

# Case Report: Successful resolution of four POTS cases using retinal neuromodulation for non-invasive assessment and treatment of autonomic function

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### Abstract

In this report four cases of positional orthostatic tachycardia syndrome (POTS) are discussed. Each was formerly considered intractable. Each patient was assessed with a battery of neuro-developmental optometric tests to determine irregularities in brain-processing of both visual and non-image-forming retinal signals. POTS-relevant retina-brain pathways are discussed relative to both the autonomic and central nervous systems. To treat the syndromes, neuro-optometrically designed eyeglasses were prescribed to alter phototransduction via differential activation of the rod, cone and ipRGC photoreceptor cells to create a cascading effect on POTS-relevant neural pathways in the brain. This neuromodulation mechanism is believed to have restored retinal circuitry balance, along with resulting changes in the autonomic and central nervous system, and is responsible for complete, apparently permanent resolution of syncope in each of the patients. Details of the cases are discussed.

### Introduction

Research has demonstrated that the retina is comprised of brain tissue and is part of the central nervous system (Ehinger, 1982). It arises from brain tissue (Landi, 2009) (Pueyo, 2017). Like the rest of the brain, the retina simultaneously processes concurrent signals from both extrinsic and intrinsic sources. Light stimulates the 120 million+ receptors in each retina (120 million rods, 6

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million cones and a critical 12 thousand ipRGC cells), activating five different main areas of the retina. Filtering of these 120 million+ real-time entering signals results in only 1.2 million exiting feed-forward signals, with up to twenty times more feedback signals exerting real-time control of this dynamic filtering process (Vetter, Smith, & Muckli, 2014). Some of the exiting signals are routed through the limbic system and others routed through the brainstem, where they combine with other sensory inputs. Depending on which receptors are activated, the exiting information differs, inducing a wide spectrum of resulting reactions in both brain chemistry and body functions and subsequent changes in signaling responses.

In the same way that a cardiac stress test can provide information regarding cardiovascular tolerance, retinal “stress” testing—measuring retinal tolerance of a myriad of induced conditions—along with many other kinds of neuro-optometric testing, is beneficial in assessment and treatment of a wide range of neurological conditions.

Because the retina is an integral part of the central nervous system, retinal circuitry can be used as a conduit into the constant, dynamic interactions between—and among—parallel cortical and subcortical processes. Thus neuro-optometric tests measuring retinal tolerance can be beneficial in assessment *and treatment* of neurological function.

Most importantly, retinal *stimulation* can influence signaling in both autonomic and central nervous system (Odermatt, 2007) (Muindi, 2014) (Meltzer, 2017) providing a mode of at least partial remediation for a large number of challenging neurological conditions. An emerging subset of neuroscientists specializing in optometry is now prescribing customized eyeglasses to alter biochemical and neurological activity in increasingly targeted ways. These neuro-optometric methods can precisely modify the direction, intensity and wavelength of light entering the retinas, along with altering the specific areas of the retina that are stimulated. This controlled stimulation of the rods, cones and photosensitive ganglion cells alters phototransduction and initiates a cascade of differential signaling in visual and *non-image-forming* retinal pathways. After precision neuro-optometric testing, it is possible to prescribe customized eyeglasses to alter biochemical and neurological activity in beneficial ways, addressing many previously intractable conditions.

Traditional optometry focuses almost entirely on the 6 percent of the visual field’s retinal processing used to manage central eyesight in a stationary, non-proprioceptive, non-aural, depth-, color- and light-fixed environment. Traditional optometrists are not concerned with brain function. By contrast neuroscientists specializing in optometry focus on the remaining 94 percent of the incoming visual field’s retinal processing—including the complex retinal integration with the auditory and balance systems—and are entirely focused on brain function. For them, the retina is simply another part of the brain.

Retinal circuitry’s effect on body functions suggests that retinal stress tolerance is a good clinical indicator of stability and balance in the interactions between the central and autonomic nervous systems. Therefore, neuroscientists specializing in optometry should be part of a multidisciplinary team when assessing and treating neurological conditions, including specifically those thought to result from both physical and event-based emotional brain trauma. Neuro-developmental optometric 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 respond appropriately to ephemeral environmental changes. Neuro-optometric prescriptions designed for brain function, rather than eyesight, are a crucial step in management of autonomic function disorders.

## Background of the cases

In this report we discuss four case studies of patients who had syncope (fainting spells) due to positional orthostatic tachycardia syndrome (POTS). Traditional POTS treatment typically involves mechanisms like biofeedback, stress management, sleep recommendations and coping skills. Many cases—including the four reported here—have been considered unresolvable and the best a patient can hope for is management of the condition. Prior unsuccessful treatment for the four cases discussed below took place over 14, 12, [3+] years, and 10 months, respectively. However, after receiving their new neuro-optometrically-designed prescription eyeglasses, each of the four patients exhibited substantial resolution of their POTS symptoms, and permanently stopped fainting within a few weeks. Other symptoms also were resolved. For each of the cases we present an analysis of why the neuro-optometric treatment was successful.

During the assessment phase, each of the four patients underwent traditional neuro-optometric “stress” testing using vehicles including—but not limited to—mid-line shift assessment, fixation disparity, phoria analysis, yoked-prism walk, Lang Stereo-test II and Z-bell<sup>SM</sup> non-image-forming retinal pathway assessment. They received individualized eyeglasses to correct imbalances in the circuitry processing and re-synchronize their incoming retinal signals.

Two of the four patients did not need glasses to see—either for reading or normal sight—and their center vision tested at 20/20. The other two patients were easily corrected with nearsighted lenses to 20/20. However, it was determined that each did require neuro-optometric eyeglasses to stabilize a number of troubling sensory imbalances that were placing their neurological systems in states of high vigilance.

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 (Low, Novak, M.Spies, PeterNovak, & W.Petty, 1999) (Low, Sandroni, Joyner, & Shen, 2009). 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 (Chen & Badea, 2011).

In each of the cases the neuromodulating corrective lenses used were Trivex material. They had a 1.53 refractive index, an Abbe value of 44 (low chromatic aberration), blocked 100% of UVA and UVB ultraviolet light and transmitted 91% of entering light (X-Cel Optical).

## Four POTS cases

Four patients who had been previously diagnosed with positional orthostatic tachycardia syndrome (POTS) had frequent symptoms of syncope due to autonomic dysregulation as diagnosed by their physicians. Because of their prior diagnoses, 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.

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.

Relevant complaints at her optometric exam included dry eyes, slight decrease in acuity at a distance and headaches at the end of each school day. She got headaches whenever she did her homework or concentrated intensely. POTS affected her to the extent that she would pass out at least 4 times per week when shifting to a standing position. As a result of these episodes she had a medical history of stitches, cracked teeth and a broken arm. Eye health was normal externally and internally. Eye movement control was tested using standard neuro-optometric testing for pursuits and saccades. The testing included a King-Devick eye movement test (Waddington, 2017), Vergence ranges at distance and near as well as the standard Von Grafe phoria. Her habitual eye position was slightly upward in her left eye and downward in her right. Each time she needed to use her eyes together, the left had to pull downward or the right upward, requiring energy and neuromuscular control. A prescription was designed to slightly angle incoming light one prism diopter in her left eye so that she no longer had to expend as much effort in pulling her eyes to the same height. Using the prism she could easily synchronize the retinal circuitry between the two eyes. Her tolerance range for fixating on visual targets was enlarged with the new lenses. This prescription also immediately induced a noticeable reflexive shift in her head and body position, so that her neck wasn't as tense.

In a follow-up several weeks later, she reported a complete cessation of syncope episodes. Supplemental annual evaluations at one year and two years confirm that the problem is thought to be permanently resolved—after fourteen years of living with the condition.

The second patient was a 5' 8", 230 pound, 25-year-old, less active female. At age 13 she was diagnosed with POTS, chronic fatigue syndrome, fibromyalgia and migraines. At age 18 she was further diagnosed with irritable bowel syndrome, and at age 22 with mastocytosis. Current medications were Lyrica, Adderall, Mestinon, Florinef, Singulair and Lexapro. She reported syncope episodes 2 - 3 times weekly. We might surmise that because the patient's 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, including, specifically, assessing ranges of comfort, tolerance and recovery ability in the patient's aiming and focusing systems, it was found that after her gaze was disrupted there was a significant lag in her ability to regain fixation and fusion on visual targets, despite her 20/20 central vision. As with the first patient, pupillary reactions were normal. Testing for a remedial prescription 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 that dispersed light onto the peripheral portion of the retina for more

efficient figure/ground interaction. This allowed the patient to maintain central attention on a selected target while also continuing to be aware of her surroundings. At her 4-week follow-up the patient reported feeling more relaxed when wearing her glasses throughout the day, and her syncope had been completely resolved. After 6 more months it is assumed that the fainting episodes from the POTS has been completely resolved. Additionally, and anecdotally, it is thought that POTS resolution contributed to her cardiologist's decision to abort plans for installation of a pacemaker.

The third patient was a 5' 6", 125 pound, 20-year-old female who was being monitored at the Mayo Clinic for POTS. She had a history of Lyme Disease and also five concussions from martial arts. She could not tolerate peripheral visual stimuli and had not been able to drive, enter a grocery store (because of unfiltered visual scene overload) or attend school classes. She wore contact lenses to correct her nearsightedness to 20/20 in each eye.

Neurological testing showed that the patient was significantly not able to tolerate movement in her visual field, and habitually aimed her eyes inward.

The patient's contact lenses were kept at the same prescription to address her central eyesight, but she was given two different pairs of glasses to wear on top of the contact lenses for her peripheral eyesight. One prescription was to provide comfort; the other one was designed to push her toward substantial neuro-optometric brain reconfiguration, and while she experienced them as slightly uncomfortable she was able to tolerate wearing them. In addition, for both prescriptions, a slight occlusion foil was placed on the nasal portion of her left lenses to alter the ratio between incoming light striking the central retina and that striking the peripheral retina. The patient was also prescribed two colors of lens filters to use for 15 seconds each, twice per day.

After neuro-optometric treatment the patient now is able to drive, read and go to grocery stores again. Her syncope has been resolved. On her follow-up visit to the Mayo Clinic after wearing her glasses for six months, her physicians were very surprised that she had made so much progress.

The fourth case was a slender 12-year-old farsighted female who had been to eight medical professionals after hitting her head during a fall on a bathroom floor. Previously she had been a happy, thriving, high achieving sixth grader. Yet, within a few days of falling, she began to experience dizziness and weakness. Within three weeks she was unable to read, count past five, put two Lego pieces together, or walk for more than two minutes. During the six-month period of seeing medical professionals her diagnosis changed to ultimately include concussion, severe migraines, POTS and Alice in Wonderland Syndrome (AIWS). Her dysautonomia caused major swings in hemodynamics leading to surges in her pulse to 130 bpm simply from standing up and plunges in her blood pressure to 70's/50's. She was not able to properly perfuse her brain, leading to severe symptoms.

A diary of her daily postural vital signs allowing medical therapy with beta blockade and increased salt intake helped to improve her hemodynamics to more stable ranges. This correlated with some overall improvement, but she remained highly symptomatic and non-functional. Other medical and alternative therapies such as hyperbaric oxygen, chiropractic manipulation, massage therapy, meditation and light therapy were tried, with each providing some brief temporal relief of symptoms, but did nothing to achieve long-lasting resolution of her underlying post concussive syndrome. She consulted with well-respected pediatric specialists in the region, and three vision

specialists, including a neuro-ophthalmologist. However, ten months after her concussion she was still suffering, and had made little progress.

Neuro-developmental optometric testing revealed that she had significant problems with her peripheral processing, and the integration of her peripheral and center vision systems. As in the previous case discussed above, her neuro-optometric prescription was designed to be worn over the contact lenses that corrected for farsightedness. The new lenses were designed to improve peripheral awareness and immediately helped bring her world back into focus. Within hours of getting her glasses, the patient began to return to physical normalcy. As is common with neuro-optometric treatment of peripheral processing difficulties, within the first hour, she stated that things looked “clearer,” (though note that her center vision acuity had not changed). She started to be able to read paragraphs, and within a few weeks, entire pages. Within a month of wearing her glasses, the patient was able to study math again and her physical strength improved dramatically. Her dysautonomia completely stabilized. She has not suffered a single migraine or episode of AIWS since getting her new prescription. Despite missing her entire sixth grade year, she is now a thriving seventh grader—vivacious, hard-working, motivated, and re-building her confidence in the world.

These case results suggest that some POTS patients can be non-invasively treated with specialized eyeglasses designed to balance sympathetic and parasympathetic responses with cortical activity. The vehicle is neuromodulation via retinal stimulation. The four patients with POTS described above, provide only one example of the power of neuro-optometric treatments.

## Discussion

Although eyeglasses typically are thought of as bending light to strike the macula (producing clear eyesight), ambient light in the periphery may also be selectively harnessed to affect chemical signaling pathways in subcortical non-image-forming systems, as well as in classic cortical visual processing systems (Vigh, 2002). Designing eyeglasses to disperse light differently on individual areas of the retina affects both the central and autonomic nervous systems (Chellappa, et al., 2011).

Entering light strikes the distinct dorsal, ventral, temporal, nasal and macular sections of the retina. Each section evolves from different groups of transcription factors regulating gene expression (Tromban-Tink & Barnstable, 2008). 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 intrinsically photosensitive retinal ganglion cells (ipRGCs) for processing of ambient light (Tu, et al., 2006) (Kusakabe, Takimoto, Jin, & Tsuda, 2009).

Cone cell 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 (Szmajda, Grünert, & Martin, 2008) (Cheong, Tailby, Martin, Levitt, & Solomon, 2011).

Rod cell 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.

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 (Chellappa, et al., 2011) (Van Gelder, 2008). The number of cells involved in this mechanism is relatively small. Only about 1% of the retinal ganglion cells are melanopsin containing ipRGC types and the remaining 99% of ganglion cells do not contain melanopsin. However, the ipRGC are critical in that signaling has an independent chemical signaling path from that of the visual (retinoid) cycles found in the cones and rods (Sexton, Buhr, & Van Gelder, 2012).

Within the context of these complex systems, neuro-optometric use of eyeglasses leads to more than simply altering central eyesight. Stimulation of three types of the above-described three photosensitive receptors initiates a cascade of signaling in both visual and non-image-forming retinal pathways, resulting in measurable shifts in attention, posture, proprioceptive awareness, balance, and millisecond-range eye movements, as well as alterations in EEG findings and circadian rhythms and hypothalamic functions.

## Conclusions

Measuring tolerance to retinal load using neuro-developmental optometric techniques is an important next step in management of autonomic function disorders. As one example of this approach, the four patients with POTS described above each have demonstrated that retinal system contributions to syncope in a vulnerable nervous system should not be ignored, and that neuro-developmental optometric techniques provide powerful tools for diagnosis and treatment of such conditions. From a more general perspective, neuro-optometry can play a vital role in medical assessment—if not treatment—of many neurological conditions. Neurodevelopmental optometry provides some of our most powerful tools for assessing and repairing brain function.

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