CASE REPORT

The Use of Yoked Prism and Neuro-Optometric Rehabilitation Therapy to Treat Abnormal Egocentric Localization in a Patient with Traumatic Brain Injury

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ABSTRACT

Background

Abnormal egocentric localization is a common yet often underdiagnosed consequence of traumatic brain injury (TBI). Affected individuals may experience dizziness, vestibular deficits, spatial disorientation, eye strain, and headaches. Egocentric localization refers to a person's perceived vertical midline relative to their body position. When this internal sense of midline is shifted to one side, it can disrupt spatial orientation and postural control. Yoked prism lenses are used as an intervention to realign the perceived visual midline, thereby reducing disorientation and improving balance and navigation in daily environments. In many cases, additional treatment through neuro-optometric rehabilitation therapy (NORT) is recommended to improve visual-motor integration processing and spatial awareness leading to an enhancement of overall visual function.

Case Report

A 43-year-old woman sustained a TBI after an accident where a wooden plank struck her head. The patient presented with dizziness, photosensitivity, eyestrain, and difficulty navigating crowded environments. After 6 initial sessions of NORT, the patient did not experience any reduction of her symptoms. Upon further evaluation, she was found to have abnormal egocentric localization. The patient reported marked improvement in symptoms and functionality following the introduction of yoked prism.

Conclusion

Accurate detection and diagnosis of abnormal egocentric localization is essential when examining patients who have sustained a TBI. Delayed diagnosis can prolong symptoms of disorientation and dizziness and severely impact a patient's quality of life. Evaluation of egocentric localization should be considered as part of the guidelines for initial examination when working with this population.

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BACKGROUND

Egocentric localization is described by Ciuffreda and Ludlam as a disruption of the egocenter, the internal reference point that defines an individual's perceived midline.[1] This can lead to significant functional sequelae, including spatial disorientation, imbalance, and difficulty navigating the environment. These disturbances are thought to arise from altered visual–vestibular integration and oculomotor dysfunction, which shift the patient's perceived spatial midline away from true body alignment.[1] In this case report, the patient's symptoms and findings demonstrate how abnormal egocentric localization

can contribute to postural instability, dizziness, difficulty reading, and discomfort following traumatic brain injury (TBI). Recognition of this deficit allowed for targeted intervention with yoked prism, which facilitated perceptual realignment and improved functional mobility and patient comfort.

This altered egocenter reflects a misalignment between the perceived and actual body midline, a mechanism that closely relates to but is distinct from visual midline shift syndrome (VMSS). Padula and Argyris characterized VMSS as a post-trauma visual disorder in which the visual midline itself is displaced, resulting in shifts in perceived spatial orientation and postural control. They characterize VMSS by hemiplegia, hemiparesis, flexion, and side neglect.[2] While VMSS primarily describes the perceptual shift in visual space, abnormal egocentric localization represents the underlying disruption in how the individual integrates visual, vestibular, and proprioceptive cues to establish themselves in space. Thus, abnormal egocentric localization can be understood as a critical component contributing to the development and persistence of VMSS.

Following TBI, patients often experience a broad range of visual and perceptual disturbances, many of which can be attributed to an underlying disruption in egocentric localization. These symptoms often coexist with oculomotor dysfunctions such as convergence or accommodative insufficiency, saccadic inaccuracy, and poor binocular coordination, which further destabilize spatial perception.[1] Clinically, individuals may describe feeling as though they are being pulled to one side, that objects appear tilted or shifted, that they don't feel grounded, or that their body alignment does not match the visual world around them. When unrecognized, abnormal egocentric localization can contribute to persistent imbalance, visual fatigue, and lack of confidence during ambulation. Patients may feel wary of daily activities that require accurate spatial awareness, such as walking or driving.[1] Recognition of this dysfunction is therefore essential, as targeted interventions such as yoked prism lenses and neuro-optometric rehabilitation therapy (NORT) can help restore perceptual alignment and improve overall spatial orientation.

The perception of "straight ahead" is a fundamental aspect of egocentric localization, and its neural basis has been closely linked to parietal and occipital lobe function. Ferber and Karnath have suggested that damage within these cortical regions can lead to significant distortions in perceived straight-ahead orientation.[3] Their findings support the view that accurate egocentric localization depends on the integration of visual and proprioceptive inputs mediated by these cortical areas. In the context of a TBI, disruption to these neural networks can produce similar perceptual shifts, manifesting clinically as abnormal egocentric localization or visual midline displacement.

A simple and accessible test of egocentric localization involves the examiner slowly moving an object, such as a pen or pencil held about 15 inches away, from the patient's periphery towards their midline. The patient should be instructed to verbalize when they believe the object is aligned with their perceived visual midline. It is important that the examiner is positioned off to the side of the patient so as not to interfere with the patient's midline perception. Testing is repeated several times from both horizontal and vertical directions to assess consistency and determine whether a reproducible shift is present. This test allows the examiner to obtain a gross understanding of the patient's subjective straight-ahead position. Standardized procedures for assessing egocentric localization remain limited, however more quantifiable methods have been described.[1] These include the Bernell Spatial Location Board – Height Adjustable Model and the Bernell Vision Disc, the latter of which was not intended for this measurement but can be adapted. Quantification of egocentric localization may also allow for more precise assessment of changes following yoked prism intervention.

Binocular vision dysfunctions, including accommodative, vergence, and oculomotor disorders, are extremely common in patients who have experienced a TBI, and a full work-up to assess their sensorimotor status is necessary in this population.[4] These underlying dysfunctions can compound and exacerbate the symptoms associated with abnormal egocentric localization. Once the patient's visual

skills have been fully evaluated and considered, yoked prism can serve as a treatment option for abnormal egocentric localization to shift the visual field towards the direction of the patient's perceived vertical or horizontal midline. For example, a patient with egocentric localization shifted to their left would benefit from base right prism. By shifting the patient's visual field into the position that corresponds to their perceived midline, the prism correction may help reorient their spatial awareness and improve their ability to navigate their surroundings.[5] In addition to treatment with yoked prism, neuro-optometric rehabilitation therapy may be utilized to improve sensorimotor function and further reduce symptoms when indicated.

CASE REPORT

A 43-year-old female presented after sustaining a TBI due to a building accident where a 2x4 wooden plank struck her head. The patient was seen in the Vision Rehabilitation Service at the University Eye Center. The patient reported that it was a closed head injury, and she did not experience any loss of consciousness. She was evaluated by her primary care physician following the event, who diagnosed her with a concussion. At her initial presentation, 6 months after the injury, the patient reported photosensitivity that was exacerbated by moving or swaying lights. The Post-Traumatic Visual Symptom Survey (PTVS) was administered at this visit to determine the patient's symptoms and the severity at which she was experiencing them. The patient reported a score of 3 (the highest possible score per category, indicating a nearly constant occurrence) for the following symptoms: dizziness, restricted field of vision, bumping into objects on one side more than the other, sensation of the floor or ceiling tilting, difficulty moving or turning eyes, pain with eye movement, poor posture, bothered by movement/crowded environments, photosensitivity, unable to sustain near work, headaches and loss of place when reading. Her total PTVS score was 87 of 120 points, indicating that she was highly symptomatic. She reported taking 60 mg of methylphenidate twice a day to help with fatigue secondary to her TBI. Her systemic health was otherwise unremarkable. She completed 12 sessions of physical therapy to address pain and stiffness in her back and began to see an acupuncturist weekly to manage her back pain.

The patient presented without spectacle correction and denied a history of spectacle wear. Upon evaluation, her cover test revealed a variable 2-4PD esophoria at near with a 2PD esophoria at distance. No tropia was present and the patient was not symptomatic for diplopia. The patient's accommodative near point of convergence was receded with a 5-inch break and 12-inch recovery. The non-accommodative near point of convergence was also receded with a 24-inch break and no recovery. The patient's fixation was unsteady OD and OS, and both pursuits and saccades were jerky with frequent fixation losses and excessive blinking, a sign of motor overflow. The patient manifested a low compound astigmatic refractive error in each eye, with a small near add based on her age. The final prescription was +1.00 -0.75 at axis 85 in the right eye, +0.50 -0.75 at axis 90 in the left eye, with a +0.75 add. The patient's distance base out vergence ranges showed a 25PD break and 12PD recovery, and her base in vergence ranges showed a 4PD break and 2PD recovery. Her near base out vergence ranges showed a 30PD break and 12PD recovery, and her base in vergence ranges showed a 10PD break and 6PD recovery. Phorias were measured with Modified Thorington and testing revealed a 5PD eso at distance, and 3PD eso at near with no measurable vertical deviation. The Developmental Eye Movement (DEM) Test was administered and the patient scored less than 1% on both the horizontal and ratio components using the highest norms available for a 13 year old. The patient scored in the 10%ile on the Visual Tracing Test (VTT) using the highest norms available for a 12 year old. Keystone Visual Skills and Van Orden Star testing showed unstable binocular findings and alternate suppression at both distance and near. Due to the severity of her symptoms of nausea and disequilibrium, visual-vestibular testing was not performed. The patient was diagnosed with basic esophoria, oculomotor dysfunction, and visual-vestibular dysfunction. New glasses for distance

and near were prescribed, and neuro-optometric rehabilitation therapy (NORT) was recommended.

In the early stages of NORT, techniques were utilized that stressed oculomotor and vergence skills to address the signs and symptoms of oculomotor dysfunction and basic esophoria. She was initially too symptomatic to incorporate therapies that addressed her visual motion sensitivity and visual-vestibular dysfunction. Oculomotor techniques included visual tracing, Michigan Tracking, and Hart Chart saccades. The patient also attempted monocular thumb pursuits and binocular thumb jump ductions while seated, but was unable to perform them due to the exacerbation of her symptoms of dizziness and nausea. Peripheral awareness techniques via the Macdonald chart also induced these symptoms. In the office, the patient attempted computerized tracking, however the brightness of the computer screen was bothersome and induced eye strain and fatigue.

After completing 6 sessions of NORT, the patient was not progressing as expected and was reporting almost constant symptoms of dizziness and disequilibrium. During the 7th session, the patient shared a recent incident where she was at a festival and felt her entire world shifting to one side. Her partner was with her at the time and told her she had been leaning over and walking towards her right. She felt very disoriented during this experience and left the festival; it took her several days to recover at home. This prompted further testing, which included egocentric localization testing. A slight shift to the right was noted. Yoked prism was trialed, and the patient reported relief with base left prism. Both 1PD and 2PD yoked base left prism was trialed, and the patient felt most comfortable with 1PD base left. The patient was observed to have an unsteady gait when walking down the hallway with her habitual glasses, where she was leaning slightly to the right. She lost her balance when trying to turn around and put her hands out to maintain balance while walking. She demonstrated a much steadier gait with 1PD base left yoked prism over her habitual glasses; she was not leaning to her right and was able to consistently walk in a straight line. She reported a subjective improvement in her balance, and felt she had an improved awareness of her surroundings while

Table 1: Clinical findings at initial evaluation and re-evaluation following incorporation of 1 PD base-left yoked prism. Normative values adapted from Morgan's expected findings as reported by Scheiman and Wick.[13] These values are provided for reference and may vary based on testing method and patient age.

	Habitual Glasses	Yoked Prism Glasses	Normative Data
Cover test near	2–4$^{\Delta}$ EP	2$^{\Delta}$ EP	Orthophoria to 6$^{\Delta}$ XP
Cover test distance	2$^{\Delta}$ EP	Orthophoria	Orthophoria to 2$^{\Delta}$ XP
Near point of convergence break/recovery	12 cm / 30 cm	8 cm / 13 cm	≤5 cm / ≤7 cm
Distance base out vergence blur/break/recovery ($^{\Delta}$)	X/25/12	X/25/18	9/19/10
Distance base in vergence blur/break/recovery	X/4/2	X/6/4	X/7/4
Near base out vergence blur/break/recovery	14/30/12	16/40/35	17/21/11
Near base in vergence blur/break/recovery	X/10/6	X/18/16	13/21/13
Developmental Eye Movement Test	<1%ile	81%ile	Age-adjusted norms
Visual Tracing Test	10%ile	47%ile	Age-adjusted norms
Post-Traumatic Visual Symptom Survey score	87	26	Lower scores indicate fewer symptoms
Keystone Visual Skills	Unstable alignment	Expected alignment	Expected alignment
Van Orden Star	Alternate suppression	Normal, no suppression	No suppression
Visual-vestibular testing	Unable to complete	Normal	–

wearing the trialed prism. Her distance and near glasses were updated incorporating 1PD base left yoked prism into the prescription.

Once the patient received her glasses, she reported being much more comfortable navigating her environment, and she was able to read for longer periods of time. She no longer felt disoriented when scrolling through her phone when wearing the yoked prism glasses. A re-evaluation was performed through her yoked prism prescription and the findings are compared to her initial evaluation findings in Table 1. The patient now showed a 2PD esophoria at near and was orthophoric at distance on cover test. Her accommodative near point of convergence improved to a 3-inch break with a 5-inch recovery. In the phoropter, the patient's distance base out vergence ranges improved to a 25PD break and 18PD recovery, and her base in vergence ranges showed a 6PD break and 4PD recovery. Her near vergence ranges also improved and showed a 40PD break and 35PD recovery for base out, and her base in ranges showed a 18PD break and 16PD recovery. The DEM testing improved from a ratio of less than 1% at her initial evaluation to an 81%ile. Her Visual Tracing Test performance improved from 10%ile to 47%ile. The PTVS was re-administered, and the patient's total score decreased from 87 to 26. The frequency of her symptoms was no longer higher than a score of 2 (frequent occurrence). The only symptoms that she graded as a 2 were photosensitivity and decreased attention span when reading. Keystone Visual Skills and Van Orden Star testing revealed stable, expected findings indicating alignment at distance and near. Visual-vestibular testing including dynamic visual acuity was normal, as well as the Cohen Test (a clinical assessment involving viewing a stationary flat fusion target while the patient performs horizontal head shakes), which demonstrated no suppression or nystagmus. Notably, the patient did not feel nauseous or disoriented during and after visual-vestibular testing.

At her following NORT appointments, she continued to report that the visual symptoms and fatigue that she presented with, as well as her constant eye strain, pressure, and headaches, were greatly reduced once adjusting to the glasses. She reported that she was now able to read a book at night for over 30 minutes without getting fatigued, which she was unable to do since prior to her injury. She also noted an improvement in her reading comprehension, and reported she was able to recall specific details about what she had read and now engage in thoughtful conversation with her partner. Her symptoms of dizziness and disorientation were completely resolved, and her energy levels felt dramatically increased. She expressed that she had more free time in the evenings, as prior to receiving her prism glasses she normally spent her evenings recovering from the day's activities.

The patient ultimately completed 40 sessions of NORT. At her six-month follow-up, she demonstrated sustained improvement in her symptoms. Her egocentric localization was re-assessed and remained centered with her habitual 1PD base left prism glasses. Following these outcomes, the patient completed her NORT program and transitioned to routine annual comprehensive evaluations.

DISCUSSION

Although treating the sensorimotor disorders associated with TBI is integral to the rehabilitation of these patients, it is important not to overlook associated visual-spatial disorders such as abnormal egocentric localization. Yoked prism can be an effective method of treatment to address and correct for anomalous egocentric localization.[1] A proposed mechanism is that yoked prism influences the magnocellular processing involved in proprioceptive, kinesthetic, and vestibular integration. One case study sought to investigate the neural mechanisms that take place in patients with VMSS, both with and without prism correction via the use of event-related potentials from noninvasive electrophysiological recordings. The examiners found that without prisms, delayed response latencies indicated that there was inefficient magnocellular system processing in somatosensory, language, and executive brain regions. With prisms, electrophysiologic findings suggested faster and

more efficient visual processing and activation patterns typically involved in normal vision.[6] These findings suggest that corrective prism may facilitate neural reorganization in VMSS patients that contributes to the reduction in symptoms of disorientation, disequilibrium, and dizziness as well as an improvement in cognitive processing.[5] Although yoked prism correction is an important intervention when treating TBI patients with VMSS and therefore abnormal egocentric localization, it is also important to utilize NORT to address any underlying sensorimotor symptoms.

In this case, the decision to trial and ultimately prescribe 1PD base left yoked prism was guided by the patient's egocentric localization testing and by observing the patient's ambulation with and without the yoked prism. Small prism values are typically prescribed for abnormal egocentric localization, as they provide a subtle, yet clinically meaningful, shift of the visual field toward the patient's perceived midline, while minimizing disruption to binocular alignment and enhancing spatial orientation and postural stability.[7] The patient was given adequate time to assess each trial and report which prism power felt most comfortable. Observations of gait and balance with and without prism confirmed that even this small amount produced a noticeable improvement in her ability to navigate her environment safely.

Of the improved clinical findings upon re-evaluation after the incorporation of yoked prism, the change in DEM Test performance was particularly notable. Although the DEM Test is traditionally considered as a measure of saccadic efficiency and visual-verbal automaticity, more recent evidence suggests that performance on the test reflects a broader combination of visual processing speed, fixation behavior, and higher-order visuocognitive functions.[8] Leigh and Zee also describe saccadic eye movements as being supported by distributed cortical and subcortical networks, including parietal and frontal regions involved in spatial attention and visual guidance, rather than being purely low-level motor events.[9] In this case, the patient's improvement on the DEM Test may be best understood as a consequence of improved spatial stability following alignment of the egocenter with yoked prism. This reduction in spatial disorientation may have enhanced the efficiency with which visual information was processed during testing, suggesting that correction of abnormal egocentric localization may have downstream effects on visual processing. These findings are also consistent with the patient's reported improvement in reading endurance with use of her yoked prism glasses.

Although this patient experienced a substantial reduction in symptoms and demonstrated functional improvement following the introduction of 1PD base left yoked prism, it is important to consider that these improvements cannot solely be attributed to prism correction. Prior to prism correction, the patient had already completed 6 sessions of NORT, targeting oculomotor and vergence skills, which may have contributed to progressive neuroadaptation and partial symptom reduction that became more evident over time. It is also possible that the initial NORT sessions facilitated the patient's ability to subsequently adapt to and benefit from yoked prism correction. This concept may be loosely compared to the "sandwich" approach in strabismus management, where vision therapy is utilized both before and after surgery to prepare the sensorimotor system for change and then reinforce binocular integration and stability afterward.[10] Similarly, the early sessions in this case may have helped prepare the patient for the introduction of yoked prism and contributed to the improvements she reported in balance, navigation, reading endurance, and dizziness. Because the prism was introduced while therapy was ongoing, it is difficult to determine the exact contribution of each intervention independently, and this proposed relationship between early therapy and enhanced adaptation to yoked prism in cases of egocentric localization remains speculative. Re-evaluating the patient after stabilization of symptoms without the yoked prism may have provided additional insight into the specific effect of prism correction on egocentric localization and functional performance.

Another consideration in this case is the long-term necessity of continued yoked prism wear following completion of NORT. At present, there

is no standardized protocol defining when prism correction can be safely reduced or discontinued in cases of abnormal egocentric localization. Although NORT aims to improve the underlying visual-spatial deficits commonly present in the TBI population, some patients may continue to benefit from, or function comfortably with, continued use of yoked prism even after completion of therapy. In this case, the patient remained comfortable and functionally stable with 1PD base left yoked prism at both completion of NORT and her 6-month follow-up. Whether gradual reduction or discontinuation of prism would be appropriate over time remains uncertain and may depend on the persistence of egocentric localization findings under both prism and non-prism conditions at future exams, as well as the patient's real-world functional demands.

Abnormal egocentric localization can be an overlooked condition in the TBI patient population. Outside of vision rehabilitation providers, many consider egocentric localization to be an unproven concept, and the use of yoked prism and neuro-optometric rehabilitation therapy as a form of treatment remains controversial.[11] To ensure appropriate care, it is essential to increase awareness and acceptance of this condition among primary care optometrists and ophthalmologists. Greater familiarity can help clinicians feel more confident in identifying suspected cases and making timely referrals when indicated. Fortunately, testing for this condition is accessible, non-invasive, and can easily be performed in a clinical setting.

Without intervention, abnormal egocentric localization can significantly impair a patient's ability to function safely and independently. Individuals often struggle with walking and navigating their environment, leading to an increased risk of falls and other accidents.[12] With appropriate treatment, patients can regain their sense of spatial orientation, which improves their ability to perform daily activities and reduces their risk of accidents and injuries. Beyond physical risks, abnormal egocentric localization can also have a severe impact on a patient's mental health. If left untreated, patients may develop anxiety, depression, or other psychological symptoms related to their distorted sense of spatial orientation.[2] Early detection and targeted intervention are therefore essential to minimizing both the physical and psychological complications associated with this condition.

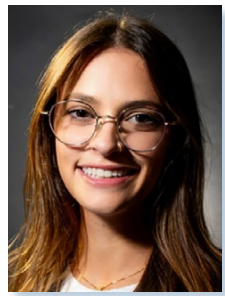
Conclusion:

Greater awareness and recognition of abnormal egocentric localization is essential to ensure that fewer patients go overlooked and untreated. Testing for egocentric localization should be incorporated into baseline evaluations for patients with a history of TBI. When left unrecognized, this condition disrupts daily activities such as walking, driving, and reading, and can increase the risk of falls and injury. Beyond the physical consequences, it can also contribute to significant psychological distress in the form of anxiety, frustration, and reduced confidence. As demonstrated in this case, improvements in visual performance measures such as reading endurance may reflect enhanced integration of visual-spatial information following realignment of the egocenter, with downstream effects on functional visual efficiency. With timely and appropriate intervention, including yoked prism and neuro-optometric rehabilitation therapy when indicated, patients with abnormal egocentric localization may regain balance and stability, reduce discomfort and anxiety, and experience meaningful improvements in overall visual function and quality of life.

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