Neurolens: a comprehensive way to treat Digital (computer) Vision Syndrome

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Background

Using digital devices regularly for prolonged hours is a common theme in today's technologically advanced world, both for personal and professional purposes. This is especially true for young children (~10 hours/day) and adults (~8 hours/day). Most users experience eye strain or related symptoms after using digital devices, commonly referred to as Digital Vision Syndrome (DVS) or digital eye strain (Rosenfield, 2016). It is therefore of the utmost importance that these individuals are provided with an easy-to-use treatment option that alleviates eye strain related symptoms, protects their eyes from harmful radiation and helps them lead a comfortable digital life. One of the commonly reported causes of DVS are the non-strabismic binocular vision disorders (accommodation and vergence disorders). Non-strabismic disorders are traditionally corrected using near adds, special coating lenses (for example, blue light filter lenses), prisms and vision therapy. However, these treatment options have a few limitations. For instance, vision therapy, although effective, does not provide instant relief and is heavily reliant on patient compliance. Most patients with DVS symptoms exhibit different magnitudes of eye misalignment at different viewing distances (Maples et al., 2009). Unfortunately, standard prisms provide a constant correction at different viewing distances and therefore may not be beneficial. Blue light filter coatings, often marketed and prescribed as a treatment option, only protect the eyes from harmful high energy radiation and do not alleviate DVS symptoms (Palavets & Rosenfield, 2019). This is not surprising given that these coatings do not have any impact on the common causes of DVS related symptoms; for instance, eye misalignment. It is also important to remember that digital eye strain due to non-strabismic disorders cannot just be limited to the eyes and is much more complex, involving both binocular and extraocular aspects. Given the near-dominant world we live in, it is increasingly important that clinicians have a comprehensive understanding of the underlying physiology, awareness of the various DVS symptoms, and knowledge of the treatment options that could effectively relieve their patients' symptoms.

Digital Vision Syndrome: Pathophysiology

There is no unified hypothesis as to why uncorrected refractive errors or non-strabismic disorders, such as convergence insufficiency, cause asthenopia-related symptoms. Several theories have been proposed to explain this association. One widely accepted theory is that the strain on the extraocular muscles (EOM) due to eye misalignment overstimulates the trigeminal nerve causing DVS symptoms, clinically referred to as Trigeminal Dysphoria. In this theory, the pathophysiological pathway involved is similar to the one involved in migraines (Digre, 2018). The trigeminal nerve is the fifth cranial nerve which innervates several parts of the face. The nerve has three branches: ophthalmic, maxillary and mandibular. The first two branches are purely sensory, but the third branch is involved in both sensory and motor functions. It has been previously reported that the ophthalmic branch, which supplies the eye and orbit, also supplies a large portion of the dura. This sensory link between the eye and the central nervous system through the trigeminal nerve is thought to be the causal link. The pathophysiology includes an eye misalignment leading to an increased effort by the visual system to realign to avoid double vision and strabismus. This constant effort to realign causes an overstimulation of the trigeminal nerve, which ultimately leads to an irritated nerve. This irritation then results in a painful stimulation of several parts of the eye, head and neck, leading to symptoms such as headache, neck pain and eye strain. The trigeminal 'caudalis' nucleus which relays information between the eyes and the central nervous system extends into the cervical spine in the neck. If the entire trigeminal nucleus is irritated during trigeminal dysphoria, it might explain why problems in the eyes lead to a pain in the neck.

Given the unique cross-linkage between accommodation and vergence, eye misalignments could often be caused due to an altered accommodation behavior. The accommodation system is primarily innervated by the parasympathetic nervous system, particularly the ciliary muscle, which is responsible for accommodation. Previous studies have reported that a dual innervation - meaning both the sympathetic and parasympathetic innervation - is responsible for maintaining the tonic/resting state of accommodation, and any imbalance in this dual innervation leads to an altered accommodation response at near (Bullimore & Gilmartin, 1988; Chen et al., 2003).

This imbalance between the sympathetic and parasympathetic stimulation is another explanation for why disorders in the eyes cause DVS related symptoms such as headaches. Previous studies have reported that increased levels of stress, mental effort or attention lead to enhanced sympathetic and parasympathetic innervation causing an imbalance in the autonomic innervation to the eye. It has been theorized that the increased sympathetic innervation in response to stress or mental effort leads to an overall reduction in the accommodative response at near. This reduced accommodative response leads to a compensatory increase in the parasympathetic innervation to the ciliary muscle, ultimately increasing the accommodative effort. This increased accommodative effort then leads to an eye misalignment because of the increased accommodative-convergence (AC) input. As shown in figure 1, this eye misalignment overstimulates the trigeminal nerve, sending pain impulses to different parts of the face and causing symptoms such as headache, neck pain, etc. Previous studies have reported that an increased load on the ciliary muscle leads to the activation of the trapezius muscle, a large triangular shaped muscle extending over the back of neck and shoulders (Sanchez-Gonzales et al., 2018; Domkin et al., 2019). This activation could explain the association between accommodation disorders and neck/shoulder pain. Other studies have also pointed out that eye misalignments or accommodative (focus) response errors would also lead to postural imbalances that could cause neck and shoulder pain (Sanchez-Gonzales et al., 2019, Ritcher, 2008).

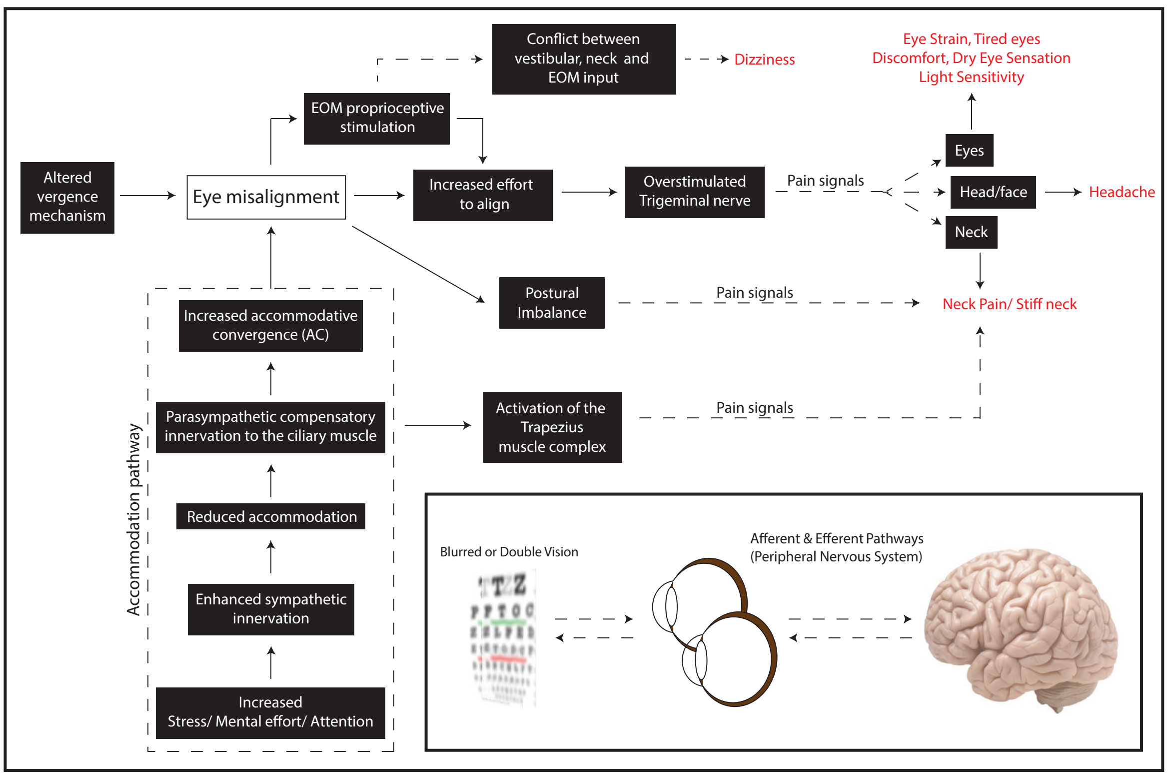

Figure 1: Hypothesized pathophysiological pathway of DVS symptomology related to vergence disorders.

Although the exact function is not totally understood, the sensory receptors of the EOMs provide proprioception (sense of awareness of the position or movement). This afferent proprioceptive signaling provides an extra-retinal signal on the position of the eyes to the visual system (Weir, 2006). As shown in figure 1, this afferent input could signal the visual system about the misalignment, leading to an increased effort to realign ultimately causing an overstimulated trigeminal nerve. When the eyes are misaligned either vertically or horizontally, it might lead to a conflict between the proprioceptive inputs from the vestibular system, neck muscles and the EOMs. This explains why an individual with eye misalignments often experiences symptoms such as nausea and dizziness. The pathophysiology of DVS related symptomology is likely not limited to the eyes and could be much more complex. Therefore, a comprehensive treatment for such a problem cannot be limited to the eyes.

Neurolens

Visible blue light and its impact on the eyes has made blue light protection a popular treatment offered by eye doctors in response to the increased prevalence of symptoms associated with computer and digital device use. Research shows that too much exposure to high energy short wavelength radiation can damage the eyes and skin, and can significantly affect sleep patterns. Increased use of digital devices emitting blue light is thought to increase the risk of blue light induced ocular damage. Accordingly, lenses with coatings that filter blue light have been designed for, and clinicians often prescribe them to, patients with DVS symptoms. As shown in figure 2 (data in blue), recent work shows that these coatings decrease harmful effects of blue light by 10-24% and reduce DVS related symptoms such as eye strain and discomfort in 20-30% of the patients (Leung, 2016).

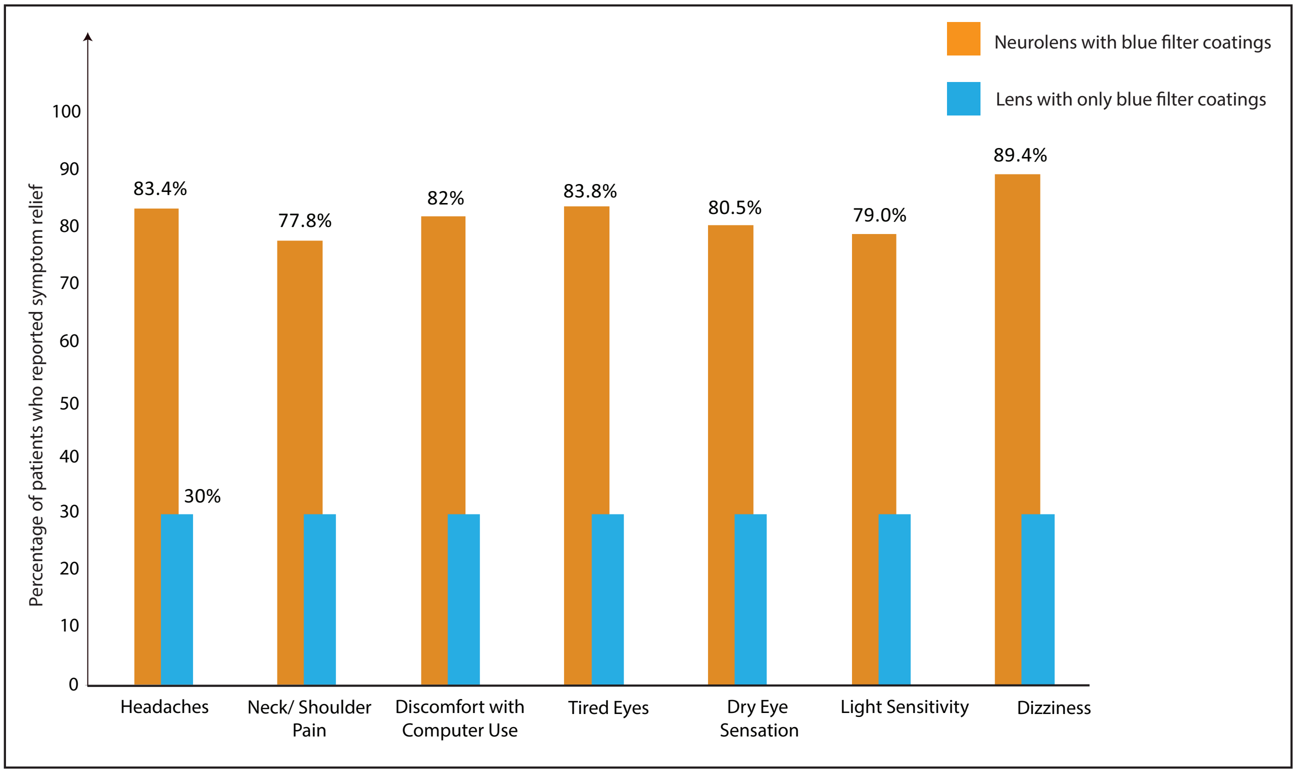

Figure 2: Proportion of patients who benefited post Neurolens wear compared to the symptom relief data on the efficacy of blue light filter coatings (Leung, 2016). Although, Leung's study did not report any symptom relief data on DVS symptoms such as dizziness or light sensitivity, we have taken their highest improvement score with blue lenses for DVS related symptoms such as visual comfort or eye strain and considered it as the baseline for the purpose of data comparison.

Neurolenses paired with blue light filter coating provide a comprehensive treatment in the sense that they not only provide protection from harmful blue light rays damaging the eyes, but also significantly alleviate DVS symptoms by correcting the eye misalignment using a customizable lens design that incorporates a contoured prism. Most patients with DVS symptoms exhibit different magnitudes of eye misalignment at different viewing distances. Unlike standard prisms, Neurolens employs a proprietary lens design that seamlessly varies the prismatic correction provided to the eyes at different distances. This allows clinicians to customize the lens correction for each individual patient depending on both patient needs and the clinical findings. As shown in figure 2 (data in orange), patient survey results post 60-day Neurolens wear collected from individual practitioners across the country show that Neurolenses with blue light filter coatings effectively relieve various DVS symptoms in more than 80% of Neurolens wearers. This is significantly more than what was reported in patients who wore standard lenses with blue light filters (~30%). About 83% of the symptomatic patients feel improvement in their headaches post Neurolens wear. About 78% of Neurolens wearers report improvements in neck pain, and 82-84% feel improvement in their eye tiredness or eye discomfort with computer use, which are commonly reported symptoms after prolonged near digital work. Importantly, 80% of symptomatic patients also reported that they would be willing to recommend Neurolenses to their friends and family.

Conclusion

Most individuals experience eye strain or related symptoms after using digital devices, commonly referred to as Digital Vision Syndrome or digital eye strain. A comprehensive treatment should involve both an option to correct the eye focusing and alignment errors along with an option to reduce the exposure to harmful high energy radiation from digital devices. Neurolenses, with customizable contoured prism and choice of blue light filter options, provide a comprehensive intervention to significantly reduce DVS symptoms associated with digital use. This symptom reduction allows individuals to comfortably navigate through their digital life, making ***digital well-being*** a real possibility.

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