TINTED LENSES IN THE TREATMENT OF VISUAL STRESS IN A PATIENT WITH A TRAUMATIC BRAIN INJURY A CASE REPORT

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Abstract

Various symptoms secondary to head injuries can be associated with reading difficulties unrelated to binocular and accommodative disorders. Visual stress (VS) is described as the inability to read comfortably without distortion and discomfort. The symptoms of the Visual Stress Syndrome (VSS) include: eye-strain, intermittent blur, changes in the spacing of letters, headaches, frequent loss of place in reading, nausea, dizziness, and discomfort. VS may be attributed to cortical hyper-excitability.

Specific colored lenses may offer relief. We present a case report of a Traumatic Brain Injury (TBI) patient who had a number of the symptoms that are included in VSS. In addition to the basic optometric evaluation, we utilized two standardized eye movement tests to establish baselines for several parameters of oculomotor efficiency. We then used a set of colored overlays on reading material to determine the color most beneficial to the patient. The eye movement tests were then conducted with the selected overlay. Tinted lenses, conforming to the overlay, were then prepared and inserted in a clip-on to be used over the patient's reading glasses. After one month of use with the tinted lenses, the standardized tests were again performed. The findings indicated positive changes in various oculomotor parameters. The patient also reported increased comfort with reading that decreased without the use of the clip-on tinted lenses. This case demonstrates the potential benefits of oculomotor testing and application of tinted lenses to treat VSS associated with TBI that is not associated with an accommodative or vergence dysfunction. The test methods and the findings are also discussed.

Key Words

Adult Developmental Eye Movement Test (A-DEM), eye movements, reading, tinted lenses, traumatic brain injury, Visagraph II™, Visual Stress (VS), Wilkins Visual Stress Syndrome (VSS)

INTRODUCTION AND BACKGROUND

Traumatic Brain Injury (TBI) patients can exhibit many types of visual signs, including: accommodative, binocular and oculomotor dysfunctions, refractive error shift and visual field loss. They often report symptoms including blurred vision, double vision, eye-strain, difficulty reading, and reduced ability to sustain visual attention.[1-7] Photophobia and eye-strain secondary to head injuries can be associated with reading difficulties unrelated to binocular and accommodative disorders.[1] Wilkins has labeled this inability to read comfortably without distortion and distress as Visual Stress (VS). He proposed that its symptoms constitute a Visual Stress Syndrome (VSS) that can include: eye-strain, intermittent blur, changes in the spacing of letters, headaches, frequent loss of place in reading, nausea, dizziness, and discomfort.[8] Wilkins further proposed that the VSS may be associated with a cortical hyper-excitability, and that precise colored lenses may offer relief in inhibiting the cortical excitability. He has written a review and interpretation of the scientific evidence gathered over the last decade, along with methods to determine the use of colored overlays and lenses to improve reading for individuals with VS.[9]

We discuss a patient with photophobia, blurry vision, and movement of print, nausea and dizziness when reading. These symptoms followed a TBI. In addition to the basic optometric evaluation, our special testing included oculomotor assessments by two standardized tests to establish baselines. The patient then chose, from a specific array of colored filters, the overlay she felt gave most relief of her symptoms. The oculomotor assessments were then repeated with that overlay. The chosen colored filters were prescribed in the form of clip-on lenses, and the patient was instructed to wear them for all near-point tasks. After one month the above special testing regimen was repeated, and the results are reported.

Case Report

In 2004, a 47-year-old white female presented with photophobia, blurry vision, movement of print, nausea and dizziness when reading. Five years prior, the patient incurred a TBI after being trapped in a falling elevator. Her medical history was significant for insomnia and depression. She was being treated with Zoldipem 10mg and Trazadone 300 mg at bedtime respectively with no reported side effects. Before the TBI, the patient reported an unremarkable medical/ocular history. Refractive analysis determined that she was a myopic astigmat (-0.50 x 90 OU) with a correctable visual acuity of 20/20 at distance, and at near with a reading add of +1.75 OU. These prescriptions were essentially those of her current glasses. The nearpoint accommodative and binocular findings were within expected limits through her distant and near prescriptions. The gross oculomotor examination indicated that there were no restrictions

or nystagmus. Her visual fields, color vision and pupillary responses were normal and unremarkable as well. Examination of the external and internal eye structures revealed no abnormalities or disease in either eye. Based on the reported symptoms, further testing of her oculomotor functioning was pursued.

Special Oculomotor Testing Overview

Special eye movement testing was performed utilizing two standardized oculomotor tests with her nearpoint prescription. The first test was an eye movement scanning task, i.e., the Adult Developmental Eye Movement Test (A-DEM).[10] This test is based on the original Developmental Eye Movement Test (DEM).[11,a] However, the A-DEM is a modification of the original test because its targets are double rather than the single digits of the DEM. It is partially subjective in that the patient is instructed to verbalize the digits as quickly and accurately as possible. The second standardized oculomotor testing instrument was the Visagraph™ II[12,b] (Visagraph). The task here requires the patient to perform silent textual reading; the resulting eye movements are recorded objectively by employing a limbal reflection technique infrared and computer analysis technology.

The Tests

1. The A-DEM

This test consists of three sub-tests with the same distribution of numbers as the original DEM. The A-DEM makes use of double rather than single digits in the visual target array. This results in twice the amount of numbers to be called out during the test. It also increases the visual-verbal retrieval demand on rapid number calling, as compared to the original DEM.

The subject views the test cards at 33 cm. At this distance, the numbers subtend an angle that corresponds to a visual acuity of 20/60. The testing protocol is the same as the DEM.[11] After the practice run (Test A), the time for the subject to rapidly name 80 pairs of vertically arrayed numbers on two test plates of 40 pairs per plate (Test B) is recorded. The subject then is instructed to rapidly name 80 pairs of numbers presented in a horizontal array (Test C), and this is also recorded. See Figure 1. The horizontal to vertical score ratio is then determined by dividing the horizontal score (in seconds) by the vertical score (in seconds).

Figure 1. Horizontal Test for the A-DEM test

We sought to establish a valid and steady A-DEM test score baseline for comparative purposes between the results (without tinted lenses vs. with tinted lenses). To achieve this, we used a recommended protocol[13] to account for a practice effect by repeating Tests B and Test C three times and using the last scores. We applied this protocol to all subsequent A-DEM, and Visagraph (see below) testing.

Initial A-DEM Testing Results

The results for our patient indicated a significant oculomotor inefficiency. Her vertical (V) and horizontal (H) number calling scores were: V= 111 secs; H=135 sec, as well as the resultant ratio (H/V=1.22) were below expected for her age. The expected ratio and standard deviation for her age is 1.05 (0.11). [10] These results indicated delayed language (visual to verbal transformation) automaticity as well as an oculomotor dysfunction.

2. The Visagraph[12]

The testing on this instrument was performed according to recommended protocols developed for the instrument.[13,14] This provided a standardized, objective, automated method to assess specifics of eye movements with and without tinted lenses. The patient was required to read selected text from the Visagraph reading passages at high school level.

Initial Visagraph Testing Results

Scoring was based on two selections with a total of 200 words. Reading comprehension of the material was at an 80% in all trials to be acceptable for scoring fixation rates. Our patient showed a significant number of fixations (412/200 words) and a regressions rate of 23%. These were well below her age expected levels and indicated an oculomotor inefficiency based on the instrument's normative values.[15]

Figure 2: The Colored Intuitive Overlays ™

3. Intuitive Overlays Testing

Colored Intuitive Overlays™[16,c] were used to determine if a specific color diminished the patient's reported symptoms in reading. There are 20 overlays of different colors ranging from yellows, pinks, purples, and blues. See Figure 2.

The testing is based on the screening protocol described by Wilkins for the Intuitive Overlays.[17] This involves placing a series of colored overlays over a sample of text in order to determine which color overlay (if any) minimizes the symptoms. The best color for an overlay differs from one person to another. Consequently, when choosing an overlay it is important that there is an adequate range of colors and that the overlays sample all the colors in a logical and systematic fashion.

Our patient selected a specific blue overlay as providing the most comfort while reading an article on a glossy page in a magazine. This was repeated subjectively on several different articles in magazines. This method was chosen since this was the condition where the patient observed the greatest symptoms and visual distortions of the words in reading. There was incandescent lighting in the examination room. She reported reduction in motion of the print, loss of place and vertigo with the overlay, as opposed to reading the same text without the overlay.

Next, we repeated the standardized oculomotor tests with the blue overlay covering the reading material.

Initial A-DEM Testing With the Blue Overlay

The selected blue overlay was placed on the A-DEM test plates and the test was re-administered. The patient indicated a subjective improvement in her ability to scan and call out the numbers in the test. Her vertical (V) and horizontal (H) number calling scores were: V=112 secs; H=120 sec with a resultant ratio of 1.07. Thus, the V and H number calling scores were still below expected for her age. However, the resultant ratio placed her within the expected range for her age; 1.05 (0.11).[10] These results continued to indicate delayed language (visual to verbal transformation) automaticity in spite of an improvement in oculomotor function coupled with reduced symptoms.

Initial Visagraph Testing with the Blue Overlay

The overlay was placed on the Visagraph test plates and the test was re-administered, according to recommended protocols developed for the instrument.[12,14] The results showed an improvement in reduced total reading time reflected in the number of fixations (379/200 words) and a regressions rate of 24%. This was just an 8% decrease in the number of fixations. These were still below her age expected levels and indicated an oculomotor inefficiency based on the Visagraph's normative values.[15]

Diagnosis/Treatment

We diagnosed the patient with the Wilkins Visual Stress Syndrome secondary to her TBI. Based on the initial special testing results with and without the blue colored overlays, we prescribed tinted lenses that matched the luminance characteristics of the blue overlays. These were mounted in a clip-on frame instead of tinting her lenses since she had multiple pairs of lenses for distance and near. See Figure 3.

The patient was instructed to use these lenses over her present bifocal glasses during all reading and other nearpoint activities. If significant improvement was achieved with the tinted lenses, then tinting each pair would be considered. In addition to the lenses, optometric vision therapy (VT) was recommended to the patient to develop her oculomotility and reading efficiency as well as enhance her binocular vision status. However, she decided not to elect VT at this time due to the relief she gained with the blue lenses and her busy work schedule.

Figure 3: Selected blue lenses in a clip-on frame

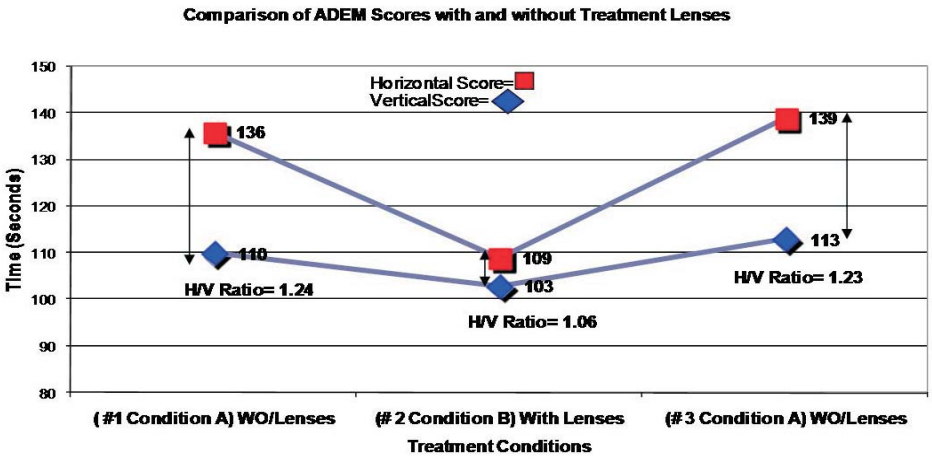

Figure 4: ABA comparison of scores on A-DEM. The square and diamond on the left indicate the horizontal and vertical timing scores respectively without the clip-on lenses (#1 Condition A). The square and diamond in the middle indicate the horizontal and vertical timing scores respectively with the clip-on lenses (# 2 Condition B). The square and diamond in the right indicate the horizontal and vertical time scores respectively without the clip-on lenses again (# 3 Condition A).

One Month Follow-Up Examination

The patient assured us that she complied with our instructions and reported a significant improvement in reading comfort and efficiency; there was a noticeable decrease in reading fatigue, headaches, vertigo and photophobia. She noticed the reduction in comfort when she did not use the clip-ons. The patient was then retested on the standardized oculomotor tests at this examination. However, we now elected to utilize a more vigorous pre and post clinical test comparison approach in order to determine if the blue lenses, in fact, changed her oculomotor performance during the past month.

To achieve this, we applied a single-case subject experimental design for the A-DEM and Visagraph testing. These designs are typically used to determine selected behavioral changes an individual exhibits as the result of treatment. The subject serves as her or his own control. We applied the A-B-A design:[18] A refers to the non-treatment segment (no blue overlay) of the test; B refers to the treatment (with the overlay) segment of the test; the second A refers to a repeat of the test without the overlay. There was a 15-minute rest between the testing in the A-B-A sequence.

A. Post Treatment Testing of the A-DEM

1. **Without the Clip-on Lenses (Condition A)**
   The horizontal and vertical number calling times were 136 secs and 110 sec respectively. This resulted in a H/V ratio of 1.24. All of these values are well below the age expected, and were comparable to the initial A-DEM scores. On both occasions, the result indicated significant visual to verbal automaticity and oculomotor dysfunctions.
2. **With the Clip-on Lenses (Condition B)**
   Her horizontal and vertical number calling scores were 109 secs and 103 secs. with the resultant ratio of 1.06. This was at the expected level for her age: 1.05 (0.11)[10] The patient had reduced her horizontal scanning time score in the A-DEM by 26% with the blue lenses.
3. **Without the Clip-on Lenses (Second Condition A)**
   The results once more indicated a reduction in oculomotor efficiency (139 secs; 113 secs) with the resultant ratio of 1.23.
   These findings were virtually the same as the first Condition A. These results between the different test conditions are shown in Figure 4.
4. During this testing, the patient reported significantly reduced subjective symptoms of discomfort

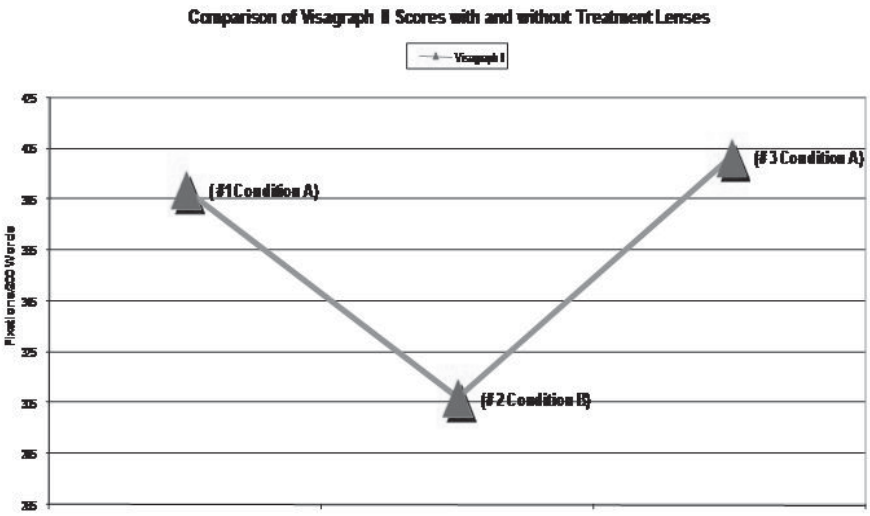

Figure 5: ABA comparison of fixation values on the Visagraph II. The triangle on the left indicates the fixations/200 words read without the clip-on lenses (#1 Condition A). The triangle in the middle indicates the fixations/200 words read with the clip-on lenses (#2 Condition B). The triangle on the right indicates the fixations/200 words read without the clip-on lenses again (#3 Condition A).

and dizziness with improved reading efficiency with the clip-on lenses; in both instances without them, she had reduced efficiency, and reported movement in the print, and photophobia.

B. Post treatment testing with the Visagraph

1. Without the clip-on lenses (Condition A)

The patient read text from the Visagraph passages at the high school level. We scored it based on two selections with a total of 200 words. In this Condition A there were a significant number of fixations (389/200 words) and a regressions rate of 23%. These were similar to her pre-treatment findings that were below her age expected. This again suggested an oculomotor inefficiency based on established normative values.[15]

2. With the clip-on lenses (Condition B)

The findings showed a decrease in the number of fixations (307/200 words), but the regression rate of 23% stayed the same. This represents a 21% lessening of fixations from the first Condition A. Based on Taylor's normative data of fixation rates,[15] the findings in Condition B increased approximately six grade levels in reading and oculomotor efficiency from the first Condition A.

3. Without the clip-on lenses (Second Condition A)

The number of fixations was 402/200 words and the regressions rate was 25%. Both findings were close to the initial Visagraph testing and Condition A of the post treatment assessment. These again demonstrated findings well below her age expected levels and a return to an oculomotor dysfunction. These were quite similar to her pre-treatment findings.

These findings of the number of fixations/200 words during the A-B-A assessment is graphically shown in Figure 5.

Discussion

There is an apparent relationship between TBI, visual dysfunction, and associated symptoms and discomfort in many patients.[19,20] The use of colored filters has been shown to improve reading efficiency in certain individuals, including children. They have been shown to reduce fatigue and increase fluency and can be used with both dyslexic and non-dyslexic children and adults.[9] Colored filters and lenses also appear to be of benefit in neurological disorders affecting vision.[21] Such conditions may include epilepsy, seizure disorders, multiple sclerosis, and migraine headaches.[22] In such instances, there is an increased risk of seizures consistent with the hypothesis that the visual cortex is hyper-excitabile. This hyper-excitability was discovered by increased blood oxygenation as shown in functional MRIs. The stimuli were "annoying" black-and-white striped patterns in migraine patients. The spatial frequencies of these stripes were particularly at epilepsy inducing levels. It had been suggested that specific colored filters can reduce this hyper-excitability and the associated symptoms.[23, 24]

In this present case, the patient experienced a significant increase in reading efficiency and comfort with reduced symptoms with the selected blue lenses. The A-DEM findings gave evidence that the patient was now reading more efficiently. The objective Visagraph results further reflected the positive changes in her oculomotor function and efficiency performance in reading tasks with the blue lenses.

A basis of these positive changes in reading was suggested by Wilkins'[8] in his discussion of the effect of black and white stripes as a cause of stress within the visual system. He observed that when certain people view material such as horizontal black-and-white square wave grating stripes, they report visual discomfort. They report that stripes of specific spatial characteristics appear to flicker, become distorted, blurry, and these changes become visually annoying. Wilkins proposes that the lines of a paragraph of text can be considered as a pattern of stripes. Thus, it is possible that some of the perceived alterations of text and some of the discomfort and headaches that occur when reading are because of the way some text approximates a striped pattern. He further proposes that the stripes' irritating effects on vision may be the result of an inappropriate firing of cortical cells due to a spread of excitation within the cortex. Wilkins further suggests that this can cause perceptual distortions that disrupt reading and information processing. Accordingly, this cortical hyper-excitability is inconsistent with efficient visual perceptual information processing. It seems that the tinted lenses adjust the imbalanced cortical excitation that occurs in response to a visual stimulus. Thus, with our patient the blue lenses theoretically redistributed the excitation so as to reduce the excitation in hyper-excitabile regions. This could account for the reduction in perceptual distortions with the colored lenses.[25]

Others have reported abnormalities in cortical gain control that may be caused by damage as occurs in TBI.[26] Solan et al[27] reinforced the relationship between specific blue wavelengths of light and eye movement efficiency in reading. Blue fil-

ters resulted in a significant improvement in the number of fixations, regressions and rate of reading in reading disabled children. In addition, it has been reported that visual difficulties following head trauma benefited from various methods of applied lenses.[1,21, 22]

Conclusion

This case demonstrates the value of specialized oculomotor testing and the potential benefits of tinted lenses to treat a patient with symptomatic VS associated with TBI. It is noteworthy that these symptoms were not associated with an accommodative or binocular dysfunction. The information in this case provides evidence for the improvement of visual function and oculomotor efficiency consistent with current theories supporting the use of specific color therapy.[1,21-22] With supplementary oculomotor vision therapy, the efficiency and comfort may have been further improved. Our vigorous analysis of oculomotor performance during standardized testing with the tinted lenses revealed noticeable improvements. However, at least equally important was the patient's subjective report of more comfortable reading with the lenses.

The authors have no financial or other interest in the VisagraphII™ or the Colored Intuitive Overlays™. Only Dr. Richman has a financial interest in the DEM.

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