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Case Report

Retinal Neuromodulation as a Non-Invasive Assessment and Treatment of Autonomic Function

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Received: December 02, 2017; **Published:** January 24, 2018

Abstract

The retina is a part of brain tissue concurrently receiving signals from extrinsic and intrinsic sources. Stimulation of the 126 million receptors that react to light activates its five main sections. Filtering of those 126 million entering signals, results in only 1.2 million exiting signals. Depending on which receptors are activated, the exiting information differs, inducing various reactions and responses in brain chemistry and body functions.

An emerging subset of optometrists use retinal tolerance to assess and treat neurological function by influencing signaling in both autonomic and central nervous systems. Their customized prescriptions are designed for alteration of biochemical and neurological brain activity, rather than central eyesight on a non-moving target. This case reports two patients who had fainting spells due to positional orthostatic tachycardia syndrome (POTS) each received individualized eyeglasses to synchronize imbalanced incoming visual circuitry. Each patient stopped fainting after receiving the new prescriptions.

Retinal circuitry's effect on body functions suggests that retinal stress tolerance might be a clinical indicator of stability of the balance between central and autonomic nervous system interaction. This furthers the position of the optometric profession to be beneficial as part of a multidisciplinary team.

Classic optometry is thought of as simply sharpening central eyesight and checking for eye health problems. However, the retina is involved with modulation of limbic system and brainstem functions also. Tools include various lenses, prisms and filters, which when combined to balance incoming signals, decrease the stress level of the patients and improve their ability to handle environmental changes.

Neuro-optometric prescriptions designed for brain function, rather than eyesight, might be a next step in management of autonomic function disorders. Each of the two patients described in this case study had 20/20 central eyesight and did not need any glasses in order to see more clearly.

Instead, each did require glasses to stabilize several sensory imbalances, because visual contributions in a vulnerable nervous system should not be ignored.

Keywords: *POTS; Neuro-Optometry; Neuromodulation; Retina; Autonomic Function*

Introduction

Cardiac stress tests provide an informative method of gathering information regarding cardiovascular tolerance. An analogous test measuring retinal tolerance is beneficial in assessment and treatment of neurological function. Research has demonstrated that the retina is comprised of brain tissue and is part of the central nervous system. Retinal circuitry can be used as a conduit into the constant, dynamic interaction involving parallel cortical and subcortical processes. By implication, tests measuring retinal tolerance can be beneficial in assessment and treatment of neurological function. Similarly, retinal stimulation can influence signaling in both autonomic and central nervous systems.

An emerging subset of optometrists is now prescribing customized eyeglasses to alter biochemical and neurological activity. These neuro-optometric methods modify the direction, intensity, amount or wavelength of entering light. Stimulation of three types of photoreceptor groups initiates a cascade of signaling in visual and non-visual retinal pathways. For this reason, it is possible to prescribe customized eyeglasses to alter biochemical and neurological activity.

This report provides two case studies, and an analysis of why the treatments were successful. In both cases, the lenses used were Trivex material. They had a 1.53 refractive index, an Abbe value of 44 (low chromatic aberration), block 100% of UVA and UVB ultraviolet light and transmit 91% of entering light [1].

Two Case Studies

Two patients with positional orthostatic tachycardia syndrome (POTS) had frequent symptoms of fainting spells due to autonomic dysregulation. During the optometric testing, neither blood pressure nor pulse was assessed on these patients. Pupil reactions on each patient were normal, with no afferent pupillary defect present. Each was successfully treated by the use of individualized therapeutic eyeglasses. One pair of lenses angled light, reflexively inducing a shift in head and body position. The other pair was tinted to filter the incoming wavelength of light, stimulating the autonomic nervous system. Both patients stopped fainting when wearing the lenses. One patient's cardiologist no longer needed to install a pacemaker.

The first patient was a 5'6", 112 pound, 17 year old, active female, who had been diagnosed with dysautonomia at age three, and lupus and migraines at age eight. She was taking Plaquenil for Lupus and Concerta for attention problems during school. Visual complaints at her examination included dry eyes, slight decrease in acuity at a distance and headaches at the end of each school day. If she didn't do schoolwork, she didn't have headaches. POTS affected her weekly to the extent that she would pass out at least 4 - 5 times per week when shifting suddenly to a standing position. Due to these episodes, she had a medical history of stitches, cracked teeth and a broken arm. During the initial optometric testing, pupil reactions were normal, with no afferent pupillary defect present. Eye health was normal externally and internally. Central eyesight was 20/20 in each eye. Eye movement control was tested using various neuro-optometric methods. It was determined that her habitual eye position was slightly upward in her left eye and downward with her right. Each time she needed to use her eyes as a team, the left had to pull downward or the right upward, requiring energy and neuromuscular control. By prescribing glasses to slightly angling incoming light one prism diopter in her left eye, she no longer had to expend as much effort in pulling her eyes to the same height in order to synchronize the retinal circuitry. Her tolerance range for fixating on visual targets was enlarged with the new lenses, and she reported that the passing out stopped occurring.

The second patient was a 5' 8", 230 pound, 25 year old, less active female, who was diagnosed at age 13 with chronic fatigue syndrome, fibromyalgia, migraines and POTS, at age 18 with irritable bowel syndrome and at age 22 with mastocytosis. Current medications were Lyrica, Adderall, Pyridost Bro, Florinef, Singulair and Lexapro. She reported syncope episodes 2 - 3 times weekly. Because her diagnoses began during puberty, there is a possibility that her autonomic nervous system was on overload at that time, having trouble adapting to hormonal changes. After an optometric testing battery, assessing ranges of comfort, tolerance and recovery ability in her aiming and focusing systems, it was found that she repeatedly was unable to quickly regain fixation and fusion on a visual target after her gaze was disrupted. Central eyesight was 20/20- eyeglasses did not help her see targets more clearly. As with the first patient, pupillary reactions were normal. Testing included various prisms and tints placed in front of her eyes to determine which was the most favorable in enhancing her adaptability. A slight 10% solid American Optical cruxite tint subjectively felt most comfortable to her. It was prescribed with a small amount of lens power to allow for more efficient figure/ground interaction. She felt more relaxed with full time wear, and at her 4 week check-up, she reported no more fainting episodes.

Discussion

Positional Orthostatic Tachycardia Syndrome (POTS) is a condition where regulation of cerebral blood flow is dysfunctional, and blood vessels constrict rather than expand when more blood plasma volume is required. This deficiency in cerebrovascular autoregulation is often exacerbated when shifting from a seated to a standing position. If blood flow, blood plasma volume and capillary integrity are not automatically synchronized, sudden positional changes sometimes result in palpitations and dizziness, and in some cases, fainting. In other words, a person should be able to maintain normal cerebral blood flow in spite of changing blood pressure, but patients with subtypes of POTS cannot autoregulate [2]. Some proposed mechanisms of POTS involve reduced venous return, reduced cerebral blood flow, reduced plasma volume due to pooling elsewhere, or sympathetic over-activity. Other common theories assume that the vessels themselves, rather than the blood volume, might be the problem with too much blood capacity by altered capillary permeability or stretched veins. Many of the hypothesized mechanisms for POTS involve the autonomic nervous system (ANS), which is affected by exposure to light. Changes in the ANS can be measured by pupil functions in the eye, such as pupil size or eye movement [3].

Although eyeglasses typically are thought of as bending light to strike the macula (producing clear eyesight), ambient light may be selectively harnessed to affect chemical signaling pathways in subcortical non-image forming systems, as well as in classic cortical visual processing systems. Designing eyeglasses to disperse light differently on individual areas of the retina affects both the central and autonomic nervous systems [4]. For instance, when taking medications intended to alter the central nervous system, side effects include double vision; medications that have side effects of blurry eyesight affect the autonomic nervous system. Also, visual fatigue can be affected by tints (Tagami Ohnuma., *et al.* 1984).

Entering light strikes five separate portions of the retina (dorsal, ventral, temporal, nasal and macular). Each section evolves from different groups of transcription factors regulating gene expression [5]. Retinal stimulation activates three types of receptors-cones for central eyesight (to focus on a target), rods for peripheral eyesight (to aim at the background) and ipRGCs (intrinsically photosensitive retinal ganglion cells) for processing of ambient light [6,7]. Approximately 1% of the retinal ganglion cells are melanopsin containing ipRGC types. The other 99% of the ganglion cells don't contain melanopsin. The ipRGC signaling has an independent chemical signaling path from visual (retinoid) cycles found in the cones and rods [8]. This atypical use of eyeglasses leads to more than simply altering central eyesight. Stimulation of three types of photosensitive receptors initiates a cascade of signaling in both visual and non-visual retinal pathways, resulting in measurable shifts in attention and eye movements.

- The cone information travels through the parvocellular pathway and is also filtered by amacrine, bipolar and horizontal cells, eventually leaving the nerve fiber (ganglion cell) layer. The magnocellular and parvocellular blend before leaving the optic nerve, and then again with other sensory signals at the lateral geniculate nucleus (LGN) before heading to structures such as the superior colliculus and visual cortex. At the LGN, there are koniocellular layers which are believed to further link the magnocellular and parvocellular pathways [9,10].

- The rod information travels to the visual cortex for peripheral eyesight. On its way, signals are processed, categorized and converted into pertinent information by a filtering process using various types of amacrine, bipolar and horizontal cells, eventually arriving at the ganglion cells. The rod pathway information that arrives at the melanopsin containing ganglion cells, interacts with the ipRGC information. The combined signals from ipRGC and rod information comprise the magnocellular pathway and exit the ganglion nerve fiber cell layer after mixing with the parvocellular signals via specialized amacrine cells.

- The ipRGC information travels to the hypothalamus and activates chemicals involved in circadian rhythms and general health, and also to other non-visual structures in the brain for non-image forming purposes [4,11]. The number of cells involved in this mechanism is relatively small. Only about 1% of the retinal ganglion cells are melanopsin containing ipRGC types. However, the ipRGC signaling has an independent chemical signaling path from visual (retinoid) cycles found in the cones and rods [8].

Conclusion

Results suggest the possibility that patients with POTS, who cannot be stabilized with medications, may be able to be treated with specialized eyeglasses designed to balance sympathetic and parasympathetic responses with cortical activity. The two patients with POTS described above, provide only one example of neuro-optometric treatments. Neuro-optometry can play a vital role among medical professionals by using measurements of retinal stress tolerated before double vision and blurry eyesight is induced.

The mounting scientific evidence regarding retinal circuitry's effect on body functions suggests that retinal stress tolerance might be a clinical indicator of stability of the balance between central and autonomic nervous system interaction. This furthers the position of the optometric profession to be beneficial as part of a multidisciplinary team.

A device to test retinal stress tolerance could provide a clinical indicator in assessment of brain activity for surgeons and physicians. It would provide a significant amount of useful information regarding patients' tolerance levels to environmental changes. Ranges of visual stress that can be tolerated vary from person to person. Despite this individual variation, measuring tolerance to retinal load using optometric techniques might be a next step in management of autonomic function disorders. The two patients with POTS described above each have demonstrated that visual contributions to syncope in a vulnerable nervous system should not be ignored.

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Volume 9 Issue 2 February 2018