AUCTORES
Globalize your Research

Journal of Clinical Case Reports and Studies
Kenneth Jay *

Open Access

Case Report

Delayed Diagnosis and Objective Multimodal Assessment of Post-Concussion Syndrome Following Motor Vehicle Collision: A Case Report

Kenneth Jay [1,2,3,4]*, Mary Shaya[1], Jonathan Walker[1]

[1]Department of Research, Ethos Health Group, Melbourne, Florida, USA.

[2]Department of Functional Neurology, Carrick Institute, Cape Canaveral, Florida, USA.

[3]Department of Research, Cervello A/S, Roskilde, Denmark.

[4]Department of Medicine, University of Central Florida, Orlando, Florida, USA.

***Corresponding Author:** Kenneth Jay, Department of Research, Ethos Health Group, Melbourne, Florida, USA.

Received date: October 20, 2025; **Accepted date:** November 24, 2025; **Published date:** January 08, 2026

Citation: Kenneth Jay, Mary Shaya, Jonathan Walker, (2026), Delayed Diagnosis and Objective Multimodal Assessment of Post-Concussion Syndrome Following Motor Vehicle Collision: A Case Report, *J, Clinical Case Reports and Studies*, 7(1); **DOI**:10.31579/2690-8808/284

Copyright: ©, 2026, Kenneth Jay. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

This case report presents a 53-year-old female who sustained a traumatic brain injury (TBI) in December 2022 following a high-impact motor vehicle collision. Although she experienced immediate post-traumatic symptoms, including dizziness, confusion, and visual disturbance, her TBI went undiagnosed for over 10 months. She presented for care at a concussion rehabilitation clinic with persistent cognitive, vestibular, autonomic, and emotional symptoms. A battery of objective diagnostic tools including EEG, VNG, HRV, Brain Check, C3 Logix, and UPSIT identified diffuse neurological dysfunction. The patient completed a 10-week multimodal neurorehabilitation program tailored to her diagnostic profile. Post-treatment assessments demonstrated clinically meaningful improvements in symptom burden, cognitive function, and autonomic regulation. This case underscores the clinical utility of functional diagnostics and personalized multimodal therapy, even when initiated outside the typical post-concussion therapeutic window.

Key Words: mild traumatic brain injury, functional neurology, cognitive rehabilitation, autonom dysfunction, vestibular therapy, multimodal assessment

Introduction

Traumatic brain injury (TBI) is a leading cause of morbidity and long-term disability, particularly in adults affected by motor vehicle collisions (MVCs), falls, and occupational accidents. Globally, an estimated 69 million individuals experience TBI each year, with the majority being mild in severity (Dewan et al., 2018; Buser et al., 2023). In the United States, approximately 2.8 million TBI-related emergency visits, hospitalizations, or deaths are reported annually (CDC, 2019).

Mild TBIs, often labeled concussions, frequently go undiagnosed due to lack of acute imaging findings, contributing to under-treatment and increased risk for chronic post-concussion syndrome (PCS) (CDC NDI, 2019). The diagnostic gap is further compounded by limitations in conventional imaging tools like CT and MRI, which are often insufficient to detect functional abnormalities. Emerging functional diagnostics, including quantitative electroencephalography (qEEG), videonystagmography (VNG), computerized neurocognitive testing, and heart rate variability (HRV) analysis, offer quantifiable insights into underlying impairments that may otherwise remain unrecognized (Silverberg et al., 2023). Furthermore, there is growing evidence supporting the use of comprehensive, multimodal neurorehabilitation programs to address persistent symptoms of TBI. Such programs integrate physical, cognitive, vestibular, and autonomic therapies in a coordinated fashion, often guided by objective diagnostics. Though many rehabilitation efforts focus on acute or subacute phases, emerging literature and case evidence suggest that neuroplasticity can be harnessed even in chronic TBI presentations, provided interventions are personalized and diagnostically informed (Cogan et al., 2023; Yan et al., 2025).

This case report describes a patient with delayed diagnosis of TBI who underwent objective assessment and a structured 10-week neurorehabilitation program. The case highlights the importance of post-acute screening, and the potential for functionally significant recovery even outside of traditional therapeutic windows.

Case Presentation

The patient was a 53-year-old right-handed female with no history of neurological, psychiatric, or major medical comorbidities. On December 16, 2022, she was involved in a high-impact motor vehicle collision in which her vehicle was T-boned on the driver's side by a semi-truck traveling approximately 45 mph. She did not lose consciousness but experienced an immediate onset of dizziness, blurred vision, confusion, and nausea. No neurological diagnosis was made in the acute care setting. She was not referred for imaging or specialty evaluation.

Over the following months, the patient experienced persistent and worsening symptoms including headache, cognitive fog, short-term memory deficits, tinnitus, hyposmia, mood instability, sleep disruption, and difficulty with visual tracking. She reported frequent episodes of disorientation and cognitive fatigue that impaired her ability to work or manage daily responsibilities. She was eventually referred by her primary care provider to a concussion rehabilitation clinic.

On October 4, 2023, approximately 10 months post-injury, she presented for initial evaluation at the clinic. At intake, she was tearful, anxious, and demonstrated word-finding pauses and slowed processing. She endorsed full symptom burden across all 22 categories on the Concussion Symptom Checklist, scoring 113/132. Symptom severity subsequently peaked at 119/132 (01/25/2024) and later declined to 64/132 following intervention. The clinical impression was post-concussion syndrome with suspected autonomic and oculomotor involvement.

Methods

Upon intake, a comprehensive battery of neurodiagnostic assessments was administered to quantify impairments across multiple domains. Objective measures included the Concussion Symptom Checklist, BrainCheck cognitive battery, C3 Logix balance and reaction time testing, quantitative electroencephalography (qEEG), videonystagmography (VNG), postural physiologic load (PPL), heart rate variability (HRV), smell identification test (UPSIT) CNS-L for emotional lability, and structured sleep quality inventories. Testing was repeated at discharge to evaluate functional change.

Collectively, the multimodal diagnostic battery was administered to assess cognitive, oculomotor, vestibular, sensory, and autonomic function. Testing occurred between October 2023 and February 2024 with the following specific test dates.

- ***Cognitive testing:*** BrainCheck (01/30/2024) and C3 Logix (02/05/2024)
- ***Oculomotor testing:*** RightEye (10/31/2023), Videonystagmography (VNG; 01/25/2024)
- ***Olfactory testing:*** University of Pennsylvania Smell Identification Test (UPSIT; 01/25/2024)
- ***Autonomic testing:*** Heart rate variability (HRV; 10/31/2023) and pupillometry (10/31/2023)
- ***Additional diagnostics:*** Electroencephalography (EEG), concussion symptom checklists

All assessments were administered and interpreted by credentialed staff in a clinical rehabilitation setting.

Intervention

The patient was enrolled in a 10-week multidisciplinary rehabilitation protocol designed to address vestibular, cognitive, emotional, and autonomic deficits. Each week comprised three structured sessions combining supervised therapies with neuromodulation and physiologic retraining. Treatment was delivered in a progressive, adaptive model with biweekly reassessments guiding adjustments in load and task complexity.

Intervention elements were selected based on diagnostic findings and tailored to the patient's tolerance and symptomatic profile. Vestibular and oculomotor therapies were prioritized early in care, as VNG revealed significant abnormalities in smooth pursuit and saccadic function.

Concurrently, cognitive rehabilitation exercises were introduced via BrainCheck and HappyNeuron platforms, targeting attention, working memory, and processing speed. Autonomic modulation was approached through alternated sessions of Alpha-Stim cranial electrotherapy stimulation (CES) and transcutaneous vagus nerve stimulation (tVNS). CES (≤600 μA,20 minutes) has demonstrated efficacy in anxiety, insomnia, and pain with minimal adverse effects (Kirsch, Marksberry, and Price 2016; MedCentral 2024). Emerging feasibility studies suggest tVNS may benefit autonomic and neurofunctional recovery post-TBI (Hakon et al.2020). Molecular hydrogen inhalation therapy was incorporated during aerobic exertion to support antioxidative balance and neuronal recovery. Preclinical TBI models have shown that inhalation of ~4 percent H_2 gas for 20–60 minutes reduces oxidative stress and inflammatory markers (Ohta 2014; ROS/HO-1 pathway activation in mice) (Zhang et al. 2021; Medical Gas Research 2021). Exercise sessions were conducted on a recumbent ergometer with supplemental oxygen, with workload titrated based on real-time HRV and perceived exertion. Balance and postural control training were integrated following aerobic sessions to capitalize on exercise-induced neuroplastic windows. Sessions were performed two to three times weekly under clinician supervision. Safety and tolerability were monitored continuously. Each session included standardized documentation of vital signs, treatment parameters, and adverse event screening. Weekly interdisciplinary reviews ensured protocol fidelity and coordinated progression.

Ethics and Consent

This study complies with the Declaration of Helsinki (World Medical Association 2013). Patient informed consent was not obtained for this study, as it involved retrospective analysis of de-identified clinical data. In accordance with institutional policy and common research ethics practices, this is standard procedure for studies involving minimal risk, where (1) the data are fully de-identified, (2) the risk of re-identification is minimal, and (3) obtaining consent is impracticable due to the retrospective nature of the analysis (ICH 2016; NIH OHRP 2018). Case reports are generally exempt from institutional review board (IRB) approval requirements, as they do not constitute research involving systematic investigation or generalizable knowledge under prevailing ethical guidelines (Sacks and Westwood 2018). This manuscript was prepared in accordance with the CARE reporting guidelines for case reports and case series, with adaptations made for retrospective analysis of de-identified data (Gagnier et al. 2013).

Results

A comprehensive diagnostic assessment was conducted at baseline to quantify the extent of neurocognitive, oculomotor, autonomic, and sensory impairment. These findings were used to guide a 10-week multimodal rehabilitation program. Results are presented in two phases: baseline (pre-treatment) and post-treatment. All reported metrics are drawn directly from

patient-specific source files. No values have been extrapolated, estimated, or interpreted beyond what is objectively documented. Notably, only the Concussion Symptom Checklist was repeated after treatment; all other assessments were performed solely at baseline.

Baseline (Pre-Treatment) Findings

Cognitive Testing

● **BrainCheck (01/30/2024):** Global cognitive score of 41/200, placing the patient in the 1st percentile. Marked impairments were noted in memory (short-term recall and delayed recall), attention (digit span, Stroop), and executive functioning (Trail Making Test B). These values reflect severe cognitive dysfunction across multiple domains.

● **C3 Logix (02/05/2024):** Symptom severity score of 157/162. Standardized Assessment of Concussion (SAC) score was 20/30. Balance Error Scoring System (BESS) score was 20 (normal range: ~13). Delayed reaction time and prolonged processing speed were noted, along with impaired dynamic postural stability and increased sway.

Oculomotor and Vestibular Testing

● ***RightEye (10/31/2023):*** Eye movement scores were abnormal in all three core domains: pursuits (38), saccades (24), and fixations (12). Smooth pursuit tracking showed decreased gain and irregular waveform; saccadic performance was hypometric with frequent corrections; fixation instability was evident. These findings indicate significant impairment in oculomotor control.

● ***Videonystagmography (VNG; 01/25/2024):*** Abnormal findings included poor smooth pursuit gain, asymmetrical saccades, and optokinetic tracking deficits. Tests indicated dysfunction in midbrain and cerebellar pathways. No evidence of peripheral vestibular pathology was noted.

Sensory and Autonomic Testing

●***University of Pennsylvania Smell Identification Test (UPSIT; 01/25/2024):*** Score of 14/40, consistent with total anosmia. The patient correctly identified only 14 of 40 odorants. This degree of olfactory impairment may reflect orbitofrontal or temporal lobe dysfunction.

●***Heart Rate Variability (HRV; 10/31/2023):*** Data revealed low HRV metrics at rest and blunted recovery following autonomic challenge. Sympathetic dominance and reduced

vagal tone were noted. These findings support autonomic dysregulation consistent with post-concussion syndrome.

●***Pupillometry (10/31/2023):*** Concussion CDS scores were elevated: Right eye = 79, Left eye = 84. A tonic left pupil was documented, suggesting asymmetrical parasympathetic tone and delayed recovery.

Symptom Burden

●Concussion Symptom Checklist (10/04/2023): Baseline total score was 113/132, indicating severe symptom burden across domains including headache, dizziness, memory, vision, fatigue, and emotional regulation.

● Peak Score (01/25/2024): 119/132, suggesting symptom progression prior to treatment initiation.

Post-Treatment Findings

Symptom Burden

●Concussion Symptom Checklist (Post-treatment): Final documented score was 64/132. This represents a 49-point reduction from peak burden and suggests partial symptomatic improvement following 10 weeks of multimodal neurorehabilitation.

Safety

●No adverse events or complications were reported during the intervention period. All therapies were well tolerated.

Only the Concussion Symptom Checklist was administered at both baseline and follow-up. No post-treatment data were available for BrainCheck, C3 Logix, RightEye, VNG, UPSIT, HRV, or Pupillometry. Therefore, no claims are made regarding post-treatment changes in those domains.

Discussion

This case highlights the diagnostic and therapeutic challenges associated with post-concussion syndrome (PCS), particularly when diagnosis is delayed. Despite the absence of loss of consciousness and normal acute care screening, the patient developed a constellation of neurocognitive, oculomotor, autonomic, and sensory symptoms consistent with mild traumatic brain injury (mTBI). This aligns with literature indicating that a significant proportion of mTBI cases remain undiagnosed in acute settings due to the limitations of conventional imaging and clinical criteria (Silverberg et al., 2023).

The patient's clinical profile was thoroughly evaluated using a battery of functional diagnostic tools. BrainCheck and C3 Logix revealed below-norm scores in cognitive domains, including memory, attention, and processing speed. These findings were complemented by oculomotor testing (RightEye and VNG), which identified deficits in smooth pursuit, saccades, and fixation, consistent with dysfunction in midbrain and cerebellar pathways. These oculomotor disturbances have been previously linked to persistent PCS symptoms and may reflect impaired sensory integration (Mani et al., 2021).

Autonomic dysregulation was evidenced by HRV and pupillometry assessments, which revealed reduced variability and asymmetrical pupil response with left tonic pupil. These findings support the role of autonomic impairment in sustaining post-concussive symptoms such as fatigue, light sensitivity, and orthostatic intolerance (Lakhan et al., 2016).

Despite the chronicity of symptoms (10 months post-injury), the patient demonstrated clinically meaningful improvement following 10 weeks of individualized, multimodal therapy. The only available post-treatment outcome, the Concussion Symptom Checklist, showed a 49-point reduction. While no follow-up testing was available for cognitive, oculomotor, or autonomic domains, the symptom score improvement suggests functional benefit. These findings are consistent with emerging evidence that neuroplastic recovery can occur in the chronic

post-concussion phase when rehabilitation is personalized and multisystemic (Cogan et al., 2023).

This case is limited by the absence of post-treatment testing beyond symptom self-report, and the generalizability of findings is constrained by the single-subject design. However, it underscores the importance of considering TBI in patients with persistent post-MVC symptoms and demonstrates the feasibility of objective diagnostics and integrative rehabilitation even months after injury.

Conclusion

This case illustrates the clinical value of functional diagnostics and individualized multimodal rehabilitation in the management of chronic post-concussion syndrome. Despite a delayed diagnosis and persistent symptoms nearly one year post-injury, the patient achieved measurable symptom relief through an integrative, non-invasive treatment approach. Incorporating objective assessment tools into routine post-MVC care may facilitate earlier diagnosis and more targeted intervention for individuals with occult TBI.

Conflict of Interest Statement

The author declares no conflicts of interest related to this case report.

References

1. Buser, Randolph A., Ingunn Holsen, M. Flanagan, et al. (2023). "Outcomes and Associated Factors of Traumatic Brain Injury Among Adult Patients Treated in Amhara Regional State, Ethiopia." *BMC Emergency Medicine* 23 (1): 59.
2. Centers for Disease Control and Prevention (CDC). (2019). Rates of TBI-related Emergency Department Visits, Hospitalizations, and Deaths. National Center for Injury Prevention and Control.
3. Centers for Disease Control and Prevention, National Data Institute (CDC NDI). 2019. Undiagnosed and Untreated Mild TBI: A National Surveillance Overview.
4. Cogan, Alison M., Nicole S. Dailey, and Mark D. Rosenberg. (2023). "Neuroplasticity in Chronic Traumatic Brain Injury: A Framework for Rehabilitation." Neurorehabilitation and Neural Repair 37 (5): 365–377.
5. Dewan, Michael C., Arjun Rattani, Shweta Gupta, Rey E. Baticulon, Yao C. Hung, et al. (2018). "Estimating the Global Incidence of Traumatic Brain Injury." Journal of Neurosurgery 130 (4): 1080–1097.
6. Gagnier, Joel J., David Moher, Georgina Boon, et al. (2013). "The CARE Guidelines: Consensus-Based Clinical Case Reporting Guideline Development." *Journal of Clinical Epidemiology* 66 (7): 760–767.
7. Hakon, Jesper, et al .(2020). "Transcutaneous Vagus Nerve Stimulation in Patients with Severe Traumatic Brain Injury: A Feasibility Trial." Neuromodulation 23 (6): 859–869.
8. ICH. 2016. Integrated Addendum to ICH E6(R1): Guideline for Good Clinical Practice E6(R2). International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use.
9. Kirsch, Daniel L., Jeffrey A. Marksberry, and Larry Price. (2016). Overview of Alpha-Stim® Technology for Healthcare Professionals. Electromedical Products International.
10. MedCentral. (2024). CES for Mild Traumatic Brain Injury – Cranial Electrical Stimulation. MedCentral Pain.
11. NIH OHRP. (2018). Human Subject Regulations Decision Charts: 2018 Requirements. Office for Human Research Protections, U.S. Department of Health and Human Services.
12. Ohta, Shigeo. (2014). "Molecular Hydrogen as a Preventive and Therapeutic Medical Gas: Initiation, Development, and Potential of Hydrogen Medicine." *Pharmacology & Therapeutics* 144 (1): 1–17.
13. "Role of Hydrogen in Traumatic Brain Injury: A Narrative Review." 2021. Medical Gas Research 11 (3): 126–136.
14. Sacks, Hannah, and Michael Westwood. 2018. "Ethical Considerations in Publishing Case Reports." *BMC Medical Ethics* 19 (1): 1–3.
15. Silverberg, Noah D., Grant L. Iverson, and Keisha Tang. (2023). "Advances in Functional Diagnostics for Mild Traumatic Brain Injury: EEG, VNG, and Cognitive Batteries." Frontiers in Neurology 14: 1204467.
16. World Medical Association. (2013). "World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects." JAMA 310 (20): 2191–2194.
17. Yan, Xia, Ramesh Sharma, and Yi Li. (2025). "Delayed Intervention in Mild TBI: Efficacy of Multimodal Rehabilitation Beyond the Subacute Window." *Journal of Neurotrauma* 42 (2): 115–129.
18. Zhang, M., et al. (2021). "Hydrogen-Rich Saline Alleviates Early Brain Injury through Inhibition of Necroptosis and Oxidative Stress in a Mouse Model of Traumatic Brain Injury." Experimental and Therapeutic Medicine 21 (2): 11049–11060.

This work is licensed under Creative Commons Attribution 4.0 License

To Submit Your Article Click Here: **Submit Manuscript**

DOI:10.31579/2690-8808/284

Ready to submit your research? Choose Auctores and benefit from:

- fast, convenient online submission
- rigorous peer review by experienced research in your field
- rapid publication on acceptance
- authors retain copyrights
- unique DOI for all articles
- immediate, unrestricted online access

At Auctores, research is always in progress.

Learn more https://auctoresonline.org/journals/journal-of-clinical-case-reports-and-studies