A New Treatment for Computer Vision Syndrome

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Computer Vision Syndrome (CVS), also referred to as Digital Eye Strain, describes a group of eye and vision-related problems that result from prolonged computer, tablet, e-reader and cell phone use (AOA, 2016).

Symptoms of CVS include headaches, ocular fatigue, blurred vision and dryness of the eyes (Blehm, 2005). It is widely understood that headaches originate in the brainstem though interaction with the trigeminal nerve, which carries innervation to the head and to the eyes. Our hypothesis is that CVS is a form of visually induced trigeminal dysphoria caused by ocular motor imbalances that become more symptomatic following the prolonged use of digital devices.

As the use of digital devices rises exponentially in modern society, management of this disorder is rapidly becoming one of the most pressing and important challenges in eye care.

It is estimated that 65% of Americans suffer from symptoms of CVS (The Vision Council, 2016). In current practice, the treatments of CVS primarily address a lack of near focusing power or an attempt to block certain wavelengths of light. Other recommendations for relief of CVS symptoms such as proper body positioning for computer use, lighting conditions and the use of rest breaks, may be helpful but clearly do not address the underlying causes of CVS. The authors of this study believe that a more effective treatment for CVS lies in addressing problems of alignment between the mid-peripheral and central visual tracking systems. This paper decribes the results of a prospective clinical study of spectacles with contoured prismatic correction that demonstrates the efficacy of this treatment in a subset of patients with CVS. No changes were made to the focus, add power, or light filtration (no blue light blocker used) for this study; instead, the contoured prism was used to account for misalignment of visual tracking systems at all distances.

METHODS

This study was conducted at The Headache Center of Neurology Associates in Sioux Falls, SD, between January 2016 and March 2016. The study enrolled 23 patients identified as having Computer Vision Syndrome (CVS). Patients were screened for enrollment using a validated CVS questionnaire, (Seguí Mdel M, 2016).

Using this questionnaire, patients were identified as having Computer Vision Syndrome if they scored 6 or higher (scale from 0-32); patients scoring 5 or below were excluded. In addition to a qualifying score on the CVS questionnaire, each participant reported work at a computer of 10+ hours per week. The age of the patient population was between 17 and 51. One patient was lost to follow up, so the final number of patients completing the study was 22. Twenty of these patients were females and 2 were males.

BRIEF DESCRIPTION OF THE TECHNOLOGIES USED

NEUROLENS® MEASURMENT DEVICE

The neurolens measurement device creates a dynamic customized measurement of misalignment at 6meters and 50 centimeters, analyzing all the critical elements of ocular fusion, including pupillary distance, heterophoria, accommodative converge to accommodation ratio, alignment of binocular peripheral and central fusion, and central fixation disparity (figure 1).

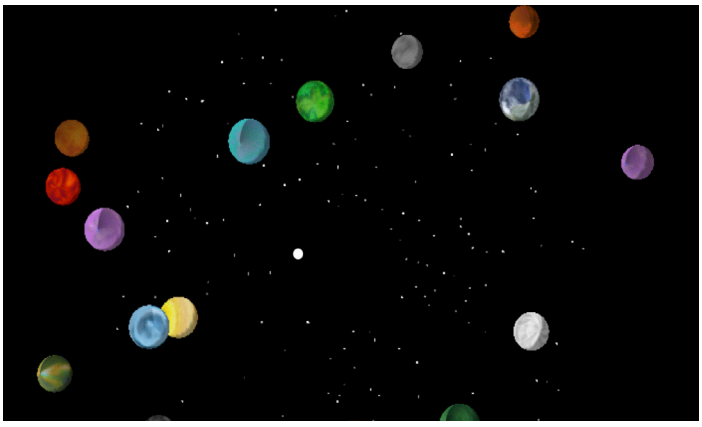

Figure 1

Data from the device provides objective measurements of the precise amount of prismatic correction needed to give patients perfect alignment of ocular fusion at distance, intermediate and near. These data are then used in the manufacture of customized, corrective neurolens® spectacles

The neurolens evaluation begins with the measurement of pupillary distance. Pupillary distance is measured by presenting a fusible visual stimulus to both eyes at a simulated distance of 6m. The center of each pupil is identified and the distance between the pupils is measured.

Testing is then performed to determine if there is evidence of a heterophoria. The patient is presented with dissimilar, non-fusible visual stimuli. Then the relative direction assumed by the eyes in the absence of a fusional stimulus is evaluated. If a phoria is identified, it is measured precisely using proprietary eye tracking software and Purkinje image analysis.

Each eye is then presented with both peripheral and central fixation targets positioned to align with the patient's underlying phoria. The targets are then slowly moved to induce an 8-diopter divergence. This maneuver is performed to relax the extraocular muscles and neutralize the tendency of the eyes to accommodate and converge when looking into an testing device.

After this relaxation exercise, the patient is then shown rotating spheres in the mid-periphery of both the right and left eye simultaneously. These rotating spheres create a powerful stimulus for the activation of the peripheral visual tracking system. The center of the circle, created by the rotating spheres, is positioned to align precisely with the center of the patient's central phoria. While the spheres continue to rotate simultaneously in the mid-periphery of both eyes , a small central target, activating the central tracking system, is shown in the center of the rotating spheres to both eyes. This central stimulus, however, is shown with alternating occlusion.

If there is no imbalance between the patient's central fixation and patient's peripheral visual tracking system, the dot appears stationary.

If there is an imbalance or disparity between central fixation and the patient's peripheral tracking system, the central dot seems to dance with alternating occlusion, as the two eyes see the central dot in two different locations.

Misalignment of central and peripheral fixation is then measured in diopters, using eye tracking and Purkinje image analysis. The fixation disparity is then neutralized prismatically, and the patient begins to see the dot as stationary even with continued alternating occlusion. This testing process is then repeated for near vision at an optical distance of 50cm.

A measurement of total binocular misalignment is then provided to the clinician, factoring both the patient's underlying central phoria and any additional disparity between central and peripheral fixation. Corrected prismatic adjustments for both distance and near measurements are then utilized, along

with the patient's refractive correction, to create a precise, customized neurolens prescription.

NEUROLENSES

Measurements taken from the neurolens ocular motility Measurement Device guided the manufacture of glasses, known as neurolenses, with contoured prisms designed to correct the measured imbalance. Based on the evaluation, patients found to have an imbalance were given spectacles with the calculated prismatic correction. A proprietary manufacturing technique allows the power of the prismatic correction to vary from distance to near vision. The neurolens design corrects misalignment of the peripheral and central tracking systems at all distances.

INITIAL VISIT

At their initial visit, all patients filled out the validated questionnaire (CVS-Q) and were asked a series of lifestyle questions. The questionnaire was scored and CVS was diagnosed in patients scoring 6 or higher and spending 10 hours or more per week on a computer. After completing the questionnaire, patients diagnosed with CVS were seen by an optometrist who performed a subjective refraction and a neurolens exam. The results of these two tests were used to create a pair of neurolenses for the patient to wear while working at their computer. Patients returned for 30-day and 60-day follow up visits. At both the 30-day and 60-day visit, the patient was again asked to complete the validated CVS questionnaire, as well as an additional questionnaire asking them if their symptoms had improved. That questionnaire also contained sections on vision quality with the lenses, adaptation to the lenses, willingness to recommend the lenses to friends and family, and willingness to purchase the lenses in the future.

At the 30 day visit, patients were measured with the neurolens Measurement Device over the top of neurolenses. After wearing the lenses, more disparity can sometimes be indentified as the patient's eyes adjust to the initial prism. Based on the results of this test and symptoms, some patients were given a second set of lenses with a contoured prism enhancement. In all, 7 of the 22 patients received updated lenses. Of the 7 who received enhancements, 6 reported a greater improvement with the second pair versus the first pair of lenses.

The validated CVS questionnaires, the study's primary measure of efficacy, were scored at each visit to determine how much improvement, if any, was made in reducing each patient's symptoms. The study also calculated the average subjective improvement based on patient responses.

FINDINGS

Figure 2 represents the total patient willingness to recommend after 30 days. 100% agree they would be willing to recommend with 55% stating they strongly agree (n=22). Figure 3 demonstrates that at the 60 day mark, total patient willingness to recommend increased. All (100%) of patients still agree they would be willing to recommend, while 72% strongly agreed (n=22). Finally, Figures 4 and 5 show substantial improvement in the qualitative symptom relief at 30 days and again at 60 days.

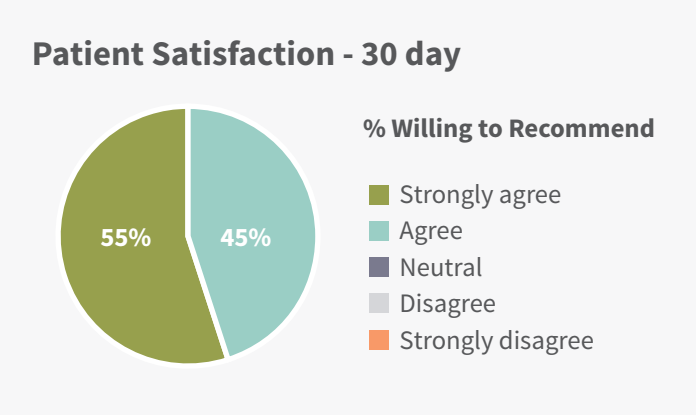

Figure 2

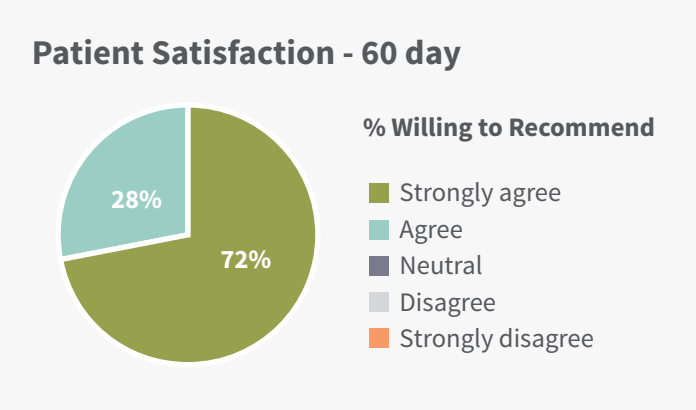

Figure 3

These results suggest that neurolens measurement and neurolens treatment are effective in relieving symptoms associated with CVS. Self-reported efficacy, utilizing a validated metric for gauging severity of Computer Vision Syndrome symptoms, the CVS-Q, indicated that 22 of the 22 patients (100%) had a positive response to the treatment. The two-sided p-value against the hypothesis of no-effect was statistically significant with a p-value < 0.01. Importantly, symptom relief lasted beyond 30 days, with a large majority of participants reporting a strong willingness to recommend and significant

symptom reduction after wearing neurolenses for 60 days. On average, patients reported an 81% improvement in their symptoms over the 60-day period.

The CVS-Q index score average decreased from an initial value of 19.5 pre-treatment to 7.4 at 30 days of wearing neurolenses and to 6.7 at 60 days. There was no significant change between 30 and 60 days, suggesting that the treatment effect was durable and persistent.

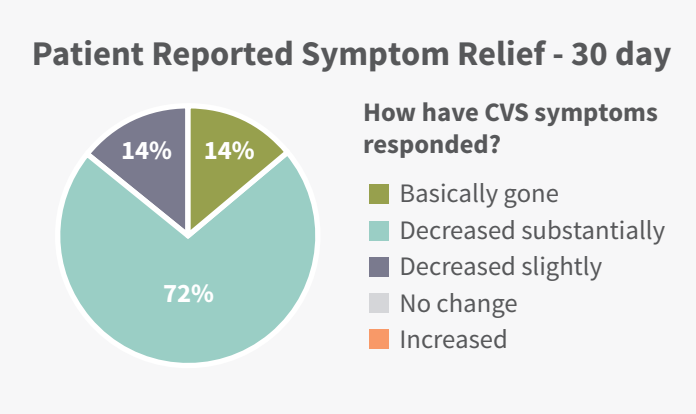

Figure 4

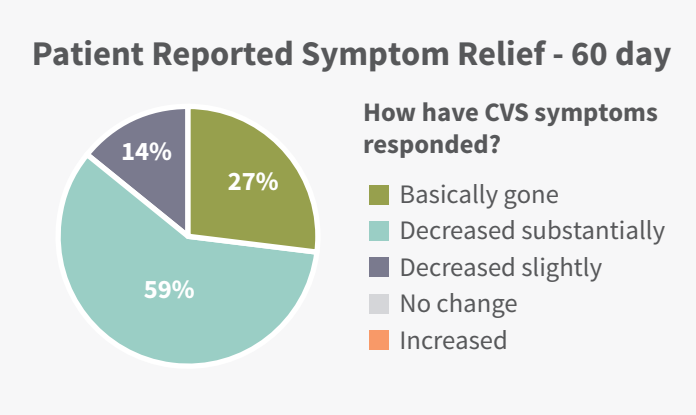

Figure 5

DISCUSSION

This paper describes a prospective study conducted to evaluate a new treatment for patients with CVS. Treatment involves the use of spectacles with a contoured prism correction. The basis of the treatment is the hypothesis that one pathophysiologic mechanism for CVS is misalignment of the visual tracking systems.

The authors of this study believe that CVS patients often suffer, not only from unrecognized phorias and deficiencies of accommodative convergence, but also from a defects in synchronization of peripheral vision tracking systems, controlled primarily by saccadic eye movements, and central vision tracking, controlled primarily by smooth pursuits. Our findings demonstrate that these basic eye movement disorders are not uncommon and appear to become symptomatic with the prolonged use of digital devices or working at near.

SACCADIC AND SMOOTH PURSUIT EYE MOVEMENTS AND THEIR RELATIONSHIP TO PERIPHERAL AND CENTRAL VISUAL PROCESSING

The visual system is constantly faced with two conflicting demands. The first is the need to move objects of interest from the peripheral retina to the central retina in order to bring images into sharper focus. The second is the need to hold objects still, so they can be better visualized (Godlove, 2013).

As a visual image moves across The retinal surface, the time needed for the visual cortex to convert light energy into a high quality neural impulse is reduced, resulting in visual blur. Primates in general have been shown to be relatively slow in transducing light information at the retinal level (Carpenter, 1988).

Saccadic eye movements provide extremely quick readjustments of eye position. The primary function of saccadic movements is to shift objects of concern from the peripheral retina to the area of central vision. Smooth pursuit eye movements then take over, stabilizing images, thereby allowing visual processing in the occipital cortex to provide greater clarity.

Smooth pursuit eye movements track more slowly and compensate for motion of the visualized object, thereby reducing blur (Krauzlis, 2004). Smooth pursuit movements, therefore, are more of a “gaze-holding” than a “gaze-moving” eye movement (Godlove).

The coordination and synchronization of the saccadic and smooth pursuit eye movements, therefore, would appear to be critical, if the eye is to provide an effortless transfer of images from the peripheral to central vision.

HOW MISALIGNMENTS OF PERIPHERAL AND CENTRAL VISUAL TRACKING SYSTEMS TRACKING LEAD TO THE SYMPTOMS OF COMPUTER VISION SYNDROME

It has long been known that mid-peripheral fusional mechanisms play an important role in maintaining central fixation and that imbalances between mid-peripheral and central tracking systems can be a source of ocular discomfort (Burian, 1939). It has also been demonstrated that even small discrepancies in peripheral and central fusional mechanisms become far more pronounced and symptomatic at higher levels of background illumination such as that encountered on digital devices (Shippman, 2015). Although these fusional issues and their consequences are well understood and documented in basic science research literature, imbalances between these two systems have been considered of little clinical significance in the past and have been largely ignored in clinical practice. The authors of this study believed, however, that imbalances in peripheral and central fusion, made more problematic by pixelated images on the illuminated screens of digital devices, play a very crucial role in the development of CVS.

The authors hypothesis is that even small imbalances of the synchronization of peripheral and central tracking as well as uncorrected heterophorias and low accommodation convergence to accommodation ratios can lead to the creation of painful stimuli from the trigeminal nerve to the eyes and head during prolonged computer use. The presence of proprioceptive afferent fibers leading from extraocular muscles to the trigeminal ganglion are well documented (Ruskell, 1983; Atasaver,1992; Weir, 2006). In patients with ocular misalignment, these proprioceptive fibers are constantly stimulated as efforts are made to re-align the eyes during the use of digital devices. This, in turn, leads to symptoms of trigeminal dysphoria with this constant afferent feedback and overstimulation of the trigeminal nerve leading to delivery of the painful stimuli to the head and eyes.

STUDY STRENGTHS AND LIMITATIONS

STRENGTHS

The strength of this study centers on the accuracy and consistency of the data collected, which suggests the effectiveness of contoured prism lenses in treating CVS. The study incorporated a relatively small sample size (n=22) but lost only one patient to follow-up. The composition of the study population (age, gender, CVS-Q index scores) was comparable to existing studies which facilitated comparisons.

LIMITATIONS

The study was a one-arm study, so a direct comparison to existing treatments was not possible to control for concurrent coincidental effects. The study was observational in nature; patients recommended the experience and received their treatments for free. This study was not placebo-controlled nor was it conducted blindly; however, the results of the study are consistent with those of an earlier double-blind, placebo-controlled study using contoured prism lenses to alleviate symptoms in similar patients (Teitlebaum, 2009).

CONCLUSION

Participants in this study were typical computer users who suffered from Computer Vision Syndrome. They represent a large portion of the general population who, on a daily basis, experience symptoms of trigeminal dysphoria. All patients were evaluated using the new neurolens Measurement Device. The device then guides the manufacturing of neurolenses, contoured prism spectacle lenses designed to eliminate the measured imbalance. Patients found to have an imbalance based on evaluation with the neurolens Measurement Device instrument were given spectacles with the recommended prismatic correction. A unique proprietary manufacturing technique allows the power of the prismatic correction to vary from distance to near vision.

Efficacy was evaluated utilizing a validated metric for measuring severity of Computer Vision Syndrome symptoms (CVS-Q), indicated that 22 of the 22 patients (100%) had a positive response to the treatment. The two-sided p-value against the hypothesis of no-effect was highly statistically significant (p-value < 0.01). Based on the findings of this study, the authors of this study believe that this new therapeutic approach for the treatment of CVS should be more widely considered.

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APPENDIX: CVS QUESTIONNAIRE

To be completed by PATIENT:

Indicate whether you experience any of the following symptoms during the time you use the computer at work. For each symptom, mark with an X:

a. First, the frequency, that is, how often the symptom occurs, considering that:
    a. NEVER = the symptom does not occur at all
    b. OCCASIONALLY = sporadic episodes or once a week
    c. OFTEN OR ALWAYS = 2 o4 3 times a week or almost every day
b. Second, the intensity of the symptom:
    a. Remember: if you indicated NEVER for frequency, you should not mark anything for intensity

	a. Frequency			b. Intensity	
	NEVER	OCCASIONALLY	OFTEN OR ALWAYS	MODERATE	INTENSE
1. Burning					
2. Itching					
3. Feeling of a foreign body					
4. Tearing					
5. Excessive blinking					
6. Eye redness					
7. Eye pain					
8. Heavy eyelids					
9. Dryness					
10. Blurred Vision					
11. Double vision					
12. Difficulty focusing for near vision					
13. Increased sensitivity to light					
14. Coloured halos around objects					
15. Feeling that sight is worsening					
16. Headache					

APPENDIX: CVS QUESTIONNAIRE

To be completed by EMPLOYEE
Calculation of TOTAL SCORE. Apply the following expression:

Score = For each symptom, multiply Frequency x Intensity such that:

- Frequency
  - Never = 0
  - Occasionally = 1
  - Often or always = 2
- Intensity
  - Moderate = 1
  - Intense = 2

	a. Frequency	b. Intensity	Frequency x Intensity	RECODE (0=0; 1 or 2 = 1; 4=2)
1. Burning				
2. Itching				
3. Feeling of a foreign body				
4. Tearing				
5. Excessive blinking				
6. Eye redness				
7. Eye pain				
8. Heavy eyelids				
9. Dryness				
10. Blurred Vision				
11. Double vision				
12. Difficulty focusing for near vision				
13. Increased sensitivity to light				
14. Coloured halos around objects				
15. Feeling that sight is worsening				
16. Headache				
		TOTAL		

If the recoded score is ≥6, the patient is considered to suffer Computer Vision Syndrome

- The result of frequency x Intensity should be recoded as: 0=0; 1 or 2 = 1; 4 = 2