Original Research Article

The Onset and Recovery Timeline of Visual Photosensitivity Following Mild Traumatic Brain Injury with Special Focus on Habitual Digital Device Screens Users

Matuli Das, Narendra Kumar Das[1]

Departments of Ophthalmology and [1]Neurosurgery, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India

Abstract

Primary Objective: Visual photosensitivity following mild traumatic brain injury (mTBI) can cause mild discomfort to significant pain and can affect a person's ability to lead a regular life and perform normal activities. The purpose of the present study is twofold: (1) To determine the recovery pattern of visual photosensitivity following mTBI and (2) to find out whether the onset of visual photosensitivity and its recovery pattern is any different among habitual screen users (HSU) (chronic exposure to digital device screens). **Materials and Methods:** This study was a hospital-based prospective, analytical, observational study. The study period was from July 2017 to March 2019. All the mTBI patients with visual photosensitivity who fulfilled the inclusion Criteria were followed up for 1 year to capture their recovery profile. **Results:** In 60% of the patients, the time of appearance of visual photosensitivity was at around 3 month's post-mTBI. Nearly 66.6% of patients suffering from visual photosensitivity following mTBI recovered within 3 months following the onset of their symptoms. The symptoms of visual photosensitivity appeared earlier among the HSU as compared to nonscreen users ($P = 0.0039$). The recovery from the symptoms of visual photosensitivity following mTBI is delayed in HSU ($P = 0.0028$). The patients in whom the symptoms of visual photosensitivity persisted beyond a year were predominantly HSU ($P = 0.0062$). **Conclusions:** The present study has given a new insight on the timeline of recovery for the patients with visual photosensitivity following mTBI. To the best of our knowledge, this is the only study which has shown how chronic exposure to blue light from digital device screens can affect the recovery of visual symptoms such as visual photosensitivity following mTBI.

Keywords: *Habitual screen users, mild traumatic brain injury, visual photosensitivity*

Introduction

Traumatic brain injury is a major cause of death and disability, with an estimated incidence of 10 million cases per year.[1] Concussion or mild traumatic brain injury (mTBI) is the most common form of traumatic brain injury, accounting for 75% of all brain injuries annually.[2]

Visual symptoms associated with moderate and severe traumatic brain injury are usually profound and have historically overshadowed the impact of mTBI. Even mTBI can significantly affect visual functions. This is due to the fact that about 70% of the brain's sensory processing is visual related.[3,4] Traumatic brain injury disrupts the blood–brain barrier, leading to the infiltration of immune cells into the brain and subsequent inflammation and neurodegeneration or disruption of neural networks, thus resulting in the manifestation of symptoms.[5,6]

The most common visual deficits associated with mTBI include oculomotor dysfunction (accommodative, version, and vergence) and their associated reading problems, photosensitivity, and visual field defects.[4,7,8]

Visual photosensitivity is an abnormal intolerance to light. It is a subjective symptom associated with several ophthalmic and neurological conditions.[9] Visual photosensitivity causes discomfort when the eyes are exposed to natural or artificial light sources outdoors or indoors. Glare, involuntary blinking, squeezing of eyelids, and watering in bright light or bright colors can be the symptoms associated with visual photosensitivity. In

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Das M, Das NK. The onset and recovery timeline of visual photosensitivity following mild traumatic brain injury with special focus on habitual digital device screens users. Asian J Neurosurg 2020;15:479-83.

Submitted: 23-Jun-2019 **Revised:** 21-Dec-2019
Accepted: 04-May-2020 **Published:** 28-Aug-2020

Address for correspondence:
Dr. Narendra Kumar Das, Plot No 434/5988, Gautam Nagar, Lewis Road, Bhubaneswar - 751 002, Odisha, India.
E-mail: narendrakdas@gmail.com

Access this article online

Website: www.asianjns.org

DOI: 10.4103/ajns.AJNS_187_19

Quick Response Code:

severe cases, the patient can complain of headache, nausea, and blurring of vision.[10] Watching TV, reading, driving, working on computers, and walking outside in sunlight also can become limited.

Visual photosensitivity following mTBI can cause mild discomfort to significant pain and can affect a person's ability to lead a regular life and perform normal activities.

A patient who has otherwise recovered from a traumatic brain injury may not be able to go back to his normal life due to the persisting symptoms of visual photosensitivity. This could be very disturbing for the patient. There is always a concern among these patients regarding the timeline of their recovery from photosensitivity following mTBI and their return to work or resumption of social activities. At present, there are very few studies with a specific focus on the recovery pattern of visual photosensitivity following mTBI.

Nowadays, a large number of people are habitual (chronic) screen users due to their professional needs or social activities. They are spending long hours in front of digital device screens, thus exposing themselves to computer blue light.[11] The prolonged exposure to computer blue light can potentially cause damage to retinal cells.[12] There is a possibility that visual symptoms following mTBI may behave differently in individuals who are habitual screen users (HSU) as compared to nonscreen users (NSU). However, no literature was available regarding the timing of appearance and resolution of visual photosensitivity among HSU with mTBI.

The purpose of the present study is twofold: (1) To determine the recovery pattern of visual photosensitivity following mTBI and (2) to find out whether the onset of visual photosensitivity and its recovery pattern is any different among HSU.

Materials and Methods

This study is a hospital-based prospective, analytical, observational study. All patients attending the neurosurgery outpatients department or casualty, clinically diagnosed as mTBI, above the age of 10 years were included in the study. All patients diagnosed with mTBI with glaucoma, dry eye, retinal diseases, iritis, vitreous hemorrhage, central corneal opacities, advanced cataract or history of any ocular surgery, repeated mTBI, migraine, or psychiatric illness were excluded from the study.

All patients underwent a detailed history taking, systemic and ophthalmic examination including best-corrected visual acuity, color vision, tonometry, gonioscopy, Schimer's test, tear film breakup time, OCT retinal nerve-fiber layer, and Humphrey visual field analysis. All patients were asked to fill up the photosensitivity questionnaire (Visual Light Sensitivity Questionnaire-8 [VLSQ-8]) forms.[10]

The study period was from July 2017 to July 2019. Patients with mTBI were followed up at 1- month, 3-month, 6-month, and 1-year post injury. Each patient who developed visual photosensitivity was followed up for 1 year after the appearance of their symptom of visual photosensitivity to observe the recovery pattern. All the patients suffering from visual photosensitivity were advised to use dark-tint glasses when exposed to light.

The diagnosis of mTBI was based on the WHO operational criteria for the clinical identification of mTBI:[13] (I) One or more of the following: Confusion or disorientation, loss of consciousness for 30 min or less, post-traumatic amnesia of <24 h 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 min postinjury or at presentation to the hospital.

The patients/individuals who have been using computers or exposed to digital device screens for more than 8 h/day constantly over a period of 2 years before mTBI were identified as HSU. The rest of the patients were categorized as NSU.

Visual photosensitivity is difficult to diagnose and measure objectively. Verriotto *et al*. have developed and validated a VLSQ-8 for the diagnosis and assessment of visual photosensitivity.[10] We have used VLSQ-8 in our study to diagnose and monitor the progress of visual photosensitivity in patients with mTBI.

Statistical significance between the groups was determined by using Fisher's exact test. $P \leq 0.05$ was considered to be statistically significant.

All details were recorded in the patient data form.

Patient consent was taken for participation in the study.

Results

Three hundred consecutive patients between the age group of 10–62 years with the diagnosis of mTBI were studied and analyzed. Out of 300 patients, 186 were male and 114 were females.

Mode of injury was road accidents in 59% followed by falls in 20% of patients. Sport-related injuries were responsible for 12% of patients and assault in 9% of the patients.

Out of the 300 mTBI patients studied, 54% (162) were found to be suffering from visual photosensitivity. The time of appearance or the onset of photosensitivity among the mTBI patients was variable [Table 1].

Among all the patients who developed visual photosensitivity, 60% (96) of the patients developed visual photosensitivity at around 3 months following mTBI. In 26% (42) of the patients, the symptoms of visual photosensitivity appeared by 1 month following injury,

while in 14% (24) patients, there was the delayed onset of visual photosensitivity, which started appearing by 6 months post-mTBI.

On comparing the two groups of the patients, the NSU and HSU, the symptoms of visual photosensitivity appeared earlier among the HSU as compared to NSU ($P = 0.0039$) [Table 1].

The recovery pattern: Patients were divided among three groups for the ease of analysis.

- (Group 1): Visual photosensitivity manifested by 1 month following mTBI.

In 71% of the patients, the recovery from visual photosensitivity occurred after 3 months of its appearance, whereas in 21% patients, the symptoms resolved by 6 months following its manifestation. The recovery pattern in this group was similar for both HSU and NSU. However, in 8% of the patients, the symptoms of visual photosensitivity persisted even after 1 year. The patients in whom the symptoms of visual photosensitivity persisted beyond 1 year were all HSU [Table 2].

- (Group 2): Visual photosensitivity manifested by 3 month following mTBI.

Seventy-five percent of the patients in this group recovered within 3 months after the appearance of symptoms of photosensitivity. The recovery was slow among HSU as compared to NSU ($P = 0.0164$). The patients in whom the symptoms of visual photosensitivity persisted at 1 year were predominantly HSU ($P = 0.0284$) [Table 3].

- (Group 3): Visual photosensitivity manifested by 6 month following mTBI.

The recovery pattern in this group was mostly similar for both HSU and NSU. However, in 50% of the patients, the symptom of photosensitivity persisted beyond a year. Majority (75%) of the patients in whom the symptom of visual photosensitivity persisted were HSU [Table 4].

- Analysis of recovery pattern irrespective of time of appearance of visual photosensitivity.

Nearly 66.6% of patients suffering from visual photosensitivity following mTBI recovered within 3 months following the onset of their symptoms. As compared to NSU, the recovery from the symptoms of visual photosensitivity following mTBI was delayed in HSU ($P = 0.0028$). The patients in whom the symptoms of visual photosensitivity persisted beyond a year were predominantly HSU ($P = 0.0062$) [Table 5].

Main observations of this study are

1. Fifty-four percent of patients with mTBI developed visual photosensitivity in our study
2. In 60% of the patients, the time of appearance of visual photosensitivity was around 3 months following mTBI
3. Nearly 66.6% of patients suffering from visual photosensitivity following mTBI recovered within 3 months after the onset of their symptoms
4. The symptoms of visual photosensitivity following mTBI appeared earlier among the HSU as compared to NSU ($P = 0.0039$)
5. As compared to NSU, the recovery from the symptoms of visual photosensitivity following mTBI was delayed in HSU ($P = 0.0028$)
6. The patients in whom the symptoms of visual photosensitivity persisted beyond a year were predominantly HSU ($P = 0.0062$).

Discussion

The main aim of the study was to determine the recovery pattern of visual photosensitivity following mTBI and also to note whether the time of onset and the recovery of visual photosensitivity are any different among HSU.

Fifty-four percent of our patients developed visual photosensitivity following mTBI. The prevalence of visual photosensitivity among different studies was approximately 50% in post-mTBI population and 10% in the normal

Table 1: Time interval of onset of visual photosensitivity following mild traumatic brain injury

	Within 1 month postinjury (*n*=42; 26%), *n* (%)	Within 3 months postinjury (*n*=96; 60%), *n* (%)	Within 6 months postinjury (*n*=24; 14%), *n* (%)
NSU (*n*=78)	12 (15.3)	54 (69.4)	12 (15.3)
HSU (*n*=84)	30 (35.7)	42 (50)	12 (14.3)

NSU – Nonscreen user; HSU – Habitual screen user

Table 2: Recovery pattern: The group in which visual photosensitivity developed by 1 month postmild traumatic brain injury

	Recovery by 3 months (*n*=30; 71%)	Recovery by 6 months (*n*=9; 21%)	Symptoms persisting at 1 year (*n*=3; 8%)
NSU (*n*=12)	10	2	0
HSU (*n*=30)	20	7	3

NSU – Nonscreen user; HSU – Habitual screen user

Table 3: Recovery pattern: The group in which visual photosensitivity developed by 3-month postmild traumatic brain injury

	Recovery by 3 months (*n*=72; 75%)	Recovery by 6 months (*n*=12; 12.5%)	Symptoms persisting at 1 year (*n*=12; 12.5%)
NSU (*n*=54)	46	5	3
HSU (*n*=42)	26	7	9

NSU – Nonscreen user; HSU – Habitual screen user

Table 4: Recovery pattern: The group in which visual photosensitivity developed by 6-month postmild traumatic brain injury

	Recovery by 3 months (*n*=6; 25%)	Recovery by 6 months (*n*=6; 25%)	Symptoms persisting at 1 year (*n*=12; 50%)
NSU (*n*=9)	3	3	3
HSU (*n*=15)	3	3	9

NSU – Nonscreen user; HSU – Habitual screen user

Table 5: Recovery pattern: Irrespective of time of appearance of visual photosensitivity

	Recovery by 3 months (*n*=108; 66.8%)	Recovery by 6 months (*n*=27; 16.6%)	Symptoms persisting at 1 year (*n*=27; 16.6%)
NSU (*n*=75)	59	10	6
HSU (*n*=87)	49	17	21

NSU – Nonscreen user; HSU – Habitual screen user

population.[4,14,15] This reaffirms the fact that visual photosensitivity is a common problem among the people suffering from mTBI.

Reports on time of onset or appearance of visual photosensitivity following mTBI are few, and none have shown any specific focus on the timeline of appearance and resolution of this symptom. Center for disease control and prevention (CDC) report[16] indicates that some of the symptoms following concussion mTBI may appear right away after injury; however, in others symptoms may not be noticed for days or months after injury or until the person resumes his/her everyday life following trauma. Another study reported that there is increased sensitivity to light in sub-acute phase (7–19 days) after head injury.[17] Postconcussional manifestation can be apparent within few weeks post injury due to the inactivation of neural network and recovery may start by 7 weeks due to compensatory reactivation of neural network.[18]

Time of onset of symptoms of visual photosensitivity following mild traumatic brain injury

The time of onset of symptoms of visual photosensitivity was variable in this study. Sixty percent of the patients developed visual photosensitivity at around 3 months following mTBI. In 26% of the patients, it appeared around 1 month after mTBI, whereas in 14% of the patients, visual photosensitivity developed around 6 months post-mTBI. The variable time of onset of photosensitivity in patients with mTBI may be due to the degree of inactivation of neural network, which may be dependent on the extent of insult to neural networks during injury.

Prolonged use of digital device screens is becoming a necessity these days. The exposure of blue light emitted from digital device screens is becoming increasingly prominent in our society and a large segment of the world population is now subject to daily exposure (from a few minutes to several hours) of artificial light at an unusual time of the day.[11]

The symptoms of visual photosensitivity appeared earlier among the HSU as compared to NSU in this study [Table 1]. This was statistically significant (P = 0.0039). The possible reason for early manifestation may be due to preexisting damage to the photoreceptors and retina pigment epithelium cells among HSU.

Recovery pattern of visual photosensitivity following mild traumatic brain injury

In 66.6% of the patients, irrespective of time of onset, the symptoms of visual photosensitivity resolved by 3 months. However, 16.7% of patients required 6 months for their symptoms to clear. In the remaining 16.7% of the patients, the symptoms of visual photosensitivity following mTBI persisted beyond 1 year.

The available literature on the timeline of recovery from visual photosensitivity is not very specific. Most of the symptomatic patients following mTBI improve within few months postinjury. The substantial neurological recovery happens by 3 months.[21] Many reports suggested that visual photosensitivity is a phenomenon that appears to resolve in parts over an extended period of time in approximately 50% of mTBI population.[8,14] The literature also suggests that the symptoms of photosensitivity following mTBI may last from minutes to days, weeks, months, or even longer in some cases. In most of the cases, symptoms usually resolve, however, approximately 15% of the people can have long-term sequelae.[19,20]

Recovery pattern among habitual screen users versus nonscreen users

As compared to NSU, the recovery from the symptoms of visual photosensitivity following mTBI is delayed in HSU (P = 0.0028) [Table 2].

The patients in whom the symptoms of visual photosensitivity persisted beyond a year were predominantly HSU (P = 0.0062).

There are few studies that have demonstrated retinal cell damage following the exposure to digital device blue light. These studies suggest that since light has a cumulative effect it may damage the photoreceptors and retina pigment epithelium cells following prolonged exposure to digital device screens lights. These reports also suggested that computer blue light can reach deeper into the eye than the ultraviolet light and might damage the retina.[11,12] This may be the reason for the early appearance of symptoms of visual photosensitivity, slow recovery, and symptoms persisting for a longer period among HSU following mTBI. However, this needs to be studied further.

Limitation of this study

It is a single-center study.

A longer follow-up of patients with visual photosensitivity following mTBI may give more insight.

Conclusion

The present study has given a new insight on the timeline of recovery for the patients with visual photosensitivity following mTBI.

Majority of the patients who suffer from visual photosensitivity following mTBI would manifest their symptoms by 3 months postinjury. In most of the patients, the symptoms of visual photosensitivity would recover by 3 months after its manifestation. However, in HSU, the recovery is usually delayed with a strong possibility of symptoms persisting for a long period.

To the best of our knowledge, this is the only study that has shown how prolonged exposure to blue light from digital device screens, which has become the social need and also the professional necessity can adversely affect the recovery of visual symptoms such as visual photosensitivity following mTBI.

These findings will help in better prognostication of the patients suffering from visual photosensitivity following mTBI.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: A global perspective. Neuro Rehabil 2007;22:341-53.
2. Faul M, Xu L, Wald MM, Coronado VG. Traumatic Brain Injury in United States: Emergency Department Visits, Hospitalization and Deaths, 2002-2006. Atlanta GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010.
3. Sutter PS. Rehabilitation and management of visual dysfunction following traumatic brain injury. In: Ashley MJ, Krych DK, editors. Traumatic Brain Injury Rehabilitation. Boca Raton, FL: CRC Press; 1995. p. 187-216.
4. Capó-Aponte JE, Urosevich TG, Temme LA, Tarbett AK, Sanghera NK. Visual dysfunctions and symptoms during the subacute stage of blast-induced mild traumatic brain injury. Mil Med 2012;177:804-13.
5. Das M, Mohapatra S, Mohapatra SS. New perspectives on central and peripheral immune responses to acute traumatic brain injury. J Neuroinflammation 2012;9:236.
6. Guley NM. Mild Traumatic Brain Injury with Associated Visual System Dysfunction: Investigating Histopathology, Functional Correlates, and A Novel Therapeutic Immune Modulator. ProQuest LLC; 2016. p. 10113327.
7. Kapoor N, Ciuffreda KJ. Vision disturbances following traumatic brain injury. Curr Treat Options Neurol 2002;4:271-80.
8. Ciuffreda KJ, Kapoor N, Rutner D, Suchoff IB, Han ME, Craig S. Occurrence of oculomotor dysfunctions in acquired brain injury: A retrospective analysis. Optometry 2007;78:155-61.
9. Katz BJ, Digre KB. Diagnosis, pathophysiology, and treatment of photophobia. Surv Ophthalmol 2016;61:466-77.
10. Verriotto JD, Gonzalez A, Aguilar MC, Parel JM, Feuer WJ, Smith AR, *et al*. New method of quantification of visual photosensitivity thresold and symptoms. Transl Vis Sci Technol 2017;6:18.
11. Tosini G, Ferguson I, Tsubota K. Effects of blue light on the circadian system and eye physiology. Mol Vis 2016;22:61-72.
12. Grimm C, Wenzel A, Williams T, Rol P, Hafezi F, Remé C. Rhodopsin-mediated blue-light damage to the rat retina: Effect of photoreversal of bleaching. Invest Ophthalmol Vis Sci 2001;42:497-505.
13. Center for Disease Control and Prevention. Report to Congress on Mild Traumatic Brain Injury in United States: Steps to Prevent a Serious Public Health Problem. Atlanta: Center for Disease Control and Prevention; 2003.
14. Truong JQ, Ciuffreda KJ, Han MH, Suchoff IB. Photosensitivity in mild traumatic brain injury (mTBI): A retrospective analysis. Brain Inj 2014;28:1283-7.
15. Craig SB, Kapoor N, Ciuffreda KJ, Suchoff IB, Han ME, Rutner D. Profile of selected aspects of visually-symptomatic individuals with acquired brain injury: A retrospective study. J Behav Optom 2008;19:7-10.
16. Centers for Disease Control and Prevention. Report to Congress on Traumatic Brain Injury in the United Status. Centers for Disease control and prevention; 2015.
17. Waddell PA, Gronwall DM. Sensitivity to light and sound following minor head injury. Acta Neurol Scand 1984;69:270-6.
18. Hammeke TA, Mcrea M, Coats SM, Verber MD, Durgerian S, Flora K, *et al*. Acute and subacute changes in neural activation during the recovery from sport – Related concussion. J Int Neuropsychol Soc 2013;19:863-72.
19. Kushner D. Mild traumatic brain injury: Towards understanding manifestation and treatment. Arch Intern Med 1998;158:1617.
20. Alexander MP. Mild traumatic brain injury: Pathophysiology, natural history, and clinical management. Neurology 1995;45:1253-60.
21. Levin HS, Mattis S, Ruff RM, Eisenberg HM, Marshall LF, Tabaddor K, *et al*. Neuro behavioural outcome following minor head injury. J Neurosurg 1987;66:234.