Decoding Binocular Vision

Clinical studies on the neurolens impact to patients and practices

neurolens®
Relief is in Sight
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements

by Vivek Labhishetty (BSc Optometry, MSc, PhD)

Clear and single binocular vision is critical for normal visual behavior. Any inaccuracies in alignment (vergence) would lead to eye deviations which can be broadly classified into three types: heterophoria, fixation disparity, and heterotropia (strabismus). Conditions related to phoria or fixation disparity are clinically referred to as non-strabismic binocular vision disorders.

With about 40-80% of American children and adults reporting one or more Digital Vision Syndrome (DVS) symptoms, it is important to evaluate the binocular vision mechanism in these patients and treat them accordingly. The current testing routine involved for phoria estimations is not ideal and has several sources that could potentially cause errors in estimating the binocular function, including the subjective nature of testing, inter-examiner repeatability and the variability and complexity involved in the tests and procedures. The neurolens Measurement Device, Gen 2 (nMD2) is an accurate, efficient, precise, objective and a simple way to diagnose these patients and provide a treatment option (neurolenses) which can relieve their symptoms.

neurolens®: a comprehensive way to treat digital (computer) vision syndrome

by Vivek Labhishetty (BSc Optometry, MSc, PhD)

Using digital devices regularly for prolonged hours is a common theme in today’s technologically advanced world, and most users experience eye strain or related symptoms after using digital devices, commonly referred to as digital vision syndrome (DVS) or digital eye strain. One of the commonly reported causes of DVS are the non-strabismic binocular vision disorders (accommodation and vergence disorders), which are traditionally corrected using near adds, special coating lenses (for example, blue light filter lenses), prisms and vision therapy. However, these treatment options have limitations. 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. 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.
A Financial Impact Study: Adopting neurolens® Technology

by Gary Lovcik, OD

Competition in the eyecare space is more fierce than ever, and the diversification of a practice is paramount to its overall success. As eyecare providers address more of their patients’ needs and seek to meet those needs more comprehensively, this in turn creates additional revenue streams for the practice. One such opportunity that is particularly critical is addressing a growing base of symptomatic patients resulting from significant reliance on digital device usage in the modern age. Dr. Gary Lovcik of Anaheim Hills Optometric Center adopted neurolens technology in 2016, and grew gross revenue per patient by 18% in year one. Overall, between 2016 and 2020, Dr. Lovcik has realized $498.2K in incremental revenue stemming from sales of neurolenses alone.

Can small prism corrections improve visual comfort? Yes! Here is why

by Vivek Labhishetty (BSc Optometry, MSc, PhD)

One of the common misconceptions with binocular vision disorders is that symptomatic patients tend to only exhibit large eye misalignment coupled with other clinical signs. The evidence actually suggests that the magnitude of clinical signs does not correlate with the severity of the symptomology. For instance, a patient with 1PD exophoria and a patient with 10PD exophoria with no other ocular or extraocular problems related to DVS might experience a similar magnitude of eyestrain and need to be treated appropriately. Subjective and non-repeatable clinical diagnostic tools limit our ability to accurately detect small eye misalignments which cause DVS symptomology. Small horizontal prism corrections (< 1PD) can provide a significant relief in symptomatic patients with DVS.
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements.

Vivek Labhishetty BSc Optometry, MSc, PhD

Background

Clear and single binocular vision is critical for normal visual behavior. Our eyes focus (accommodation) and align (vergence) to the object of interest in the real world thereby maintaining clear and single binocular vision. Any inaccuracies in the alignment would lead to eye deviations which can be broadly classified into three types: heterophoria, fixation disparity and heterotropia (strabismus). Heterophoria is the relative misalignment of the eyes in the absence of fusion. In other words, it is the eye misalignment measured under dissociated conditions. It can be horizontal, vertical, cyclo deviated or any combination of the above and is typically compensated by the eye’s fusional vergence in the presence of fusion. An inability to compensate this eye misalignment would lead to a manifest deviation called heterotropia or strabismus. Fixation disparity, on the other hand, is the relative misalignment of the eyes in the presence of fusion. This deviation is typically less than the Panum’s fusional area therefore objects in space do not appear double. Conditions related to phoria or fixation disparity are clinically referred to as non-strabismic binocular vision disorders.

Traditionally, a diagnostic vision testing routine involves determination of uncorrected refractive errors which are corrected using lenses that provide the best possible vision. However, comprehensive vision care cannot just be limited to the best monocular and binocular visual acuity that can be provided. In the natural world, our eyes work together to focus and align objects to achieve a clear and single binocular vision. Therefore, to provide the best vision care, it is important to also evaluate how well our patient’s eyes work together. This is especially critical in this modern day and age where we see an increasing trend in our near vision demand associated with viewing digital devices including phones, tablets and computers. This increasing near visual demand increases the load on the accommodation and vergence mechanisms to constantly focus and align objects at closer distances. Recent reports show that, on average, American children and adults spend about 7.5 to 9.7 hours/day on digital platforms with about 40-80% of them reporting one or more Digital Vision Syndrome (DVS) symptoms such as tired eyes, eye strain and discomfort or dry eyes (Rosenfield, 2016). Therefore, it is important to evaluate the binocular vision mechanism in these patients and treat them accordingly.

To evaluate the binocular vision mechanism, clinicians measure the magnitude and the direction of the phoria at distance (6m) and near (40cms). Tests such as cover-uncover, Von Graef or modified Thorington are typically used to measure phoria. A comprehensive way to measure binocular vision would include testing the limits (NPA/NPC), amplitudes (NFV/PFV, NRA/PRA), accuracy (phoria/fixation disparity, lag/lead of accommodation) and the dynamics (vergence and accommodation facility) of both accommodation and vergence. Prism bars, flippers, RAF rulers, Maddox rods, retinoscopes and phoropters are employed to obtain this information about these two motor mechanisms. Given the unique cross-coupled behavior of the accommodation and vergence mechanism, another important measure would be to determine the strength of the cross-links between the two systems typically quantified as accommodative vergence response (AC/A ratio) and vergence accommodation response (CA/C ratio). CA/C is not commonly measured in a clinical setting. Individual clinical practices typically measure only phoria and limits (NPA/NPC). If the patient with phoria is symptomatic, treatment options aimed at reducing the phoria are traditionally recommended. Currently, several treatment options including lenses, prisms and vision therapy are available and often prescribed based on the information obtained from the above-mentioned tests (Scheiman & Wick, 2014). Given how important it is to evaluate binocular vision in this digital world, it is crucial that we test this mechanism both comprehensively and accurately; however, the current testing routine involved for phoria estimations is not ideal and has several sources that could potentially cause errors in estimating the binocular function. These sources include the subjective nature of testing, inter-examiner repeatability and the variability and complexity involved in the tests and procedures.
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements.

Sources of Error

Subjective nature of the tests

Most clinical testing routines for evaluating binocular vision are subjective, depending on either the patient’s attentive response or the clinician’s level of expertise. This subjectivity could cause inaccurate estimates of the phoric posture with poor repeatability. Furthermore, given the subjective nature of testing, these tests will not be suitable for testing young children or individuals that are differently abled where it is difficult to obtain an accurate verbal response.

Inter-examiner repeatability

Most clinical tests, given their subjective nature, are dependent on the clinicians’ ability to perform the test accurately. Although several studies have reported that the level of expertise does not lead to clinically significant differences in phoria estimations, these studies do show that the variability in the estimation is larger with novice examiners (Hrynchak et al., 2010). Another potential source for inter-examiner repeatability would be the difference in the neutralization criterion employed by the clinician. For example, when performing subjective prism cover test, some examiners choose the prism value which neutralizes the eye movement as their end point while others choose the prism which creates an opposite movement of the eye or the point of reversal. Given the steps of prism changes seen in a prism bar, this could potentially lead to a variability of about 2-4PD. A study with a small sample also reported that the smallest phoria value that can be detected by clinicians with varying levels of expertise is about 2-3PD (Fogt et al., 2000). This would mean that any misalignments less than this value would not be detected and may potentially lead to inaccuracies. Finally, while performing tests that depend on the placement of prisms, such as prism cover test or fusional vergence testing, the distance between the prism and eye can impact prism effectivity and can lead to spurious or less reliable estimations.

Tests and procedures

Another crucial aspect to consider is what measurements should be used to calculate the prismatic correction that could be prescribed to your patient. Should you decide the prism value based on dissociated phoria, fixation disparity or both? Is one more effective than the other? Although most clinicians in North America typically prescribe prisms based on the dissociated phoria, there is evidence that fixation disparity could be a better predictor and should be employed for estimating the prism value. These studies argue that fixation disparity tests provide a more natural viewing conditions with both eyes viewing similar content which could be fused (Yekta et al., 1989). Others have pointed out that neither of these alignment tests really provide any natural cues with measurements since the subjects view targets in an artificial or abnormal viewing conditions. Previous studies suggested that the practitioners could recommend prisms that make their patients feel most comfortable while viewing objects in real world (Otto et al., 2008). There is also disagreement on effectivity of prism corrections estimated based on either dissociated or associated phoria values (reviewed in Otto et al., 2008).

As mentioned before, several tests including Thorington, cover test and Von Graefe are used to measure phoria. Several studies have reported a significant difference in measured estimates between the tests with a standard deviation of about 4-5PD. One would reasonably expect to see differences between the tests given the difference in the testing procedure, stimuli used, influence of proximal convergence, ability to control accommodation and the nature of subjectivity involved in the test. For example, does the subjective test involve a patient’s response compared to a clinician’s judgement of the deviation? A study looking at the inter-examiner repeatability of different tests reported that only tests such as the Thorington have high inter-examiner repeatability while commonly employed tests such as the Von Graefe have a very low repeatability with differences as large as 3-5PD (Rainey et al., 1998; reviewed in Goss et al., 2010).
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements.

Another important difference that could lead to the lack of repeatability and inaccuracies in the estimate is amount of the time used to dissociate the eyes before taking a measurement. Previous research had reported a dissociation time as long as 5-25 min would be necessary to minimize the influence of vergence adaptation so a more accurate estimate of heterophoria could be obtained (Rosenfield et al., 1997). Unfortunately, this is not possible in a clinical setting and, given the limited ability of an unaided eye to identify and track very small and slow eye motion, it is difficult to say if measurements are indeed obtained after the eye stabilizes in a certain phoric posture under dissociated conditions. This again would potentially cause errors in the estimation. Finally, a major complexity associated with binocular vision testing is that the clinician must typically perform a battery of tests to decide on type and magnitude of the corrective option. This is especially challenging in busy individual practices to invest a significant amount of time into performing a battery of tests to estimate an accurate prism correction that can effectively relieve symptoms.

**neurolens Measurement Device, Gen 2 (nMD2)**

![Image of neurolens Measurement Device, Gen 2](image)

*Figure 1: An illustration of the neurolens Measurement Device, Gen 2. An example data trace of a subject’s left eye (blue) under dissociated conditions. Eye position, in prism diopters (PD), is plotted as a function of time offset. After dissociation, the left eye slowly drifts towards the phoric position. neurolens measurement algorithm measures the phoria position once the dissociated eye stabilizes, defined as the neurolens region of interest (ROI). However, when a clinician subjectively measures phoria or even when a patient subjectively responds, depending on the time of measurement, indicated approximately with red arrows, the amount of phoria value can vary anywhere from 2-7 PD. That is approximately a 5PD variability that can be induced depending on the time of the measurement. This could be one of the potential causes of variability with the traditional clinical methods that measure eye alignment.*

The neurolens Measurement Device, Gen 2 (nMD2) is a diagnostic tool that measures binocular vision. It is an objective, efficient, patient-friendly, accurate, precise and simple way to measure eye alignment along with the inter-pupillary distance and AC/A measurements. The nMD2 does not rely on subjective responses, therefore eliminating both clinician and patients’ biases or variabilities. The objective measuring aspect of the nMD2 is achieved by employing an eye tracking system which robustly tracks patients’ eyes in a continuous fashion while the eyes are dissociated. This allows the system to measure the phoria once the eye stabilizes under dissociated conditions leading at an accurate and repeatable estimate of the phoria (Figure 1). The system can identify phoria smaller than 1PD and can detect changes as small as 0.1PD. An internal clinical study done using three different systems on 15 subjects with and without non-strabismic disorders found that the repeatability of the nMD2 was 0.53PD for distance and 0.86PD for near phoria measurements which is significantly lower than 2.5-5PD reported with the traditional methods such as Von Graefe and Thorington. Furthermore, the examiner’s level of expertise or the patient’s responsiveness do not affect the nMD2 measurements. The nMD2 continuously monitors the eye movement and measures both dissociated phoria and fixation disparity at distance and near. To ensure accurate estimates were obtained and the eye movement data was not corrupted with large eye/head movements, the nMD2 also provides a measurement quality index (MQI) which informs the examiner about the quality of measurement obtained (MQI > 0.7 is considered a good measurement with the eye movement having been neutralized within 0.25PD).
The nMD2 is simple in the sense that it employs an iterative procedure which takes the misalignment measurements into account and provides a final neurolens prism correction (neurolens value), in units of PD, which the clinicians can readily use to treat their patients. Unlike prescribing guidelines like Sheard’s Criterion, Percival’s Rule or the 1:1 rule, the neurolens value utilizes a proprietary algorithm that was developed based on patient outcomes across hundreds of thousands of measurements and outcomes. The nMD2 is efficient in that it finishes the basic binocular vision testing including phoria/fixation disparity and AC/A and provides a neurolens correction value within 180 seconds; and, it can be performed by a clinical technician. Finally, it also provides a visual representation of the patients’ misalignment which can be used to explain the problem causing the symptoms along with the solution being recommended to the patient.

As shown in figure 2, neurolens correction prescribed based on the neurolens prism value has proven very successful delivering a very high level of symptom relief for patients with various DVS related symptoms such as headaches, neck pain, discomfort with computer use, etc. Unlike a regular prism, neurolenses incorporate a contoured prism design which allows clinicians to provide different amounts of prism at distance and near. Overall, approximately 83% of neurolens wearers reported improvement in the typically reported DVS symptoms including discomfort with computer use (82%), tired eyes (83.8%) and headaches (83.4%). After a 60-day wear of neurolenses, prescribed based on the neurolens prism value reported by the nMD2, approximately 80% of the symptomatic patients reported that they are willing to recommend neurolens to their friends and family.

**Conclusion**

An average American spends about 7-10 hours/day on digital devices of which approximately 40-80% individuals experience some sort of DVS related symptoms including headaches, neck pain and tired eyes. Furthermore, individuals with traumatic brain injury (TBI), or post LASIK surgery, or young adults with myopia have also been reported to be strongly associated with non-strabismic disorders. It is therefore critical that these individuals are provided with the best possible comprehensive vision care including an accurate and efficient binocular vision evaluation. The neurolens Measurement Device, Gen 2 (nMD2) is an accurate, efficient, precise, objective and simple way to diagnose these patients and provide a treatment option (neurolenses with contoured prism) that can relieve their symptoms ultimately helping them to lead a symptom-free digital life.
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements.

**Table 1**: Summary of the differences between the traditional subjective methods used to estimate eye misalignment and nMD2.

<table>
<thead>
<tr>
<th>Source of Error</th>
<th>Traditional Methods</th>
<th>nMD2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective nature</td>
<td>Clinicians’ expertise or patient responsiveness</td>
<td>Objective and can be operated by a technician</td>
</tr>
<tr>
<td>Inter-examiner</td>
<td>Variability with clinical expertise</td>
<td>Yes</td>
</tr>
<tr>
<td>repeatability</td>
<td></td>
<td>Yes. Does the examiner choose a prism neutralization that induces no eye movement or opposite eye movement (reversal)?</td>
</tr>
<tr>
<td>Neutralization criterion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy of the end point</td>
<td>Depending on the test (prism bar) employed, can vary between 2-4 PD</td>
<td>Measurement Quality Index (MQI) &gt; 0.7 would indicate that the end point is within 0.25PD</td>
</tr>
<tr>
<td>Smallest phoria that can be identified</td>
<td>~2-3PD</td>
<td>Misalignment less than 0.1PD would be detected</td>
</tr>
<tr>
<td>Prism effectivity</td>
<td>Depending on where the prisms have been placed relative to the patient’s eyes, prism effectivity can be different</td>
<td>Vertex distance is always kept constant</td>
</tr>
<tr>
<td>Tests and Procedures</td>
<td>Should you decide the prism value based on the dissociated phoria, fixation disparity or both?</td>
<td>Clinicians typically use dissociated phoria</td>
</tr>
<tr>
<td>Repeatability</td>
<td>Depending on the test employed, it can be anywhere between 3-5PD</td>
<td>0.53PD for distance and 0.86PD for near measures</td>
</tr>
<tr>
<td>Dissociation time</td>
<td>Variable depending on the test and is limited by the unaided eye’s ability to track very small and slow eye movements</td>
<td>Eye trackers can accurately track the eye during dissociation and association measures</td>
</tr>
</tbody>
</table>

**References**


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 the 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 re-align 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 eyes and the central nervous system extends until the cervical spine in the neck. If the entire trigeminal nucleus is irritated during trigeminal dysphoria, it might explain why problems in eye 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).

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 eye and could be much more complex. Therefore, a comprehensive treatment for such a problem cannot be limited to the eyes.
Visible blue light and its impact on the eye 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).

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.

References


Background

Competition in the eye care space is more fierce than ever, and the diversification of a practice is paramount to its overall success. Just as financial advisors recommend that we diversify our financial portfolios, it is vitally important as eye care providers to offer a charismatic portfolio of unique optical and medical solutions to our patients. As we address more of our patient’s needs and seek to meet those needs more comprehensively, this in turn creates additional revenue streams for the practice. When we begin to address multiple patient needs, we discover even more opportunities to improve their vision and quality of life. One such opportunity that is particularly critical is addressing a growing base of symptomatic patients resulting from our significant reliance on digital device usage in the modern age.

The demands of the digital age mean that patients’ eyes are working harder than ever. Nearly 2/3 of adults experience the painful symptoms of eye misalignment, including chronic headaches, neck pain, eye strain and dry eye sensation; however, only 1/10 adults share these symptoms with their eye care provider\(^1\). With the daily utilization of digital devices accelerating dramatically, management of these symptoms is rapidly becoming both one of the most pressing challenges and immediate opportunities for eye care providers.

Allow me to put this challenge into context. In the United States, approximately 2.7 million people have glaucoma, 24.4 million have cataracts and 4.9 million have dry eye\(^2\). Based on the aforementioned statistic, over 187 million in the United States alone could be suffering from the painful symptoms of eye misalignment. If you are not currently prescribing a lens solution to address this growing symptomology, you are missing out on a truly rewarding avenue for dramatic patient outcomes and practice growth.

Neurolenses are the world’s first and only prescription lenses that incorporate contoured prism into their lens designs in order to bring the eyes into alignment and provide symptom relief, particularly when using digital devices, reading or doing detail work. This paper presents a data-driven economic framework to achieve sustainable growth and financial success based on adopting neurolens technology and optimizing its usage within the practice. This optimization process includes adopting a simple three-step process: identifying symptomatic patients through lifestyle indexing, measuring these patients using the neurolens Measuring Device (nMD) and prescribing neurolenses in order to bring patients’ eyes back into alignment. The findings of this study showcase substantial profitability gains resulting from the successful incorporation of these technologies and processes.

Adoption of neurolens Technology

This study focuses on Anaheim Hills Optometric Center, my clinic for over 30 years in Anaheim Hills, CA. The practice sees approximately 190 patient exams per month. The Anaheim Hills demographic is upper middle class, which is consistent with my clinic’s patient population. Our practice is primarily insurance-based, with 78% of patients paying via managed vision care plans (VSP, EyeMed, MESC, VPA, Davis, etc.) and 2% via Medicare, with the final 20% paying cash.

I have been an early adopter for many technologies, including Optos, OCT, Maculogix and others. I began using the neurolens Measuring Device (nMD) in my pre-screening process in October 2015. This device gives an objective, accurate, repeatable and fast assessment of the patient’s binocular vision. My staff performs the test as part of every patient exam at no cost to the patient.
Utilizing the resulting information to determine a patient’s candidacy, I prescribe neurolenses in order to correct or reduce the patient’s measured misalignment at all distances. With the integration of these tools, my practice routinely solves patient problems we were previously unable to solve, such as headaches, neck pain and eyestrain, among others.

Neurolenses have been a staple product and service in our office since 2015, and this technology has given me the ability as a clinician to address both clarity of vision as well as comfort of vision. When you deliver patients from poor visual clarity, you change their view. When you deliver patients from painful symptoms, you change their life. I have seen the dramatic patient outcomes firsthand, as symptomatic wearers cry tears of joy in my office because neurolenses have provided relief from their daily headaches or eye strain. These dramatic patient outcomes have been a consistent source of encouragement and motivation to me as a practitioner, and are the primary reason I am such a vocal proponent of neurolens technology; however, adopting this technology has also led to dramatic financial outcomes.

Financial Outcomes

Of the many technologies I have adopted in my practice, neurolens technology has resulted in the highest return on investment, or ROI. Since I adopted neurolens technology in September 2015, I have grossed over a half million dollars in incremental revenue attributed to neurolenses alone. As a premium lens solution that creates substantial value for the wearer, neurolenses are sold for a premium and are paid for entirely out of pocket. This is an important distinction to me, as more lives are being captured by 3rd party payers, eroding practice profitability. As a little cog in the wheel, there is very little I can do personally to slow this medical movement; but I can capture additional private pay revenue. When patients are in experiencing pain or ocular fatigue, they are highly motivated to forego using their managed vision care benefits on lenses in favor of a private pay alternative that provides much-sought pain relief. We obviously encourage them to utilize their vision benefits to subsidize their exam and frame, then pay entirely out of pocket for their neurolenses. In fact, I have taken to calling neurolenses the “ray of sunlight between the 3rd party clouds.”

For this study, we compiled and compared the clinic’s annual financial data from 2009 through 2020. Over that time, our number of lens pairs dispensed increased modestly at an average rate of 3% per year (126/month in 2009 vs. 158/month in 2019); to account for this increase, we will discuss financial outcomes on a per patient basis. As an important note, in the time frame observed, no other material changes have been made to my practice; we have not added any other substantial technology, nor have we increased our marketing spend. Based on the trends in the reviewed data, it is clear that the addition of neurolens technology made an immediate and immense financial impact on our clinic.
As an established practice, I generally averaged 3% growth per year pre-2016, right on par with industry norms for that time period. In 2016, my practice’s first full year with neurolens technology, we added 18% to our per patient gross revenue.

Overall, our practice sold 253 pairs of neurolenses in 2016—an average of 21 pairs per month—generating just over $180K of gross revenue. In fact, between October 2015 and December 2019, I have sold almost 900 pairs of neurolenses. Comparing my per-patient profitability of neurolenses versus conventional Single Vision and Progressive designs, I estimate that I have realized $498.2K in incremental revenue in that time period—almost a half million dollars.

While significant gross revenue growth is intriguing, with 80% of my patients on some form of managed vision care plan, I am especially concerned with the money we ultimately collect. Because neurolenses are not covered by any managed vision care plans, the patient pays entirely out of pocket. This private pay acceleration in my practice has caused net income to increase at an even greater rate than gross revenue. In fact, the gap between what we charge and what we collect has closed by 20% between 2015 and 2020, from 68% to 88%. This increase was in stark contrast to the virtual stagnation of this figure from 2009 to 2015. As a fringe benefit, collecting payment straight from the patient saves significant staff time, as we are not submitting information to insurance companies as frequently.

As our clinic now collects a larger portion of what we charge, in our first year with neurolens technology, our net income per patient rose by 31% to $440, compared to $335 in 2015—a $105 net improvement per patient in just one year. Compare that 31% change to the 2% average net growth of the five previous years and it shows very clearly that the financial impact of adding neurolenses as a private pay lens option has been more financially significant than any other change I’ve made in my entire career. My annual net income per patient continues to increase at a rate of 16% per year.

You will notice that there was a similarly sharp acceleration in both gross revenue and net income per patient in 2020. A 23% increase in gross revenue per patient was my largest single-year improvement in over a decade, and a 30% improvement in net income per patient almost matched my high watermark of 31% in 2016. This increase can be attributed to two complementary factors. First and foremost, I was fortunate to hire a new lead optician that became a vocal champion of neurolens technology after receiving training and witnessing firsthand these dramatic patient outcomes. She has elevated the level of engagement of the entire staff. Second, the unique circumstances of 2020 led to me seeing an even higher number of symptomatic patients than usual. Many of my patients were spending hours each day in virtual meetings, and this was greatly exacerbating their eye misalignment symptoms.

When you look at the current state of optometry, two of our biggest challenges as optometrists—dependence on shrinking insurance reimbursement and patients finding alternative retail and online optical solutions—are both mitigated effectively simply by adding neurolens technology. As reimbursement rates from managed vision care plans continue to slide, introducing private pay options for patients can bring substantial income directly to the practice, insulating the practice from the cuts by traditional vision insurance carriers. As patients increasingly shop for their glasses from online retailers (Warby Parker, Zenni) or big box stores (Costco, Walmart), adding neurolens technology is a compelling way to keep patients in private optometry clinics. Neurolens technology is only available to independent optometrists and requires the patient to be in-clinic for the test to be performed.

Better for Doctors, Better for Patients

The addition of neurolens technology has not only increased the financial returns of my practice; this new treatment option has also improved office morale, as our patients are healthier, happier and more appreciative than ever. In the five years since I have adopted this technology, I’ve had exponentially more patients cry tears of joy in the exam chair than I’ve had in my previous 30 years of practicing optometry. These solutions have become routine in my clinic: of the over 1,000 patients we have fit in neurolenses, over 92% have experienced symptom relief. As a doctor, helping patients medically via this simple optical solution has literally rejuvenated my desire to practice optometry, and has motivated me to become even better in my chosen profession. I am paying increased attention to my patients’ health as well as their vision, which undoubtedly makes me a better provider of overall patient care.
Neurolens technology gives optometrists an opportunity to address needs that have never been addressed before in eye care, but also in other areas of medicine. Problems like headaches and neck tension routinely go unsolved by neurologists, chiropractors and other medical professionals. Over the course of an optometrist’s career, the daily practice of optometry can sometimes get a little stagnant, doing the same things over and over again for years; however, since adopting neurolens technology in my practice, we have been able to address even some of the most severely-symptomatic patients, making each day as an optometrist a fresh and worthy challenge that I wake up looking forward to.

**Conclusion**

If you’re considering adopting neurolens technology in your practice, prepare for one of the most rewarding practice enhancements you’ve ever made. With patients willing to pay more for better outcomes, offering neurolenses as a private-pay treatment option is an addition that’s greatly benefited my practice financially, driving up net income by over 31% in our first year with the technology, with continued growth each subsequent year. By providing a tool to tackle medical problems previously considered outside my scope of practice, neurolens technology has made me a better doctor, while also making daily life as an optometrist more gratifying and enjoyable. Most importantly, the addition of neurolens technology has led to better outcomes for my patients. Whether they’re suffering from chronic headaches, neck pain, eye strain or dry eye sensation, neurolens technology has greatly enhanced my ability to care for the people who entrust their vision and overall wellness to my care. I simply would not want to practice without it.
Can small prism corrections improve visual comfort? Yes! Here is why.

Vivek Labhishetty BSc Optometry, MSc, PhD

Background

DVS is an emerging public health concern where individuals experience a wide range of symptoms including headaches, eye strain, dry eye sensation and neck pain while navigating through their digital lives. Predictably, a growing trend in digital usage in the modern age has led to a steep acceleration of associated DVS symptomology (Rosenfield, 2016); therefore, it is critical to understand, measure and treat this problem appropriately. DVS could be caused by both ocular and extraocular anomalies. While ocular anomalies include uncorrected refractive errors, eye misalignments or dry eyes, extraocular anomalies include muscle strains due to compensating postural changes. Uncorrected refractive errors are typically corrected using prescription lenses, dry eyes are treated with therapeutics, and compensating postural habits are corrected by employing occupational therapy or better ergonomic habits.

An often-overlooked cause of DVS related symptomology is binocular vision disorders (BVD); for example, convergence insufficiency, where the patient typically presents with an eye misalignment (large exophoria at near compared to distance) coupled with other clinical signs such as reduction in near point of convergence (NPC). Typical treatment options for BVD involve prescription lenses, prisms or vision therapy (Scheiman et al., 2008). Lenses—especially plus lenses—are not commonly employed and are reserved for patients with heterophoria associated with a high AC/A. Prescription prism glasses, with horizontal and vertical relieving prisms, are offered to either patients with large phoria or in conjunction with vision therapy. The prism value prescribed is often based on fixation disparity analysis, Sheard’s criterion or Percival’s criterion. These glasses provide a constant prism correction to patients at all distances even though patients often present with varying amounts of misalignment at different distances.

Vision therapy is another commonly employed option for treating eye misalignment. The time course of the therapy and the treatment modality are decided based on the clinical (optometric) findings. The therapy, however, does not provide instant relief and is heavily reliant on the compliance of the patient over an extensive time course. Clinicians typically prescribe these treatment options only to symptomatic patients with large phoria. Clinicians tend to overlook patients with a smaller phoria and instead look for other causes for DVS.

There are several reasons why symptomatic patients with smaller phoria are not prescribed prisms or other corrective modalities to treat eye misalignments. One of the primary reasons is the inability to accurately measure smaller eye misalignments. As a result, only patients with a larger phoric posture are diagnosed and treated while individuals who could benefit from small prismatic corrections (less than 2PD) are overlooked. Clinicians have been testing phorias and fixation disparity subjectively for almost a century now, but it has been virtually impossible to accurately test prism in small increments of 0.10 PD for patients until the advent of the neurolens Measurement Device (nMD) in 2018. There is a need to recognize the functionality and application of small prism correction. This paper will demonstrate how prescribing small amounts of horizontal prism (less than 2PD) can relieve symptoms commonly related to DVS. So, what do we know about the relationship between small eye misalignments and DVS symptoms?

Eye Misalignment and the Severity of Symptomology

One of the common misconceptions with binocular vision disorders is that symptomatic patients tend to exhibit large phoria or fixation disparity coupled with other clinical signs. The assumption is that these large eye misalignments reflect a breakdown of the binocular vision system, especially the accommodation (focusing) and vergence (aligning) mechanisms. However, several studies have consistently reported evidence contrary to this belief.
Can small prism corrections improve visual comfort? Yes! Here is why.

For example, data from the Convergence Insufficiency Treatment Trial (CITT) study from 221 subjects showed no correlation between the amount of exophoria and the severity of the symptoms of their patients (Bade et al., 2013). The Convergence Insufficiency Symptom Survey (CISS) score was also not correlated with the severity of the clinical signs such as near point of convergence (NPC) or positive fusional vergence limits (PFV). Simply put, the evidence suggests that the magnitude of clinical signs does not correlate with the severity of the symptomology. For instance, a patient with 1PD exophoria and a patient with 10PD exophoria with no other ocular or extraocular problems related to DVS might experience a similar magnitude of eyestrain and need to be treated appropriately.

**Diagnostic tools**

Traditionally, eye alignment, i.e., phoria, tropia, or fixation disparity, is typically measured using clinical techniques that are subjective in nature. This results in poor repeatability, limiting a clinician’s ability to measure small eye deviations accurately. Patient attentiveness or the clinician’s level of expertise (Hrynchak et al., 2010) also affect the accuracy and repeatability of the test. For example, a previous study reported that the smallest phoria value that can be detected by clinicians with varying levels of expertise is about 2-3PD (Fogt et al., 2000). This would mean that any smaller misalignments may not be detected at all using traditional methods. The ability to track small and slow dissociated eye movements is also limited with the naked human eye. This introduces discrepancy in the dissociation time, ultimately affecting the accuracy of the misalignment estimation. A previous white paper provides insight into all the possible factors affecting the accuracy and repeatability of phoria/fixation disparity measurements. Simply put, the subjective nature of the procedures limit clinicians’ ability to accurately measure small eye misalignments. This would explain why there is no concrete literature on the impact of small eye misalignments on the subjective visual comfort and the benefit of correcting them.

**Trigeminal dysphoria**

DVS may not just be limited to the eye and could be much more complex, as this white paper posits in detail. Although the exact mechanism is unclear, the hypothetical pathophysiology suggests that eye misalignment leads to increased effort by the visual system to re-align 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 sensory irritation then results in painful stimulation of several parts of the eye, head and neck, leading to symptoms such as headache, neck pain and eye strain. Therefore, even small prismatic corrections of the misalignment could reduce the overstimulation of the trigeminal nerve and relieve patient’s symptoms, ultimately improving their visual comfort.

**neurolens: A Better Way to Diagnose and Treat Eye Misalignment**

![Figure 1: Contoured neurolens design and the neurolens measurement device, or nMD (inset).](image-url)
Can small prism corrections improve visual comfort? Yes! Here is why.

**neurolens Measurement Device (nMD)**

The nMD is an objective, accurate, precise, simple and efficient way to measure eye alignment and calculate a patient’s AC/A. The nMD does not rely on subjective responses, therefore eliminating both clinician and patients’ biases or variabilities. The objective measuring aspect of the nMD is achieved by employing an eye tracking system that robustly tracks patients’ eyes in a continuous fashion while the eyes are being dissociated and associated. The system can identify phoria smaller than 1PD and can detect changes as small as 0.1PD. The repeatability of the nMD is 0.53PD for distance and 0.86PD for near phoria measurements, which is significantly lower. This is better than 2.5-5PD reported with the traditional methods such as Von Graefe and modified Thorington (Goss et al., 2010). The nMD is simple in the sense that it employs an iterative procedure, which takes the misalignment measurements into account and provides a final neurolens prism correction (neurolens value). Unlike prescribing guidelines such as Sheard’s Criterion, Percival’s Rule or the 1:1 rule, the neurolens value utilizes a proprietary algorithm that was developed based on patient outcomes across hundreds of thousands of measurements and outcomes.

**neurolenses**

The neurolens value obtained by the nMD is used to prescribe neurolenses, which provide a proprietary contoured lens design, as shown in Figure 1. This technology seamlessly varies the prismatic correction provided to the eyes at different distances, allowing clinicians to customize the lens correction for each individual patient depending on both patient needs and their clinical findings. The nMD provides a neurolens value at the end of the measurement which corresponds to the distance prism prescription of the patient. Clinicians can readily use this value as a guideline to treat their patients. Unlike a standard prism, the neurolens contoured prism design allows clinicians to treat their patients with a distance prism correction and additional correction at near.

**Do small neurolens prism corrections provide any benefit?**

![Figure 2: Proportion of patients who reported improvement in symptoms post wearing less than 1PD neurolens correction.](image)

Across multiple clinical practices, neurolens prism corrections of 1PD and 2PD prescribed based on the neurolens value have proven very successful in delivering a very high level of symptom relief for patients with various DVS related symptoms, such as headaches, neck pain or discomfort with computer use (Lifestyle Index Survey). Patient survey results post 60-day neurolens wear were collected from individual practitioners across the country.
Overall, with a prism correction less than or equal to 1PD, 84% of the symptomatic patients reported improvement in their headaches post 60-day neurolens wear. About 76% of neurolens wearers reported improvements in neck pain, and 81% felt improvement in their eye tiredness or eye discomfort with computer use, commonly reported symptoms after prolonged near digital work. Similar symptom score improvements were found with both base in and base out corrections (Figure 2). Also observed were the symptom score improvements with a prism correction less than or equal to 2PD. With a 2PD neurolens correction, 86% of the symptomatic patients reported improvement in their headaches post neurolens wear. About 77% of neurolens wearers reported improvement in neck pain, and 80% reported improvement in eye tiredness and 83% reported improvement in eye discomfort with computer use.

Conclusion

Eye misalignments are one of common causes of DVS related symptomology. There is a common misconception that only patients with large phorias or fixation disparity associated with other clinical signs suffer from visual discomfort. However, there is abundant evidence that there is no correlation between the magnitude of phoria and severity of the symptomology. Commercial data collected by neurolens clearly shows that patients who received small amounts of prism correction reported significant improvements in their DVS symptoms such as headaches, eyestrain or fatigue. The neurolens Measurement Device (nMD) and neurolenses, with customizable contoured prism design, provide a comprehensive way to accurately diagnose and treat Digital Vision Syndrome (DVS), allowing patients to lead a comfortable digital life.

References


“neurolenses helped improve my eyesight, my eyes don’t feel tired or strained and I don’t experience headaches from the strain on my eyes anymore.”

– Sam Smith, neurolens Patient
If you have any questions about neurolens, please contact us

1-888-236-2219
accountmanagement@neurolenses.com