no literature or studies available on post traumatic amnesia and its association with visual field defects.

The purpose of this study was two folds

1. To find out the association between post traumatic amnesia and visual field defects following mild traumatic brain injury.
2. The implication of post traumatic amnesia on the development and recovery of visual field defects.

2. Materials and Methods

This study is a hospital based prospective, analytical, observational study.

2.1. Setting

Patients were recruited from Department of Neurosurgery (OPD/Casualty/Indoor) and evaluated in the Outpatient Department of Ophthalmology of Kalinga Institute of Medical Sciences Pradyumna Bal Memorial Hospital, KIIT University,Bhubaneshwar.

2.2. Inclusion criteria

All patients attending the Neurosurgery department or Casualty of Pradyumna Bal Hospital, KIMS, clinically diagnosed as mild traumatic brain injury (mTBI), above the age of 18 years with visual aquity equal or more than 20/40 were included in the study.

2.3. Exclusion criteria

All patients diagnosed as mTBI with glaucoma, retinal diseases, vitreous haemorrhage, central corneal opacities, advanced cataract, ocular trauma, history of intraocular surgery, psychiatric illness or repeated mTBI were excluded from the study.

2.4. Study period

The study period was from July 2017 to March 2019. Each patient with mTBI was examined for Visual field defects at 1 month, 6 months and 1 year post injury.

2.5. Methodology

All patients underwent a detailed ophthalmic evaluation including BCVA (best corrected visual acuity), color vision (Ishihara chart), Slitlamp examination, Fundus examination, Applanation Tonometry, Schimer's test, Gonioscopy, SD – OCT for RNFL and Perimetry.

Visual field testing was performed for each eye separately using Humphrey Automated Field Analyzer program 30-2 Swedish Interactive Threshold Algorithm Standard (Carl Zeiss Meditech, Inc, Dublin, California, USA. Model 745i).

All visual fields with poor reliability were excluded from analysis. Reliability was defined as less than 20% fixation loss and less than 33% for both false positive and false negative errors. [12]

2.6. Visual field index

Visual Field Index (VFI) was taken to estimate the extent of visual field damage. VFI is incorporated into the statpac software of the Humphrey Field Analyzer used. VFI is a global index which expresses the amount of visual field loss as a percentage relative to the sensitivity of a reference group of healthy observers. A completely normal visual field is aasociated with a VFI of 100%, and a perimetrically blind field will have a VFI of 0%. [16] We have taken Visual Field Index of 80% as significant visual field loss for this study.

Visual Field Index is meant to address several shortcomings of the index Mean Deviation which has been routinely used to describe overall visual field status in

individuals and groups of patients enrolled in research studies. Visual Field index has advantages over Mean Deviation for calculating an index of overall visual field defects.[17]

2.7. Mild traumatic brain injury

Diagnosis of mTBI was based on the WHO Operational criteria for clinical identification of mTBI: (I) One or more of the following: Confusion or disorientation, loss of consciousness for 30 minutes or less, Post traumatic amnesia of less than 24 hours duration and/or other transient neurological abnormalities such as focal signs, seizures and intracranial lesions not requiring surgery. (II) A Glasgow coma scale of 13-15 after 30 minutes post injury or at presentation to the hospital.

2.8. Post traumatic amnesia

All the patients underwent the Galveston orientation and amnesia test (GOAT) for determining post traumatic amnesia.[18]

The GOAT was applied within seven days following mTBI depending on the time of arrival of the patients to the hospital. GOAT score of <75 was taken as the cutoff for establishing the diagnosis of post traumatic amnesia following mTBI.

2.9. Statistical analysis

Statistical significance between the groups was determined by using Fisher Exact Test. P value ≤ 0.05 was considered to be significant.

All details were recorded in patient data form.

Patient consent was taken for participation in the study.

3. Results

560 eyes of 280 consecutive patients between the age group of 18 to 62 with the diagnosis of mTBI were studied and analyzed. Out of 280 patients, 178 were male and 102 were females. Visual fields of 40 eyes (20 Patients) were excluded from the study because they did not meet the reliability criteria. Finally 260 patients were recruited for the study.

Mode of injury was road accidents in 61% followed by falls in 19% of patients. Sports related injuries were responsible in 12% of patients and assault in 8% of the patients.

Out of the 260 mTBI patients studied, 54.6% (142) were found to be suffering from post traumatic amnesia.

Visual field defect as confirmed by Visual field index of less than 80% on perimetery examination was found among 36% (188 eyes) of patients.

To understand the association between post traumatic amnesia and visual field defects following mTBI and its implication on the development and recovery of visual field defects, the patients who developed visual field defects were divided among two groups.

Group I : Patients of mild traumatic brain injury with history of post traumatic amnesia.

Group II : Patients of mild traumatic brain injury without the history of post traumatic amnesia.

Among the patients with mild traumatic brain injury who developed visual field defects, 74.4% (140 eyes) belong to group (I) while 25.6% (48 eyes) belonged to group (II)

A strong possibility of developing visual field defect was noted among the group of patients who presented with the history of post traumatic amnesia following mild traumatic brain injury (p=0.0001). (Table 1)

The development and progress of Visual field defects following mild traumatic brain injury was similar among both the groups (Table 2). In both the group of patients of mild traumatic brain injury with and without history of post traumatic amnesia, the appearance of visual field defect peaked at 6 months post injury. Thus looking for visual field defects in mild traumatic brain injury for at least 6 months post injury become simperative.

In group II patients, 75% of patients with visual field defects recovered by the end of one year however in group I, the visual field defects did not improve or resolve but persisted in 71.4 % of patients at one year. (Table 2)

The visual field defects following mTBI are likely to persist for a longer period or may not resolve if the these patients presented with history of post traumatic amnesia (p=0.0001).

Thus the main observation of this study are

1. It is imperative to look for visual field defects even in mild traumatic brain injury for atleast 6 months post injury
2. There is a strong possibility of developing visual field defects among the group of patients who presented with the history of post traumatic amnesia following mild traumatic brain injury
3. If a patient with mild traumatic brain injury suffers from visual field defects, possibility of his/her symptoms persisting beyond 12 months increases significantly if there is history of post traumatic amnesia.

4. Discussion

The aim of this study was to find out the association between post traumatic amnesia and visual field defects in patients with mild traumatic brain injury and the implication of post traumatic amnesia on the development and recovery of visual field defects.

36% of our patients developed visual field defects following mTBI. The reported incidence of visual field defects after mTBI is variable among different studies.

Table 1: Occurrence of Visual field defect in relation to post traumatic amnesia

	mTBI with Post traumatic amnesia (Group I)	**mTBI without Post traumatic amnesia (Group II)**
mTBI with Visual field defect	70 (140 eyes)	24(48 eyes)
mTBI without Visual field defect	72 (144 eyes)	94 (188 eyes)

Table 2: Development and progress of Visual field defect (VFD) following mTBI

Table 2	**VFD at 30 days**	**VFD at 6 months**	**VFD persisting at 1 year**
mTBI with Post traumatic amnesia (Group I)	11.4%	88.6%	71.4%
mTBI without Post traumatic amnesia (Group II)	12.5%	87.5%	25%

Table 3: Recovery pattern of Visual field defect in relation to Post traumatic Amnesia

Table 2	**mTBI with Post traumatic amnesia (Group I)**	**mTBI without Post traumatic amnesia (Group II)**
Visual field defect Recovered $\leq$ 12 months	20 (40 eyes)	18 (36 eyes)
Visual field defect Persisted $\geq$ 12 months	50 (100 eyes)	6 (12 eyes)

Maj David V reported 62% of mTBI patients having Visual field defects in his study. He al so suggested that the most common Visual Field defect seen was nonspecific scatter defects 48%.[11] Scatter defects as the most frequent Visual field deficit (58%) was also reported by Suchoff et al.[19]

In another study Zihl suggested Visual field defects are probably the most frequent visual deficit resulting from brain injury, but Visual field defects may often be undiagnosed or underdiagnosed.[20] Goodrich reported 24% of those with brain injuries had some sort of Visual field defect.[21]

Out of the 260 mTBI patients studied, history of post traumatic amnesia was noted in 54.6% (142) of patients.

The risk of neuro-cranial complications after a brain injury in which patients did not experience loss of consciousness or post traumatic amnesia is only a quarter of the risk of individual that do experience loss of consciousness or post traumatic amnesia. Post traumatic amnesia is one of the best predictors of severity of brain injury.[14,15]

In our study the overall manifestation of Visual field defects following mTBI was 36% however on subgroup analysis (Group I: mTBI with history of Post traumatic amnesia, Group II : mTBI without the history of Post traumatic amnesia), the visual field defect among group I patients was 74.4% while in group II patients it was 25.6%.

The group of patients with the history of post traumatic amnesia had stronger possibilty (74.4%) of developing Visual field defect following mTBI and once these visual field defects are manifested they are unlikely to recover or resolve. However the probability of development of Visual field defects in the group without history of post traumatic amnesia was much less (25.6) and majority of the patients in this group recovered by 12 months.

The exact mechanism or reasons for development of Visual field defects in patients with mild traumatic brain injury especially among the group with history of post traumatic amnesia is not known. There is a strong possibilty that patients with history of post traumatic amnesia might trigger a stronger disruption of neural pathways.

Among available literature, few studies which are based on animal models have demonstrated that following mTBI there were structural or morphological changes in retina which co-related well with the visual field defects.[22]

The patients with mTBI and history of post traumatic amnesia may develop profound disruption of ipRGCs (Retinal ganglion cells) and lateral geniculate nucleus therefore resulting in a stronger probability of developing visual field defects in this group of patients.[23,24]

Another study demonstrated that a major component of the brain's reaction to trauma is an immune response that can cause additional long-term damage above and beyond that of the initial injury. This response was observed in their model as regions of microglial cell activation throughout areas of the brain important for visual processing.[25]

Yet another study concluded that TBI of any form can cause cognitive, behavioral and immunologic changes in later life, which underscores the problem of underdiagnosis of mild TBI that can cause long-term neurological deficits. TBI disrupts the blood – brain barrier (BBB) leading to infiltration of immune cells into the brain and subsequent inflammation and neurodegeneration.[26]

The beta chemokine RANTES (regulated on activation, normal T cell expressed and secreted) ,which is constitutively expressed by different cells in the brain ,is elevated after brain injury. This molecule encourages macrophage migration and activation and may correlate with severity of brain injury. This may be the possible reason for development of Visual field defects more frequently among the group of mTBI patients with history of post traumatic

amnesia.[27]

At present the literature is non-existent regarding the association of visual field defects and post traumatic amnesia in cases of mild traumatic brain injury. Based on the results of present study it would not be wrong to conclude that there is a strong possibility of developing visual field defects among the group of patients who presented with the history of post traumatic amnesia following mild traumatic brain injury (p=0.0001). This study also indicates that visual field defects following mTBI are likely to persist for a longer period or may become perm anent if these patients presented with post traumatic amnesia(p=0.0001) where as Visual field defects among mTBI patients without the history of post traumatic amnesia are likely to resolve in majority of patients by one year.

It is important for the health care provider to understand the relevance of visual field testing in different stages of post mTBI recovery particularly since Visual field deficit can negatively affect other rehabilitation efforts and overall quality of life.[9]

Limitation of this study is that probably this is the only study where association between post traumatic amnesia and visual field deficit has been studied . More similar studies may help in reaffirming the observations and results generated by this study.

5. Conclusion

Mild traumatic brain injury can trigger long term visual dysfunction in the form of Visual field defects. Mild traumatic brain injury with history of post traumatic amnesia probably represents a more severe form of injury resulting in significant disruption of neural pathways.

Present study indicates that it is important to look for Visual fiels defects even in mild traumatic brain injury for atleast 6 months post injury. The present study also suggests there is a strong possibility of developing visual field defects among the patients who present with the history of post traumatic amnesia following mild traumatic brain injury (p=0.0001) and these visual field defects are unlikely to resolve.(p=0.0001).

This can have significant impact on the quality of life of these patients as the patient might not be aware of his visual field defects until a disaster happens.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: A global perspective. *Neuro Rehabil*. 2007;22(5):341–353.
2. Bazarian JJ, Mcclung J, Shah MN, Cheng YT, Flesher W, Kraus J. Mild traumatic brain injury in the United States. *Brain Inj*. 1998;19(2):85–91.
3. BELANGER HG, VANDERPLOEG RD. The neuropsychological impact of sports-related concussion: A meta-analysis. *J Int Neuropsychological Soc*. 2005;11(4):345–357.
4. de Guise E, Lepage JF, Tinawi S, Blanc JL, Dagher J, Lamoureux J. Comprehensive Clinical Picture of Patients with Complicated vs Uncomplicated Mild Traumatic Brain Injury. *Clin Neuropsychologist*. 2010;24(7):1113–1130.
5. Levin HS, Mattis S, Ruff RM, Eisenberg HM, Marshall LF, Tabaddor K, et al. Neurobehavioral outcome following minor head injury: a three-center study. *J Neurosurg*. 1987;66(2):234–243.
6. Mcmahon PJ, Hricik A, Yue JK. Symptomatology and functional outcome in mild traumatic brain injury: results from the prospective TRACK-TBI study. *J Neurotrauma*. 2014;31(1):26–33.
7. Sutter P. Rehabilitation and management of visual dysfunction following traumatic brain injury. In: MJ A, DK K, Raton B, editors. Traumatic Brain Injury Rehabilitation. CRC Press; 1995. p. 187–216.
8. Capo-aponte JE, Urosevich TG, Temme LA, Tarbett AK. Visual dysfunction and symptoms during the subacute stage of blast induced mild traumatic brain injury. *Mil Med*. 2012;177(7):804–813.
9. Kapoor N, Ciuffreda KJ. Vision disturbances following traumatic brain injury. *Curr Treat Options Neurol*. 2002;4:271–280.
10. Ciuffreda KJ, Kapoor N, Rutner D, Suchoff IB, Han ME, Craig S. Occurrence of oculomotor dysfunctions in acquired brain injury: a retrospective
analysis. *Optom*. 2007;78:155–161.
11. V MD, Capo-Aponte JE, Jorgensen-Wagers K. Visual field dysfunctions in warfighters during different stages following Blast and Nonblast mTBI. *Mil Med*. 2015;180(2):178–185.
12. Kerkhoff G. Restorative and compensatory therapy approaches in cerebral blindness -a review. *Restor Neurol Neurosci*. 1999;15:255–271.
13. Taylor C, Price TRP. Neuropsychiatric assessment . In: JM S, Yudofsky, RE H, editors. Neuropsychiatry of Traumatic brain Injury ; 1994. p. 81–132.
14. Smits M, Hunik MGM, Nederkourh PJ, Dekker HM, Vos PE, Kool DR, et al. A history of loss of consciousness or post traumatic amnesia in mild head injury ; condition sine qua non " one of the risk factors. *Neurosurg Psychiatry*. 2007;78(12):1359–1364.
15. King NS, Crawford S, Wenden FJ, Moss NE, Wade DT, Caldwell FE. Measurement of post-traumatic amnesia: how reliable is it? *J Neurol, Neurosurg Psychiatry*. 1997;62(1):38–42.
16. Bengtsson B, Heijl A. A Visual Field Index for Calculation of Glaucoma Rate of Progression. *Am J Ophthalmol*. 2008;145(2):343–353.
17. Hirasawa K. A modified glaucoma staging system based on visual field index. *Graefes Arch Clin Exp Ophthalmol*. 2013;p. 2747–2752.
18. Levin HS, O'donnell VM, Grossman RG. The Galveston Orientation and Amnesia Test. A Practical Scale to Assess Cognition after Head Injury. *J Nerv Ment Disease*. 1979;p. 675–684.
19. Suchoff IB, Kapoor N, Ciuffreda KJ, Rutner D, Han E, Craig S. The frequency of occurrence, types, and characteristics of visual field defects in acquired brain injury: A retrospective analysis. *J Am Optom Assoc*. 2008;79(5):259–265.
20. Zihl J. Cerebral disturbances of elementary Visual dysfunction. In: Hillsdale JB, editor. Neuropsychology of visual perception. Lawrence Erlbaum Associates; 1989. p. 35–58.
21. Goodrich GL. Visual function in patients of a polytrauma rehabilitation center: A descriptive study. *J Rehabil Res Dev*. 2007;44(7):929–936.
22. Tzekov R, Quezada A, Gautier M, Biggins D, Frances C, Mouzon B. Repetitive Mild Traumatic Brain Injury Causes Optic Nerve and Retinal Damage in a Mouse Model. *J Neuropathol Exp Neurol*. 2014;73(4):345–361.
23. Do MTH, Yau KW. Adaptation to steady light by intrinsically photosensitive retinal ganglion cells. *Proc Natl Acad Sci*.

2013;110(18):7470–7475.
24. Gove A, Grossberg S, Mingolla E. Brightness perception, illusory contours, and corticogeniculate feedback. *Vis Neurosci*. 1995;12(6):1027–1052.
25. Guley NM. Mild Traumatic Brain Injury with Associated Visual System Dysfunction: Investigating Histopathology, Functional Correlates, and a Novel Therapeutic Immune Modulator. Theses and Dissertations (ETD). ; 2016.
26. Das M, Mohapatra S, Mohapatra SS. New perspectives on central and peripheral immune responses to acute traumatic brain injury. *J Neuroinflamm*. 2012;9(1):236.
27. Lumpkins K, Bochicchio GV, Zagol B, Ulloa K, Simard JM, Schaub S. Plasma Levels of the Beta Chemokine Regulated Upon Activation, Normal T Cell Expressed, and Secreted (RANTES) Correlate With Severe Brain Injury. *J Trauma: Inj, Infecti Crit Care*. 2008;64(2):358–361.

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