Literature Search: TBI and Vision Dysfunction 2013-14

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Mechanisms of TBI and Visual Consequences in Military and Veteran Populations

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http://vce.health.mil/resources/Mechanisms_of_TBI_and_Visual_Consequences_in_Military_and_Veteran_Populations_OptomVisSci2013.pdf

- **Purpose:** Blast-related (BR) traumatic brain injuries (TBIs) occur secondary to explosive blasts. Blast-related TBIs can be caused by the blast wave itself or by direct head trauma caused by events surrounding the blast. NonYblast-related (NBR) TBIs are caused by direct head trauma. Recent evidence shows that TBIs are associated with vision problems, particularly binocular system problems. The purpose of this study was to determine if similar types and amounts of vision problems are present in patients with BR TBIs and NBR TBIs.
- **Methods:** A retrospective analysis of eye examination records of 50 NBR TBI and 50 BR TBI patients was conducted. Frequencies of visual symptoms and abnormal vision function measurements were computed and compared for the two patient groups.
- **Results:** More than 65% of NRB TBI and BR TBI patients reported vision problems. Reading complaints were found in approximately 50% of the patients. Light sensitivity was reported significantly more often in BR TBI patients (67%) than in NBRTBI patients (33%) (p G 0.01). Saccadic dysfunction was measured more often in NBRTBI patients (85%) than in BR TBI patients (58%) (p G 0.01). High rates of accommodative dysfunction and convergence insufficiency were also found, but the group differences were not significant. Strabismus, pursuit abnormalities, fixation defects, and visual field defects were also common in both groups.
- **Conclusions:** For most findings, the mechanism of injury (NBR vs. BR) did not result in different frequencies or types of visual dysfunction. The reasons for finding higher frequencies of light sensitivity in the BR TBI group and saccadic dysfunction in the NBR TBI group are unknown, and further research is needed. Overall, the rates of vision complaints and oculomotor defects were high in both groups, indicating a need for a thorough eye examination for any patient with a history of TBI.

Visual Dysfunction in Combat Related Mild Traumatic Brain Injury: A Review

M Teresa Magone, Glenn C Cockerham, Soo Y Shin
US Ophthalmic Review, 2013;6(1):48-51
http://www.touchophthalmology.com/articles/visual-dysfunction-combat-related-mild-traumatic-brain-injury-review

- **Abstract:** Approximately half of all military personnel who have served in the conflicts in Iraq and Afghanistan are reported to have some degree of combat-related mild traumatic brain injury (TBI). Although in civilian concussion injuries symptoms typically resolve within several weeks, blast-induced mild TBI may be accompanied by prolonged symptoms and afferent and efferent visual dysfunction. Most commonly near vision problems and photophobia are the presenting symptoms. A complete eye exam including vision testing, oculomotor function, and near tasking, is highly recommended after blast-induced mild TBI to detect and improve symptoms in this young patient population. A review of the current literature is presented.

Visual function, traumatic brain injury, and posttraumatic stress disorder

Gregory L. Goodrich, PhD;[1*] Gary L. Martinsen, OD, PhD;[1] Heidi M. Flyg, OD;[1] Jennine Kirby, OD;[1] Donn W. Garvert, MS[1]; Christopher W. Tyler, PhD, DSc[2]
JRRD, 2014;(51)4:547 — 558
http://www.rehab.research.va.gov/jour/2014/514/jrrd-2013-02-0049.html

- **Abstract**: Traumatic brain injury (TBI) and posttraumatic stress disorder (PTSD) are signature injuries of the Iraq and Afghanistan conflicts. The conditions can be comorbid and have overlapping signs and symptoms, making it difficult to diagnose and treat each. TBI is associated with numerous changes in vision function, but vision problems secondary to PTSD have not been documented. To address this shortcoming, we reviewed the medical records of 100 patients with a history of TBI, noting PTSD diagnoses, visual symptoms, vision function abnormalities, and medications with visual side effects. Forty-one patients had PTSD and 59 did not. High rates of binocular vision and oculomotor function deficits were measured in patients with a history of TBI, but no significant differences between patients with or without PTSD were evident. However, compared to patients without PTSD, patients with PTSD had more self-reported visual symptoms in all four assessments and the complaint rates were significantly higher for light sensitivity and reading problems. Together, these findings may be beneficial in understanding vision problems in patients with TBI and PTSD as comorbid conditions compared with those with TBI alone.

Visual consequences of mild traumatic brain injury in veterans

Chrystyna Rakoczy, Radouil T. Tzekov

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- **Purpose:** Traumatic brain injury (TBI), a major cause of death and disability worldwide can lead to vision damage. The extent of subjective visual dysfunction present in combat veterans with mild TBI is still unknown. The purpose of this study is to evaluate subjective vision-related complaints, visual field deficit and retinal nerve fiber layer (RNFL) thickness in Servicemembers with documented mild TBI due to blast and/or blunt trauma. It is hypothesized that visual/ocular symptomology and measures will be similar between the groups.
- **Methods:** 90 patients with documented mild TBI were evaluated. All patients underwent symptom review and detailed ophthalmic examination, including visual acuity (VA). 87 patients had visual field testing (HVF) in both eyes, 75 had SD-OCT in at least one eye and 49 had contrast sensitivity (CS) tested in both eyes. Based on the history of head trauma, patients were divided into three groups: Group 1 (Gr1) blast only, Group 2 (Gr2) blunt only and Group 3 (Gr3) blast and blunt trauma.
- **Results:** Patients were categorized: 39 as Gr1, 18 as Gr2 and 33 as Gr3. The average age was 33.9, 38.4 and 35.1 years, respectively. Blurred vision (BV) was reported in (Gr1, Gr2, Gr3) 90%, 89% and 73%, photosensitivity (PT) in 85%, 73% and 79%, perception of field deficit (PVFD) in 23%, 44% and 27%. The average values for VA were: -0.063, -0.058 and -0.038 log MAR, for CS: 1.93, 1.75 and 1.69 log CS, for HVF mean deviation: -4.6, -4.4 and -4.0 dB, for total RNFL thickness: 99.7, 92.4 and 100.7 µm. There was no significant difference between the mean values of the three groups in any of the above measures. By quadrant analysis, mean temporal RNFL thickness was lower in all of the groups compared to a normal mean ($p<0.0001$), while Gr2 mean was lower compared to Gr1 ($p<0.05$).
- **Conclusions:** A large number of veterans with mild TBI reported subjective visual complaints such as BV and PT. Whether blunt, blast or both, the mechanism of injury did not affect the frequency of reported subjective symptoms. Similarly, VA, CS, HVF and RNFL thickness did not vary significantly between the trauma groups. However, measurements of temporal RNFL were lower than normal in all groups and significantly thinner in the blunt group. This leads us to believe that the mechanism of injury may determine damaging effects on already normally thin temporal RNFL. Chronology of multiple mechanism trauma may have an effect on RNFL damage as well.

Chronic visual dysfunction after blast-induced mild traumatic brain injury

M. Teresa Magone, MD;* Ellen Kwon, OD; Soo Y. Shin, MD
JRRD, 2014;51(1):71–80
http://www.rehab.research.va.gov/jour/2014/511/pdf/jrrd-2013-01-0008.pdf

- **Abstract:** The purpose of this study was to investigate the long-term visual dysfunction in patients after blast-induced mild traumatic brain injury (mbTBI) using a retrospective case series of 31 patients with mbTBI (>12 mo prior) without eye injuries. Time since mbTBI was 50.5 +/- 19.8 mo. Age at the time of injury was 30.0 +/- 8.3 yr. Mean corrected visual acuity was 20/20. Of the patients, 71% (n = 22) experienced loss of consciousness; 68% (n = 15) of patients in this subgroup were dismounted during the blast injury. Overall, 68% (n = 21) of patients had visual complaints. The most common complaints were photophobia (55%) and difficulty with reading (32%). Of all patients, 25% were diagnosed with convergence insufficiency and 23% had accommodative insufficiency. Patients with more than one mbTBI had a higher rate of visual complaints (87.5%). Asymptomatic patients had a significantly longer time (62.5 +/- 6.2 mo) since the mbTBI than symptomatic patients (42.0 +/- 16.4 mo, $p < 0.004$). Long-term visual dysfunction after mbTBI is common even years after injury despite excellent distance visual acuity and is more frequent if more than one incidence of mbTBI occurred. We recommend obtaining a careful medical history, evaluation of symptoms, and binocular vision assessment during routine eye examinations in this prepresbyopic patient population.

Development of a mild traumatic brain injury-specific vision screening protocol: A Delphi study

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JRRD, 2013;50(6):757-68

http://www.rehab.research.va.gov/jour/2013/506/page757.html

- **Abstract:** Although traumatic brain injury (TBI) can happen to anyone at any time, the wars in Iraq and Afghanistan have brought it renewed attention. Fortunately, most cases of TBI from the recent conflicts are mild TBI (mTBI). Still, many physical, psychological, and social problems are associated with mTBI. Among the difficulties encountered are oculomotor and vision problems, many of which can impede daily activities such as reading. Therefore, correct diagnosis and treatment of these mTBI-related vision problems is an important part of patient recovery. Numerous eye care providers in the Department of Veterans Affairs, in military settings, and in civilian practices specialize and are proficient in examining patients who have a history of TBI. However, many do not have this level of experience working with and treating patients with mTBI. Recognizing this, we used a modified Delphi method to derive expert opinions from a panel of 16 optometrists concerning visual examination of the patient with mTBI. This process resulted in a clinical tool containing 17 history questions and 7 examination procedures. This tool provides a set of clinical guidelines that can be used as desired by any eye care provider either as a screening tool or adjunct to a full eye examination when seeing a patient with a history of mTBI. The goal of this process was to provide optimal and uniform vision care for the patient with mTBI.

Composition of a Vision Screen for Servicemembers With Traumatic Brain Injury: Consensus Using a Modified Nominal Group Technique

Mary Vining Radomski; Marsha Finkelstein; Imelda Llanos; Mitchell Scheiman; Sharon Gowdy Wagener
Am J Occ Ther, 2014;68:422-429. doi:10.5014/ajot.2014.011445
http://ajot.aota.org/Article.aspx?articleid=1884512

- **Abstract**: Vision impairment is common in the first year after traumatic brain injury (TBI), including among service members whose brain injuries occurred during deployment in Iraq and Afghanistan. Occupational therapy practitioners provide routine vision screening to inform treatment planning and referral to vision specialists, but existing methods are lacking because many tests were developed for children and do not screen for vision dysfunction typical of TBI. An expert panel was charged with specifying the composition of a vision screening protocol for servicemembers with TBI. A modified nominal group technique fostered discussion and objective determinations of consensus. After considering 29 vision tests, the panel recommended a nine-test vision screening that examines functional performance, self-reported problems, far–near acuity, reading, accommodation, convergence, eye alignment and binocular vision, saccades, pursuits, and visual fields. Research is needed to develop reliable, valid, and clinically feasible vision screening protocols to identify TBI-related vision disorders in adults.

The sensitivity of the Bielschowsky head-tilt test in diagnosing acquired bilateral superior oblique paresis.

Muthusamy B[1], Irsch K[2], Peggy Chang HY[2], Guyton DL[2].
Am J Ophthalmol. 2014 Apr;157(4):901-907.e2. doi: 10.1016/j.ajo.2014.01.003. Epub 2014 Jan 9.
http://linkinghub.elsevier.com/retrieve/pii/S0002-9394(14)00008-7

- **PURPOSE:** To determine the sensitivity of the Bielschowsky head-tilt test and other commonly used criteria in identifying patients with true bilateral superior oblique paresis.
- **DESIGN:** A retrospective chart review was performed to identify patients seen between 1978 and 2009 who were diagnosed with acquired bilateral superior oblique paresis.
- **METHODS:** All patients had a confirmed history of head trauma or brain surgery with altered consciousness followed by symptomatic diplopia. Bilateral superior oblique paresis was defined and diagnosed by the above history, including the presence of greater extorsion in downgaze than upgaze on Lancaster red-green testing, a V-pattern strabismus, and bilateral fundus extorsion. We analyzed findings of the Bielschowsky head-tilt test, the Parks 3-step test, and reversal of the hypertropia from straight-ahead gaze to the other 8 diagnostic positions of gaze to determine these tests' sensitivity in identifying true bilateral superior oblique paresis.
- **RESULTS:** Twenty-five patients were identified with the diagnosis of true bilateral superior oblique paresis. The Bielschowsky head-tilt test had a 40% sensitivity, the Parks 3-step test had a sensitivity of 24%, and reversal of the hypertropia had a sensitivity of 60% in making the diagnosis of true bilateral superior oblique paresis.
- **CONCLUSIONS:** What previously has been described as masked bilateral superior oblique paresis simply may be a reflection of inherent poor sensitivity of the Bielschowsky head-tilt test, the Parks 3-step test, and reversal of the hypertropia in diagnosing bilateral superior oblique paresis. Hence, none of these tests should be relied on exclusively to make this diagnosis.

Versional eye tracking in mild traumatic brain injury (mTBI): effects of oculomotor training (OMT).

Thiagarajan P[1], Ciuffreda KJ.
Brain Inj. 2014;28(7):930-43. doi: 10.3109/02699052.2014.888761. Epub 2014 Mar 21.
http://informahealthcare.com/doi/abs/10.3109/02699052.2014.888761

- **OBJECTIVE:** To evaluate a range of objective measures of versional eye movements before and after oculomotor training (OMT) in individuals with mTBI. The results were compared with placebo (P) training.
- **METHODS:** Twelve individuals with mTBI (mean age = 29 ± 3 years) having oculomotor-based near-vision symptoms participated in the study. Versional eye movements were recorded objectively before and after OMT (fixation, predictable saccades, simulated reading) and P training (6 weeks each, two sessions/week, 45 minutes/session).
- **RESULTS:** Following OMT, there was a significant ($p < 0.05$) reduction in the horizontal fixational error. Saccadic gain increased both horizontally and vertically ($p < 0.05$). The saccade ratio for the simulated reading, multiple-line paradigm reduced significantly ($p < 0.05$). None of the measures changed significantly following the P training.
- **CONCLUSIONS:** The versional-based OMT had a significant, positive effect on most aspects of versional tracking. These findings are suggestive of improved rhythmicity, accuracy and sequencing of saccades following OMT in mTBI as a result of oculomotor learning.

Oculomotor neurorehabilitation for reading in mild traumatic brain injury (mTBI): an integrative approach

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NeuroRehabilitation. 2014;34(1):129-46. doi: 10.3233/NRE-131025.

- **BACKGROUND:** Considering the extensive neural network of the oculomotor subsystems, traumatic brain injury (TBI) could affect oculomotor control and related reading dysfunction.
- **OBJECTIVE:** To evaluate comprehensively the effect of oculomotor-based vision rehabilitation (OBVR) in individuals with mTBI.
- **METHODS:** Twelve subjects with mTBI participated in a cross-over, interventional study involving oculomotor training (OMT) and sham training (ST). Each training was performed for 6 weeks, 2 sessions a week. During each training session, all three oculomotor subsystems (vergence/accommodation/version) were trained in a randomized order across sessions. All laboratory and clinical parameters were determined before and after OMT and ST. In addition, nearvision-related symptoms using the Convergence Insufficiency Symptom Survey (CISS) scale and subjective visual attention using the Visual Search and Attention Test (VSAT) were assessed.
- **RESULTS:** Following the OMT, over 80% of the abnormal parameters significantly improved. Reading rate, along with the amplitudes of vergence and accommodation, improved markedly. Saccadic eye movements demonstrated enhanced rhythmicity and accuracy. The improved reading-related oculomotor behavior was reflected in reduced symptoms and increased visual attention. None of the parameters changed with ST.
- **CONCLUSIONS:** OBVR had a strong positive effect on oculomotor control, reading rate, and overall reading ability. This oculomotor learning effect suggests considerable residual neuroplasticity following mTBI.

Effect of oculomotor rehabilitation on vergence responsivity in mild traumatic brain injury

Preethi Thiagarajan, BS Optom, MS, PhD;* Kenneth J. Ciuffreda, OD, PhD
JRRD, 2012;50(9):1223-40
http://www.rehab.research.va.gov/jour/2013/509/jrrd-2012-12-0235.html

- **Abstract** : A range of dynamic and static vergence responses were evaluated in 12 individuals with mild traumatic brain injury (age: 29 +/– 3 yr) having near vision symptoms. All measures were performed in a crossover design before and after oculomotor training (OMT) and placebo (P) training. Following OMT, peak velocity for both convergence and divergence increased significantly. Increased peak velocity was significantly correlated with increased clinically based vergence prism flipper rate. Steady-state response variability for convergence reduced significantly following OMT. The maximum amplitude of convergence, relative fusional amplitudes, and near stereoacuity improved significantly. In addition, symptoms reduced significantly, and visual attention improved markedly. None of the measures were found to change significantly following P training. The significant improvement in most aspects of vergence eye movements following OMT demonstrates considerable residual brain plasticity via oculomotor learning. The improved vergence affected positively on nearwork-related symptoms and visual attention.

Effect of oculomotor rehabilitation on accommodative responsivity in mild traumatic brain injury

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JRRD, 2014;51(2):175–192
http://www.rehab.research.va.gov/jour/2014/512/pdf/jrrd-2013-01-0027.pdf

- **Abstract:** Accommodative dysfunction is a common oculomotor sequelae of mild traumatic brain injury (mTBI). This study evaluated a range of dynamic (objective) and static (subjective) measures of accommodation in 12 nonstrabismic individuals with mTBI and near vision-related symptoms before and after oculomotor training (OMT) and placebo (P) training (6 wk, two sessions per week, 3 h of training each). Following OMT, the dynamics of accommodation improved markedly. Clinically, there was a significant increase in the maximum accommodative amplitude both monocularly and binocularly. In addition, the near vision symptoms reduced along with improved visual attention. None of the measures were found to change significantly following P training. These results provide evidence for a significant positive effect of the accommodatively based OMT on accommodative responsivity. Such improvement is suggestive of oculomotor learning, demonstrating considerable residual brain-visual system plasticity in the adult compromised brain.

Effect of oculomotor vision rehabilitation on the visual-evoked potential and visual attention in mild traumatic brain injury

Yadav NK[1], Thiagarajan P, Ciuffreda KJ.
Brain Injury, 2014;28(7):922-929 (doi:10.3109/02699052.2014.887227)
http://informahealthcare.com/doi/abs/10.3109/02699052.2014.887227

- **Primary objective**: The purpose of the experiment was to investigate the effect of oculomotor vision rehabilitation (OVR) on the visual-evoked potential (VEP) and visual attention in the mTBI population.
- **Research design and methods**: Subjects (*n* = 7) were adults with a history of mild traumatic brain injury (mTBI). Each received 9 hours of OVR over a 6-week period. The effects of OVR on VEP amplitude and latency, the attention-related alpha band (8–13 Hz) power (μV^2) and the clinical Visual Search and Attention Test (VSAT) were assessed before and after the OVR.
- **Results:** After the OVR, the VEP amplitude increased and its variability decreased. There was no change in VEP latency, which was normal. Alpha band power increased, as did the VSAT score, following the OVR.
- **Conclusions**: The significant changes in most test parameters suggest that OVR affects the visual system at early visuo-cortical levels, as well as other pathways which are involved in visual attention.

Effect of oculomotor vision rehabilitation on the visual-evoked potential and visual attention in mild traumatic brain injury

Naveen K. Yadav, Preethi Thiagarajan, & Kenneth J. Ciuffreda
Brain Injury, 2014;28(7):922-929 (doi:10.3109/02699052.2014.887227)
http://informahealthcare.com/doi/abs/10.3109/02699052.2014.887227

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Vision rehabilitation for visual-vestibular dysfunction: The role of the neuro-optometrist

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*NeuroRehabilitation, 2013;*32:483–492
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- **Abstract**: This article discusses, in a clinically relevant format, the importance of including a neuro-optometrist as a member of the management team for patients with balance disorders.
- **Purpose**: To review the importance of vision and visual processing for maintaining a sense of balance and equilibrium and the role of the neuro-optometrist in the overall rehabilitation of patients with balance disorders
- **Summary**: Dizziness, balance problems and the sensation that the space world is moving (vertigo) are one of the most commonly reported problems in general medical practice. Persons with a central nervous system injury or other idiopathic causes of visual processing problems or who have functional vision problems that are not adequately managed, often experience extreme difficulty with balance and movement, as well as with their perception of space. Consequently, the patient often experiences difficulty functioning in an environment with excessive visual stimulation such as a grocery store or shopping mall. Symptoms of disequilibrium, vestibular and balance problems are commonly a result of VOR disturbance secondary to an inner ear problem and an unstable binocularity.
- **Conclusion**: The combination of neuro-optomertic rehabilitative therapy and balance therapy will result in a is an effective treatment for reducing or resolving these symptoms.

Photosensitivity in mild traumatic brain injury (mTBI): A retrospective analysis

James Q. Truong, Kenneth J. Ciuffreda, M. H. Esther Han, & Irwin B. Suchoff
Brain Injury, 2014;28(10):1283-1287 (doi:10.3109/02699052.2014.915989)
http://informahealthcare.com/doi/abs/10.3109/02699052.2014.915989

- **Primary objective**: To determine whether photosensitivity (PS) changes over time and, if so, what factors may be related to the change; furthermore, to determine whether tint density changes over time, all in mild traumatic brain injury (mTBI).
- **Design and methods**: A retrospective analysis of 62 patient records (aged 18–40 years) with mTBI and PS was conducted. All charts were obtained from the SUNY/College of Optometry clinics from 2004–2011.
- **Results**: Fifty per cent demonstrated reduced PS over time, with most occurring after year 1 post-injury (40%). Promotion of PS reduction appears to be associated with the lack of spectacle tint usage ($p = 0.01$) and the use of contact lenses ($p = 0.03$). Inhibition of PS reduction appears to be associated with tinted lenses ($p = 0.06$), hyperacusis ($p = 0.03$), dry eye ($p = 0.04$), migraines ($p = 0.03$) and loss of consciousness at the time of injury ($p = 0.05$). Concerning tint density changes over time, 71% ($p = 0.002$) maintained the same degree over time, while 27% ($p = 0.002$) reduced and 2% waxed and waned.
- **Conclusion**: Neural adaptation to PS appears to be a long-term process. Tint usage may act to inhibit this adaptive process, while the use of contact lenses may act to promote it. These findings may provide guidance in the clinical management of photosensitivity in the mTBI population.

Effect of binasal occlusion (BNO) and base-in prisms on the visual-evoked potential (VEP) in mild traumatic brain injury (mTBI)

Naveen K. Yadav & Kenneth J. Ciuffreda

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http://informahealthcare.com/doi/abs/10.3109/02699052.2014.939718

- **Purpose**: To assess quantitatively the effect and relative contribution of binasal occlusion (BNO) and base-in prisms (BI) on visually-evoked potential (VEP) responsivity in persons with mild traumatic brain injury (mTBI) and the symptom of visual motion sensitivity (VMS), as well as in visually-normal (VN) individuals.
- **Research design and methods**: Subjects were comprised of 20 VN adults and 15 adults with mTBI and VMS. There were four test conditions: (1) conventional pattern VEP, which served as the baseline comparison condition; (2) VEP with BNO alone; (3) VEP with 2 pd BI prisms before each eye; and (4) VEP with the above BNO and BI prism combination.
- **Results**: In mTBI, the mean VEP amplitude *increased* significantly in *nearly all* subjects (~90%) with BNO alone. In contrast, in VN, it *decreased* significantly with BNO alone in *all* subjects (100%), as compared to the other test conditions. These objective findings were consistent with improvements in visual impressions and sensorimotor tasks in the group with mTBI. Latency remained within normal limits under all test conditions in both groups.
- **Conclusions**: Only the BNO condition demonstrated significant, but opposite and consistent, directional effects on the VEP amplitude in both groups. The BNO-VEP test condition may be used clinically for the objectively-based, differential diagnosis of persons suspected of having mTBI and VMS from the VNs.

Head injury and risk of Parkinson disease: A systematic review and meta-analysis

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http://onlinelibrary.wiley.com/doi/10.1002/mds.25458/full

- **Abstract:** Head trauma has been implicated in the etiopathogenesis of Parkinson's disease (PD). We performed a meta-analysis to investigate the association between head trauma and the risk of developing PD. We included observational studies if they (1) clearly defined PD, (2) defined head trauma leading to concussion, and (3) presented odds ratios (ORs) and 95% confidence intervals (CIs) or provided data to compute these statistics. Random effect model was used to estimate the pooled, adjusted OR. Heterogeneity between studies was evaluated with the *Q* test and the I^2 statistic. We conducted a sensitivity analysis to assess the influence of each study and repeated the analysis by excluding the studies with the largest weights. We used funnel plot to assess the presence of publication bias. After reviewing more than 636 article titles, 34 articles were selected for full review. In total, 22 studies (19 case–control studies, 2 nested case–control studies, and 1 cohort study) were included in the meta-analysis. The pooled OR for the association of PD and head trauma was 1.57 (95% CI, 1.35–1.83). The results of our meta-analysis indicate that a history of head trauma that results in concussion is associated with a higher risk of developing PD.

Visual quality of life in veterans with blast-induced traumatic brain injury.

Lemke S[1], Cockerham GC[2], Glynn-Milley C[3], Cockerham KP[4].
JAMA Ophthalmol. 2013 Dec;131(12):1602-9. doi: 10.1001/jamaophthalmol.2013.5028.

- **IMPORTANCE:** Traumatic brain injury (TBI) is an important cause of morbidity worldwide, with increasing awareness of the role of blast exposure in military and civilian casualties. Visual problems have been reported in TBI and may affect functioning and quality of life.
- **OBJECTIVE:** To evaluate the 25-item National Eye Institute Visual Functioning Questionnaire and Neuro-Ophthalmic Supplement for utility in assessing the effect of blast exposure on perceived visual functioning among veterans with TBI.
- **DESIGN, SETTING, AND PARTICIPANTS:** Observational cohort study from a tertiary care Veterans Health Administration hospital. Reported visual quality of life was compared with existing norms, and relationships between perceived visual quality and ocular injury, diplopia, visual performance, and blast exposure characteristics were examined. Participants included inpatients with blast-induced TBI who underwent baseline examination between December 7, 2006, and January 11, 2012, at a multiple-trauma rehabilitation center and who had at least 1 intact eye and were able to undergo psychometric testing and ocular examination. Among 64 sequentially eligible patients, 60 completed visual quality testing, 1 declined study participation, and 3 were evaluated prior to inclusion of visual quality testing in the protocol. Thirty-nine patients returned for outpatient follow-up, with a median test-retest interval of 11 months.
- **EXPOSURE:** Combat blast exposure with documented TBI.
- **MAIN OUTCOMES AND MEASURES:** Composite and subscale scores on the 25-item National Eye Institute Visual Functioning Questionnaire and Neuro-Ophthalmic Supplement.
- **RESULTS:** Both tests had high test-retest reliability. Blast-exposed veterans reported significantly poorer visual quality compared with healthy samples and some patient samples with known eye disease. Scores tended to be worse for participants with identified visual performance deficits (poorer visual acuity or spatial contrast sensitivity, visual field depression or defects). Scores were not related to the extent of ocular injury or to blast exposure characteristics such as use of protective eyewear or TBI severity level.
- **CONCLUSIONS AND RELEVANCE:** Individuals with blast-induced TBI reliably completed both tests and reported significant decrements in their subjective visual experiences. Measures of subjective visual quality may be useful to identify patients needing additional visual or neurologic evaluation and to monitor the effect of visual rehabilitation on patients with blast-related visual disabilities.

Investigating the influence of blast on cellularity in the retinal ganglion cell layer in a mouse model of blast-induced traumatic brain injury using a novel semi-automated technique

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Invest Ophthalmol Vis Sci 2014;55: E-Abstract 1737
http://abstracts.iovs.org/cgi/content/abstract/55/5/1737

- **Purpose**: Blast-mediated injuries are the leading cause of combat-related injury in modern warfare. Visual dysfunction has been reported in Veterans with blast-mediated traumatic brain injury (TBI). We have previously shown retinal ganglion cells (RGC) are exquisitely sensitive to blast exposure. However, the magnitude of RGC loss in blast-mediated injury is not yet understood. The purpose of these experiments is to develop a method to quantify cellularity and investigate the influence of blast on the retinal ganglion cell layer (GCL) after blast-induced TBI.
- **Methods**: C57BL/6J mice were exposed to an overpressure wave (20 PSI) directed to the head using a custom-built blast chamber (blast-injured). Mice placed in the chamber without blast were used as controls (sham control). At 4 months post-blast, retinas from both blast-injured (n=16) and sham control (n =12) eyes were mounted whole, stained, and imaged by light microscopy. Images were uniformly collected across the retina with equal sampling from the central and peripheral retina. Images were quantitatively assessed for cellularity in the GCL using custom-written macros in Image J.
- **Results**: Retinas from both blast-injured and sham control mice had greater cell densities in the central compared to peripheral retina. In the peripheral retina, blast-injured mice exhibited a significant decrease ($p = 0.03$) in cell density compared to controls using a Students t-test. In the central retina, blast-injured mice exhibited a trend of reduced cell density compared to controls (not significant). Together, these results indicate exposure to blast causes cellular loss in the GCL in this model. Additionally, this novel semi-automated technique is able to detect subtle changes in cell density.
- **Conclusions**: These results demonstrate that this mouse model of blast-induced TBI recapitulates the neuronal loss in the GCL that contributes to visual dysfunction in humans with TBI. This semi-automated technique provides a useful method to quantitatively assess cellularity in the GCL. Extending our knowledge of RGC susceptibility and mechanistic responses that influence their fate following blast-injury will help in the development of improved clinical testing and treatment of visual deficits to those suffering from TBI.

Retinal Ganglion Cell Damage in an Experimental Rodent Model of Blast-Mediated Traumatic Brain Injury

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- **Purpose.** To evaluate retina and optic nerve damage following experimental blast injury.
- **Methods.** Healthy adult mice were exposed to an overpressure blast wave using a custom-built blast chamber. The effects of blast exposure on retina and optic nerve function and structure were evaluated using the pattern electroretinogram (pERG), spectral domain optical coherence tomography (OCT), and the chromatic pupil light reflex.
- **Results.** Assessment of the pupil response to light demonstrated decreased maximum pupil constriction diameter in blast-injured mice using red light or blue light stimuli 24 hours after injury compared with baseline in the eye exposed to direct blast injury. A decrease in the pupil light reflex was not observed chronically following blast exposure. We observed a biphasic pERG decrease with the acute injury recovering by 24 hours postblast and the chronic injury appearing at 4 months postblast injury. Furthermore, at 3 months following injury, a significant decrease in the retinal nerve fiber layer was observed using OCT compared with controls. Histologic analysis of the retina and optic nerve revealed punctate regions of reduced cellularity in the ganglion cell layer and damage to optic nerves. Additionally, a significant upregulation of proteins associated with oxidative stress was observed acutely following blast exposure compared with control mice.
- **Conclusions.** Our study demonstrates that decrements in retinal ganglion cell responses can be detected after blast injury using noninvasive functional and structural tests. These objective responses may serve as surrogate tests for higher CNS functions following traumatic brain injury that are difficult to quantify.

Repetitive Mild Traumatic Brain Injury Causes Optic Nerve and Retinal Damage in a Mouse Model

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- **Abstract**: There is increasing evidence that long-lasting morphologic and functional consequences can be present in the human visual system after repetitive mild traumatic brain injury (r-mTBI). The exact location and extent of the damage in this condition are not well understood. Using a recently developed mouse model of r-mTBI, we assessed the effects on the retina and optic nerve using histology and immunohistochemistry, electroretinography (ERG), and spectral-domain optical coherence tomography (SD-OCT) at 10 and 13 weeks after injury. Control mice received repetitive anesthesia alone (r-sham). We observed decreased optic nerve diameters and increased cellularity and areas of demyelination in optic nerves in r-mTBI versus r-sham mice. There were concomitant areas of decreased cellularity in the retinal ganglion cell layer and approximately 67% decrease in brain-specific homeobox/POU domain protein 3A–positive retinal ganglion cells in retinal flat mounts. Furthermore, SD-OCT demonstrated a detectable thinning of the inner retina; ERG demonstrated a decrease in the amplitude of the photopic negative response without any change in a- or b-wave amplitude or timing. Thus, the ERG and SD-OCT data correlated well with changes detected by morphometric, histologic, and immunohistochemical methods, thereby supporting the use of these noninvasive methods in the assessment of visual function and morphology in clinical cases of mTBI.