Article • Prescribing Prism for Aniseikonia: A Case Report and Review

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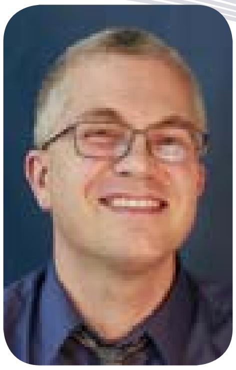

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ABSTRACT

Background:

Subjective: A 62-year-old male first reported to our clinic with a chief concern of a larger image size in the left eye. There was a history of blunt trauma to the right nasal canthus almost 40 years previously. The patient reported that he was generally healthy with a history of hay fever or the use of nasal spray.

Objective: Refraction showed low compound hyperopic astigmatism with absolute presbyopia. Over five visits in a three-year period, 12^{Δ} esophoria was measured at far using associated methods. Without prismatic correction, a 6% image size difference OS was found.

Optical coherence tomography (OCT) of the anterior segment showed central corneal thickness of 524 microns OD and OS, and OCT of the macula showed increased central thickness OS. Additional case history revealed the use of a steroid nasal spray in the left nostril only for the past two decades. His highest recorded blood pressure was 155/85. Intraocular pressure was measured at 11 mm Hg OD and 24 mm Hg OS.

Assessment: The patient was diagnosed with divergence insufficiency, possibly secondary to abducens (CN VI) partial paresis, ocular hypertension OS, and central serous retinopathy OS secondary to systemic hypertension.

Plan: The patient was prescribed 6^{Δ} BO prism OD and OS (for a total of 12^{Δ} BO). This prescription eliminated his aniseikonia without the need for a size lens. He was advised to discontinue the nasal spray and was prescribed latanoprost 0.005% QHS OS. The patient was advised that controlling hypertension might resolve the central serous retinopathy and aniseikonia and might change his need for prism.

Keywords: aniseikonia, Haase method, ophthalmic prism, Panum's fusional area, Percival's criterion, Sheard's criterion, vergence disorders

Case Report: Prism Prescribing

This case describes a patient who presented with aniseikonia despite having no significant anisometropia or ocular surgeries. The case was complicated by systemic and ocular hypertension and epiretinal membrane, likely the cause of the aniseikonia. As the patient was essentially an emmetropic presbyope, he presented some practical difficulties in prescribing iseikonic (size) lenses, but luckily, he did respond to ophthalmic prism.

First Visit

A 62-year-old Caucasian male presented to the Visual Performance 3D Clinic as a result of a referral from primary eye care with a chief complaint of moderate asthenopia at far. While he reported that his vision was "not quite double," he was experiencing a left-eye image that was "larger and closer" than the right-eye image. The patient reported that he was in generally good health and was free of ocular or systemic disease. He was using medications for benign prostate hypertrophy, a nasal spray, and occasional Opcon A, an over-the-counter topical vasoconstrictor for the eyes.

Entering visual acuities with correction were 20/25+1 OD and 20/20-1 OS. Other entrance skills were unremarkable expect for a slight esophoria on cover testing at far. The following was the subjective refraction, which was approximately 0.50 D more hyperopic than the habitual prescription:

OD: +0.25 -0.75 x 093 Add +2.00 20/20-1
OS: +0.25 -0.75 x 112 Add +2.00 20/20-2

Binocularly, the patient still experienced asthenopia. Since the expected binocular summation, or improved visual acuity OU, was not present, and esophoria was present at far, the patient was given forced-choice base-out prism to best visual acuity and comfort using a digital phoropter (Nidek/Marco). The starting point was base-out, as there was distance esophoria. Using an entirely subjective technique, 3^{Δ} base-out total prism was found to optimize patient comfort and acuity at far and was well tolerated at near. As base-out prism decreases the perceived binocular image size, it was prescribed to address the chief complaint and split between the eyes. No dilated eye exam was performed as the patient's eyes were dilated at the referring doctor's office.

Second Visit

A year and a half later, the patient returned with the continued complaint of a larger image OS, even with the base-out prism glasses. The patient said that the severity was now six out of ten. A complete dilated eye exam was thus performed at this visit to better determine the cause of the problem. Changes in health history included the diagnosis of systemic hypertension, which was being treated with Losartan, a thiazide diuretic.

The patient recalled additional case history involving a blunt injury with a stick poking one nasal canthus as a 12-year-old child. The patient remembered this happening on the right side, but considering the 50 intervening years, he could not be certain. Thus, there was the possibility of old commotio retinae and/or angle recession to the injured eye. However, according to the patient, his binocular vision problems were recent.

The patient showed an increased associated esophoria, measured with a forced-choice prism test with new circularly polarized targets to best acuity and comfort, at 9^{Δ} base out. This apparent increase in prism concerned us enough to warrant further testing. Subjective refraction at this second visit yielded a slightly more hyperopic prescription than the previous visit, with a 6% aniseikonia (smaller image OD), as measured with aniseikonic lenses and a dichoptic square bracket aniseikonia target on the AOC Polar chart.

OD: +0.50 -0.75 x 095 4.50^{Δ} BO Add +2.25
6% size magnifier
OS: +0.75 -0.75 x 110 4.50^{Δ} BO Add +2.25
20/20-1 OU

This spectacle prescription was released to the patient to be filled at an outside dispensary.

Eye health was checked for the first time at this visit. It was remarkable for slightly elevated IOP, which was 21 mm Hg OD and 23 mm Hg OS at 2:40 PM, which became even more asymmetric at 18 mm Hg OD and 24 mm Hg OS on repeated Goldmann applanation tonometry. Incidentally, systolic blood pressure was found to be uncontrolled at 155/85 RAS with a body mass index (BMI) of about 31, at the lower end of the obese range, though not morbidly so.

Optic nerve evaluation showed slightly asymmetric optic cupping of 0.5/0.5 OD and 0.65/0.60 OS, as shown with optical coherence tomography of the optic nerve head (ONH OCT). As structure determines function, a screening visual field with the Humphrey Matrix N-30-5 visual field showed no defects, which allayed our fears some concerning the apparent increase in distance esophoria.

Follow-up was scheduled in six weeks for threshold visual field, as well as to determine the stability and cause of the additional prism.

Third Visit

The patient returned in three months. He had not been successful in getting new eyeglasses, as there was difficulty in finding an optical lab with knowledge of how to make a size lens. He wished to find a simpler prescription only using prism that could neutralize the larger image size he still experienced OS.

After significant discussion, a demonstration of contact lens correction was performed. However, likely because there was no significant anisometropia, the contact lenses did not diminish the aniseikonia that this patient was experiencing. A reverse contact lens telescope was attempted in order to magnify the retinal image OD, using the Galilean principle of an overpowered minus-lens soft contact lens serving as an eyepiece and a cancelling plus spectacle lens in front. This was somewhat successful in-office, and trial contact lenses were sent home with the patient to practice application and removal, with the plan to prescribe the over-refraction in spectacle form if it was successful at home.

The concern of the patient being a glaucoma suspect remained. IOP via Goldmann applanation was OD 19, 19 mm Hg and OS 24, 26 mm Hg. Anterior segment OCT was performed to ensure that the anterior chamber angles were open. Anterior segment OCT was also used to measure central corneal thickness. The results were just below average corneal thickness

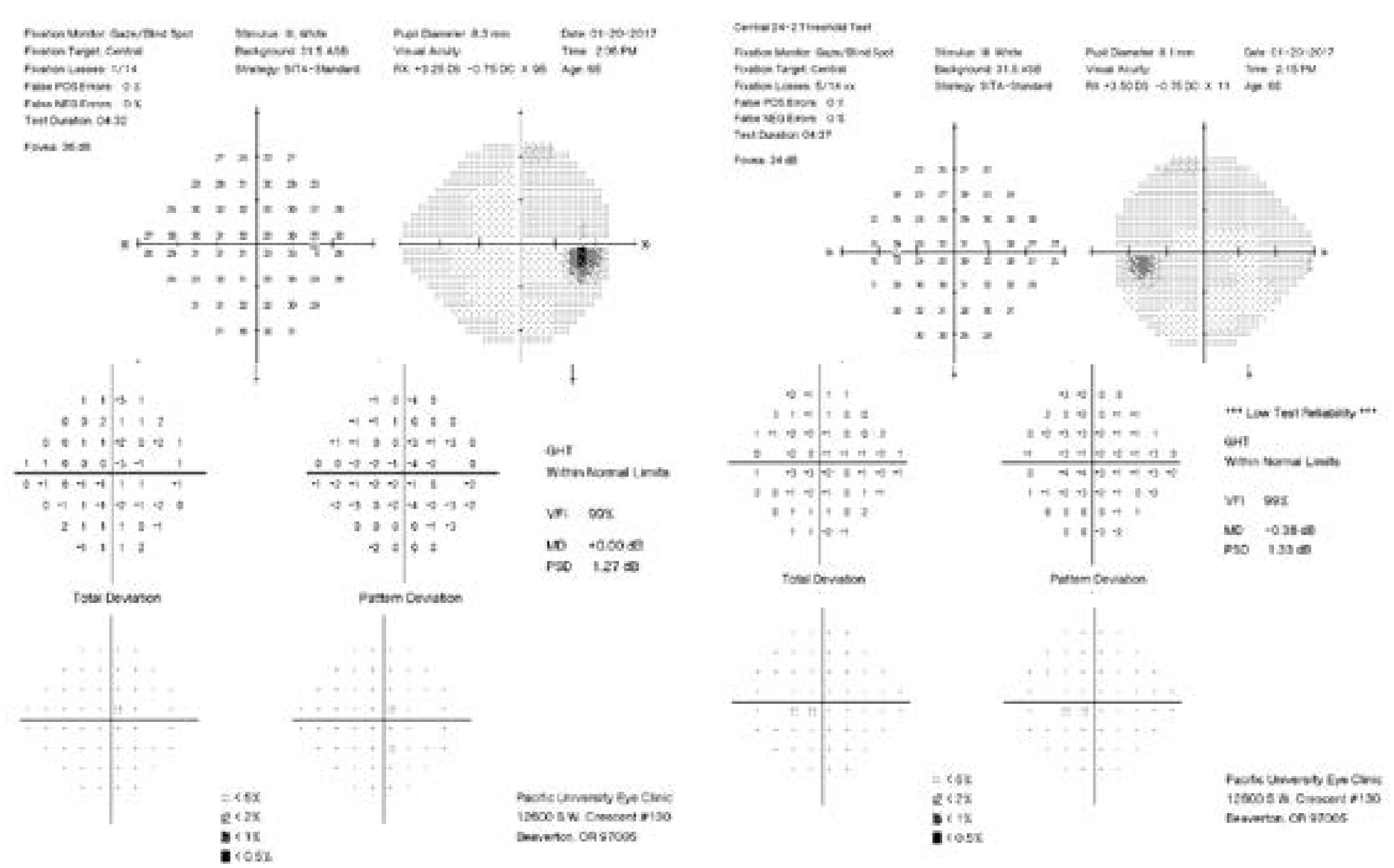

Figure 1. *24-2 SITA standard threshold visual field OS (left) and OD (right)*

of about 550 microns OU, which does not explain the IOP difference OD < OS. Function was also evaluated, this time with a 24-2 SITA standard visual field, in order to rule out glaucomatous damage. The results are shown in Figure 1. Although no glaucomatous visual field loss was seen, visual field loss would be considered a later sign of glaucoma. Based on the elevated IOP, however, we decided to treat the patient and prescribed latanoprost 0.05% for use 1 gtt QHS OS with a target pressure of 18 mm Hg OS. It is known that with monocular glaucoma medication, there will generally be some reduction in the IOP in the fellow eye through systemic absorption of the medication. Despite this, the medication was prescribed OS only because the IOP was so asymmetric, perhaps due to the childhood injury causing angle recession, aniseikonia, and perhaps even CN VI damage OS. The patient was also recommended the over-the-counter antihistamine Alaway (ketotifen) for use BID OU for itchy eyes. The patient was asked to return in 1 month for follow-up.

Fourth Visit

At this penultimate visit, the patient gleefully reported a discovery that he had made. He revealed he had been using a steroid nasal spray in only his left nostril for the past 20 years. He had discontinued this medication two weeks previously and had in addition used the first 2.5 mL bottle of latanoprost OS. He was eager to see how his IOP had changed OS. He had also decided not to pursue contact lens correction further but was willing to try prism eyeglasses of any power that helped him to avoid the use of a hard-to-find aniseikonic size lens.

At this visit, the patient's intraocular pressure had equalized at 14 mm Hg OD and OS at the same time of day (afternoon) as previous visits. This was good news but also seemed to disprove the theory that longstanding blunt trauma OS resulted in the aniseikonia and possible subclinical CN VI partial paresis OS, consistent with the distance esophoria seen at the first visit. Therefore, another OCT scan was ordered, this time of the macula (Figure 2).

These scans confirmed central serous retinopathy OS, likely secondary to systemic (not ocular) hypertension. The patient was educated about controlling his blood pressure to possibly reverse this condition, and his ophthalmologist and primary care doctors were informed. This left his visual complaint to be treated in the meantime.

Using forced-choice prism on the digital phoropter and circularly polarized fixation disparity (Haase)

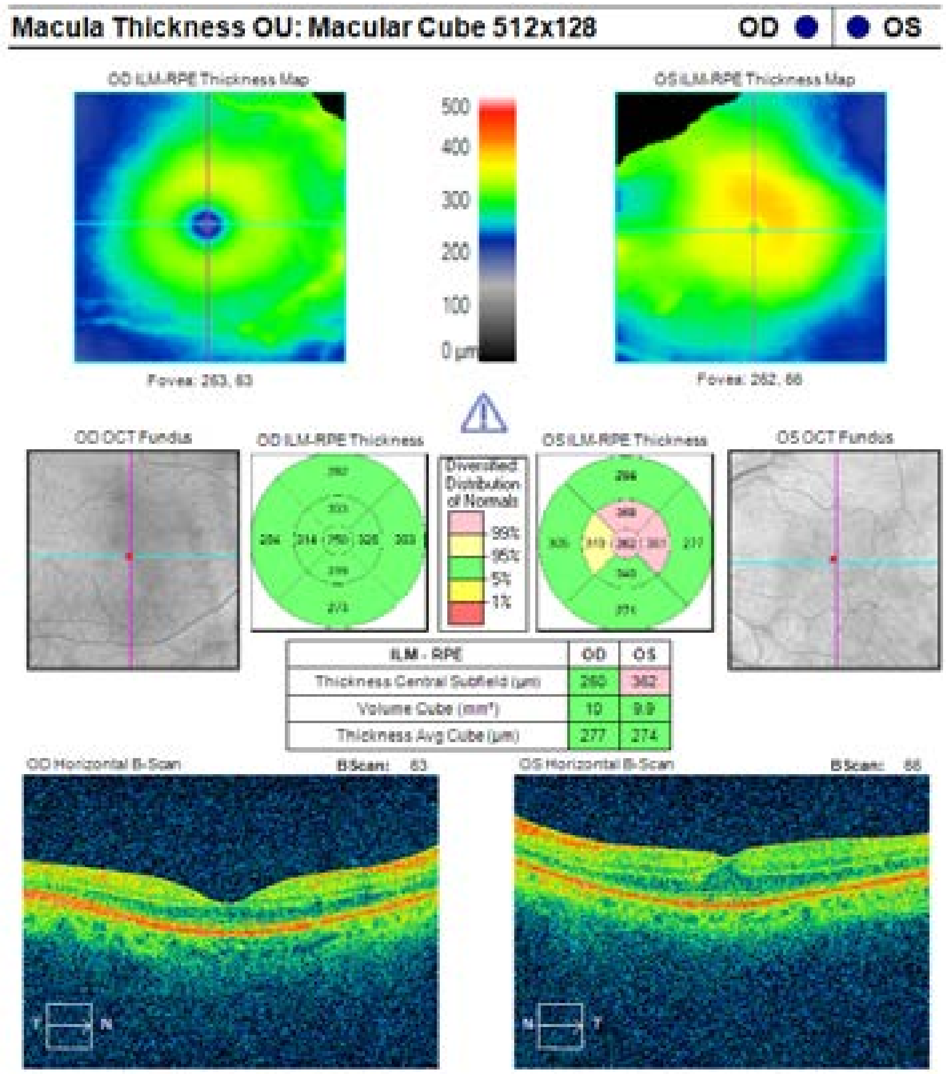

Figure 2. *Macular OCT at fourth visit*

targets, detailed below, it was discovered that 12$^{\Delta}$ base-out prism was able to minify the enlarged image in primary gaze at near and far. This was likely due to the minification effect that base-out prism causes through the SILO effect. This amount of prism also improved the visual acuity and comfort and was well tolerated at near without additional size lens adjustments, although it did work best in a single-vision prescription with some head turning for secondary gaze. The final prescription written in April of 2017 was:

OD: +0.25 -0.75 x 094 6.00$^{\Delta}$ BO Add +2.50 20/20
OS: +0.50 -0.75 x 124 6.00$^{\Delta}$ BO Add +2.50 20/20

This spectacle prescription was released, and the patient was asked to return in two months and to continue a renewed prescription of latanoprost 1 gtt QHS OS until that time.

Fifth Visit

The patient returned for a final short follow-up visit two months later. His IOP had stabilized at 12 mm Hg OD and 18 mm Hg OS. He was asymptomatic with his 12$^{\Delta}$ base-out prism spectacles. Although it may be entirely unrelated in the end, his macular OCT did not appear to improve over this short timeframe.

The patient was released to be seen again in six months at his annual exam unless he noticed changes in his vision sooner. He would continue to be monitored for partial paresis of the abducens (CN VI) nerve, although even with neuroimaging, this remains as difficult to prove as to disprove. If a partial CN VI paresis is present, the lack of visual field defects, along with uncongested optic nerves, reassures us that there is no ominous cause. In the meantime, the patient was educated to self-monitor for neurological symptoms such as headaches and increasing diplopia.

Educator's Guide: Prism Prescribing

Introduction

Ophthalmic prism is commonly used to address patients with constant diplopia due to acquired strabismus,[1] yet not all patients who have ocular misalignment complain of frank diplopia. Other symptoms include impaired visual acuity or binocular blur. These patients may present immediately after refraction with best-corrected visual acuity of 20/20 OD and OS but worse visual acuity (say 20/25) OU. This is due to the visual axes crossing within Panum's fusional area but off the horopter, which commands the zone of best binocularity.

Most optometrists are familiar with binocular summation, or the 1.4x increase in best-corrected visual acuity expected with both eyes open. While some patients do not show binocular summation, a few symptomatic ones show what might be called binocular subtraction – that is, the loss of visual acuity under binocular compared to monocular conditions. This so-called binocular blur can be explained if the patient is at the edge of Panum's fusional area. This is no different than what we teach our students about the principle of "blur before break": that is, that loss of clarity happens before diplopia does.

Relatively good numbers exist regarding the prevalence of common binocular conditions, such as convergence insufficiency and excess.[2] Without distance as well as near cover testing, basic deviations (those that measure close to the same deviation at near as at far) can be mistaken for convergence problems and thus are less well-studied. In addition, associated (such as fixation disparity) measurements may diagnose a patient with a different case type than more-common dissociated measurements. Ocular deviations may be indistinguishable from subtle, sometimes congenital nerve palsies (partial paresis) of the cranial nerves that control the extraocular muscles (CN III, IV, and VI). An example is divergence insufficiency, which is commonly caused by abducens nerve (CN VI) partial paresis.[3] Similarly, convergence insufficiency can be caused by very mild oculomotor (CN III) partial paresis.

While vision therapy (VT) remains a treatment option for patients with symptomatic vergence problems, not all of the patients with access will opt for active therapy. Due to limited time, money, or motivation, not all patients are VT candidates. Also, not all binocular vision diagnoses are equally responsive to VT. Judiciously-prescribed prism is a first-line treatment for a number of binocular vision disorders in these patients. This is true even for patients with convergence insufficiency, especially for those older than children, who would have a traditional treatment of VT.[4]

A study of the best practices in prism prescribing would be incomplete without a performance measure. The most sensitive measure of vergence misalignment is threshold stereopsis. Threshold stereopsis (global to 12.5" or less) can best be used as a performance measure for prism prescription in symptomatic patients, including those with motion sickness.[5] Performance measures like visual acuity, contrast sensitivity, and threshold stereopsis can be used to make a subjective forced choice between two otherwise clinically acceptable prescriptions.

For diplopic patients, the red lens (or red filter) test is the simplest way to prescribe the minimum prism to fusion. This is sometimes called the Fusion Prism Criterion.[6] For other cases, there are two basic ways to prescribe prism. In the Americas, motor-based and dissociated measures are most commonly used. In central Europe and parts of Asia, sensory and associated measures are most commonly used. Both of these methods will be discussed in the following educator's guide.

A Few Words on Prism Adaptation

Arguably, the main factor keeping the average optometrist from prescribing prism is spectacle lens remakes due to prism adaptation. However, two factors should eliminate this concern. First, prism adaptation happens with asymptomatic patients for whom prism should not be prescribed in the first place. These are usually patients with large phorias and even larger compensatory vergence ranges. Sometimes, they are patients with anomalous correspondence, who by definition have binocular vision of a sort, even though they are objectively strabismic.

Secondly, when prism adaptation does occur, it is reversible at the same speed. This is often avoidable simply by trial framing the proposed prism prescription. Patients who show small, single-digit prism increases over months to years are usually not true adaptors but rather are releasing counter-contractures of their extraocular muscles. This phenomenon might be compared to latent hyperopia slowly becoming manifest with the prescription of plus lenses.[7,8]

Prism Prescribing

Prescribing ophthalmic prism need not be difficult and laborious. Many clinicians avoid prescribing prism, except to renew existing prescriptions, perhaps as a result of having an early bad experience resulting in a spectacle lens redo. Methods for prescribing prism include traditional objective dissociated methods like the famous comfort criteria named after Sheard and Percival, which rely on the motor system. There are also lesser-known subjective sensory methods, most notably the Haase method used for decades in central Europe. These sensory techniques are not nearly as well known by North American optometrists.

Dissociated Methods of Measuring Ocular Deviation

Dissociative methods of determining phorias, and thus prescribing prism, include the neutralized alternate cover, Maddox rod testing, and von Graefe phorias. Limitations with these methods have long been recognized and are the reason the so-called prism "comfort criteria" were developed by Percival and Sheard. Other methods, such as the 1:1 Rule and Caloroso's Residual Vergence Demand, were created for similar reasons.

1. Percival's Criterion (1928)

Percival's[9] comfort criterion is also known as the "middle third" technique. Percival proposed that in order to experience binocular comfort, a patient's larger blur point should be no more than twice the lesser blur point. There is no mention of the phoria in Percival's criterion, but Sheedy and Saladin[10] found that it was the most reliable predictor of symptoms for dissociated esophores. This was discovered because heterophoria was the best discriminator in the esophoric group in the same authors' 1977 study.[11]

For example, for patients with a convergence blur/break/recovery of BO: 27/30/26 and divergence blur/break/recovery of BI: 6/10/8, the greater blur point is 27^{Δ} BO and the lesser blur point is 6^{Δ} BI. One-third of the greater blur point is $27^{\Delta}/3 = 9^{\Delta}$, while two-thirds of the lesser blur point is $6^{\Delta} \times 0.67 = 4^{\Delta}$. Therefore, the prism predicted by Percival to provide the best comfort would be $9^{\Delta} - 4^{\Delta} = 5^{\Delta}$ BO, which would make the ranges BO: 22/25/21 and BI: 11/15/13. Notice that twice the base-in blur is now equal to the BO blur ($2 \times 11^{\Delta} = 22^{\Delta}$), and Percival's criterion is met without regard to the numerical value of the (presumed) esophoria, or subjective patient input.

2. 1:1 Rule

The 1:1 Rule is thought to work best for esophoric patients and states that "the base-in recovery should be at least as great as the amount of the esophoria."[12] Thus, if the difference between the esophoria and the base-in recovery is divided by two, the result would be the base-out prism needed for binocular comfort.

Table 1. Residual Vergence Demand **(Modified from Caloroso B & Rouse M. Clinical Management of Strabismus, 1993.)**

Direction	Magnitude	Residual Vergence Demand
Eso	$6\text{-}20^{\Delta}$	$4\text{-}6^{\Delta}$
Hyper	$3\text{-}10^{\Delta}$	$2\text{-}4^{\Delta}$
Exo	$20\text{-}30^{\Delta}$	$10\text{-}15^{\Delta}$

An example of the 1:1 Rule would be a 12^{Δ} EP with compensatory divergence ranges of BI: 12/15/8. This comfort criterion predicts that (12^{Δ} EP – 8^{Δ} BI recovery)/2 = 2^{Δ} BO prism would be needed to provide comfort. Note that this amount of prism resets the near phoria to 10^{Δ} EP and the compensatory divergence ranges to 14/17/10, making the base-in recovery the same as the near esophoria.

3. Sheard's Criterion (1930)

Myklebust and Ridell[13] state, "Sheard postulated that symptoms from heterophoria can be avoided if the fusional reserves in the opposite direction are at least twice the size of the phoria itself." Sheedy and Saladin[11] performed the definitive study on parsimonious ways to distinguish between symptomatic orthoptics patients and asymptomatic age-matched controls. Discriminant analysis showed that Sheard's criterion was the best discriminator of symptoms in exophores, followed by fixation disparity.

For example, consider a patient with 9^{Δ} XP' and a compensatory convergence range at near of BO: 12/20/14. To find the BI prism necessary for the patient to meet Sheard's criterion, simply subtract one-third of the base-out blur as reserve from two-thirds of the exophoria, or demand. In this example, $0.67 \times 9^{\Delta} = 6^{\Delta}$, and $12^{\Delta}/3 = 4^{\Delta}$. Thus, $6^{\Delta} - 4^{\Delta} = 2^{\Delta}$ BI prism is needed for comfort. This would change the near phoria to 7^{Δ} through the 2^{Δ} BI prism and the compensatory range to BO: 14/22/16. Thus, the patient now meets Sheard's criterion, with the compensatory BO blur of 14^{Δ} equal to twice the demand of 7^{Δ} XP'.

4. Caloroso's Residual Vergence Demand (1993)

Cotter[14] describes the how the ocular deviation can be combined with the clinically based residual vergence demand (RVD) from Caloroso. This set of guidelines gives different ranges of deviations for esophores, exophores, and hyperphores and the acceptable residual prism that can be left uncorrected in each case (Table 1).

For example, a patient with 12^{Δ} EP would be expected to have an RVD of $4^{\Delta}\text{-}6^{\Delta}$ and thus could

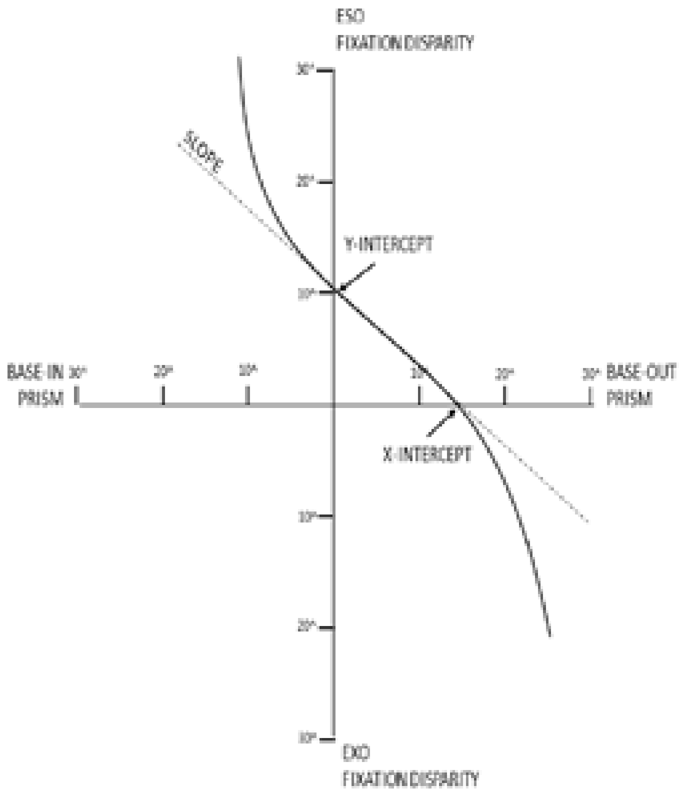

Figure 3. *Type I fixation disparity curve (Courtesy of Kerri Lyons))*

be prescribed as little as 6^{Δ} of the 12^{Δ} total to be comfortable, as up to 6^{Δ} can be left as RVD. An exophore of 20^{Δ} might be prescribed as little as 5^{Δ}, leaving the maximum of 15^{Δ} RVD. Any hyperphoria over 4^{Δ} would need at least some correction.

Although it can be verified with trial framing, notice that the RVD Criterion can be a purely objective, even paternalistic, method of prescribing ophthalmic prism. It does not rely on any performance measures like improvements to BCVA, contrast sensitivity, or stereopsis.

Sensory (Associated) Methods of Prism Prescribing

Fixation Disparity

London and Crelier state, "Since popularized by Ogle in 1949, fixation disparity has been of particular interest to clinicians."[15] Fixation disparity is defined as the binocular misalignment of the visual axes within Panum's fusional area. When fixation disparity results in fusion too far outside the center of Panum's area, known as the horopter, the patient may be symptomatic with binocular blur. Symptoms from this type of abnormal fixation disparity can be relieved with ophthalmic prisms or vision therapy.

According to London and Crelier,[15] "Sometimes fixation disparity serves as a purposeful error—an early-warning system to alert the fast vergence system of decay in fusional (disparity) vergence so it may apply compensating fusional vergence before diplopia is noticed." This normal type of fixation disparity might be better left uncorrected, as it may be asymptomatic.

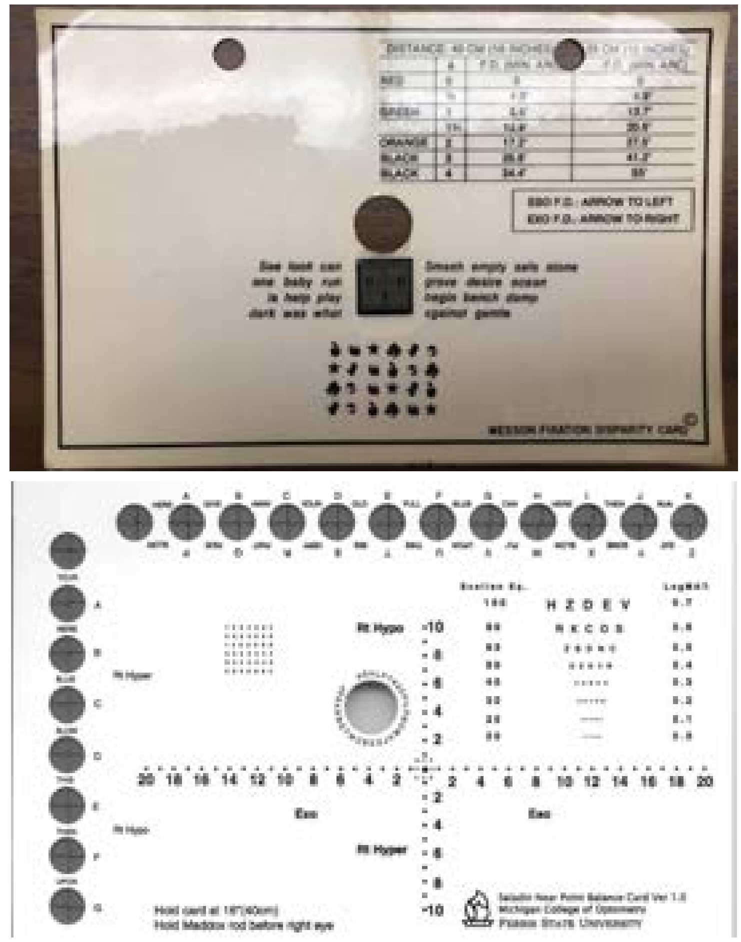

Figure 4. *Wesson (top) and Saladin (bottom) analog fixation disparity cards (Saladin card courtesy of Paul Harris)*

Although they have been the research standard for over fifty years, there are many reasons why dissociated fixation disparity curves are not clinically practical. Among these reasons are:

1. The requirement for analog equipment that is no longer in production, such as the Sheedy disparometer
2. The clinically unnecessary and uncorrectable accuracy (arc minutes instead of prism diopters)
3. The excessive chair time required in order to obtain a range of prism values that can be prescribed

In North America, the preferred way to measure fixation disparity is using the motor technique to generate the forced curves. While dissociated (or forced-diplopia) fixation disparity curves are not part of this paper, they present a prism-prescribing dilemma. Recall the shape of a Type I FD curve, shown in Figure 3.

Note that on this curve, the Y-intercept is the fixation disparity, and the X-intercept, when present, is the associated phoria. The name of my prism-

Figure 5. *Nonius cross, available in anaglyphic and polarized versions*

prescribing technique, Associated Phorometry, derives from the X-intercept on the FD curve. Targets used for fixation disparity testing are often analog polarized targets like those on the Saladin and Wesson cards, seen in Figure 4.

Haase Method

The central European method of prescribing prism is also known as the Haase method. This sensory technique is not in common use in North America. The sensory method measures the deviation of the eyes in the clinical units of prism diopters, of which there are about 1.75 per degree. Yet research in fixation disparity is generally measured in minutes of arc, of which there are of course 60 per degree. These units are consistent with that to which patients are subjectively sensitive.

London and Crelier[15] note that this sensory approach seeks "to investigate the status of the visual sensory system with no additional fusional demands." As such, it uses a specific series of targets, like the Nonius cross, a pointer, and the square bracket rectangle test, as well as three stereopsis tests.

Associated or sensory prism prescribing techniques raise several research questions for evaluating these techniques, as follows:

1. Which eye chart target(s) are best for prescribing prism?
2. Is there a predictive numerical ratio between dissociated and associated phorometry?
3. Is this ratio different for esophoria, exophoria, and hyperphoria?
4. Which improves visual performance such as stereopsis the most: objective or subjective (self-selected) prism?

Consider the first issue, with regard to significant differences in the fixation targets and how they are used clinically. The simplest prism target is the eye muscle light, which is a white point source identical to the bottom target on the Worth four-dot test. Yet although the simple eye muscle light has been the standard for prescribing prism for the past 100 years, there are several weaknesses in this technique. First

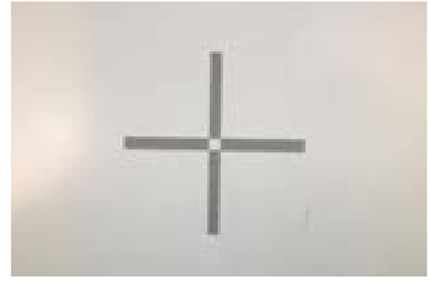

Figure 6. *The Haase method cross test for motor-compensated heterophoria, with no central fusion lock, as seen on the AOC Polar chart.*

of all, there is a population of symptomatic patients who do not experience diplopia with the muscle light. This leaves the practitioner looking for a technique to make the patient see double, usually by measuring the dissociated phoria.

The three most common dissociated phoria tests are alternate cover testing, the Maddox rod, and vertical prism dissociation, as in the von Graefe technique. While all of these are universal to the optometric profession, none of these are generally acceptable to most patients as a direct prism prescription.[15]

When it is necessary, directly measuring the necessary prism would make prescribing it much easier and more accessible. This is why the optometrist may wish to keep the patient in an associated state with filters, either anaglyphic (red/green) or polarized, but to use a more sophisticated target than a muscle light.

Considering filter techniques, one might think that a measurement of fixation disparity, or the arc minute error in binocular alignment, would be warranted. In fact, the term associated phoria originates as the prism that neutralizes fixation disparity. Yet, analog equipment classically used to measure fixation disparity, like the Saladin or Wesson cards, remains only slightly more available than the out-of-production Sheedy disparometer. Perhaps, since the invention of digital eye charts, a new way to measure associated phorias can be found.

On digital (LCD) eye charts, or even projected ones, a more sophisticated target than the muscle light is the Nonius cross, which can be shown in anaglyphic or polarized form (Figure 5). In this polarized example, notice how one-half of each horizontal and vertical line is channeled to each eye, with a white central fixation lock. In an anaglyphic presentation, the red-filtered (usually right) eye will see red lines on the black background, and the green-filtered (usually left) eye will see green lines. These would be seen by the opposite eye if the background was white. This is not quite the same as the Haase method's Nonius cross, which has the entire horizontal line projected to one

Figure 7. *Haase method pointer test for horizontal disparity, as seen on the AOC Polar chart*

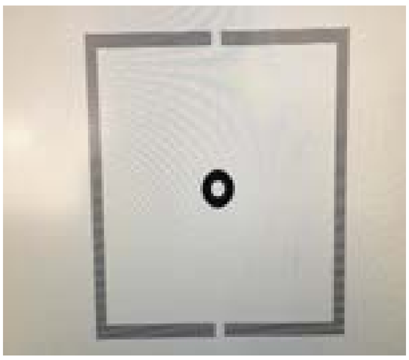

Figure 8. *Haase method rectangle test for vertical disparity, as seen on the AOC Polar chart*

eye, and the entire vertical line projected to the other, in order to avoid binocular interference.

Some versions of this Nonius cross would allow measurement of associated phorias, both horizontally and vertically, and get a better result than the simple muscle light. For example, the AOC Polar chart uses a 3D TV and circular polarization to display the Haase method targets, which are built in. The 5-step Haase Polatest method was developed in Germany in 1956 and has been perfected since.

The first step is called the Cross test, but with two significant differences to the Nonius cross found on other digital eye charts. Those differences are that there is no central fixation lock, and both vertical lines are seen by one eye while both horizontal lines are seen by the other (Figure 6). The Cross test aims to determine the motor-compensated heterophoria, not the fixation disparity. Therefore, it would be the rough starting point for prism prescribing.

The second step in the Haase method is refining the horizontal fixation disparity with the Pointer test. The Pointer target has a central fixation lock (seen here in black) with vertical lines that are seen by one eye and a fixation disparity gauge seen by the other (Figure 7). At first glance, the Pointer target appears very similar to the one used at near on the Saladin and Wesson cards, as well as the Sheedy disparometer. However, the fact that the entire vertical line is seen by a single eye, and the end stops by the other, is a critical difference. The reason is to eliminate binocular interference. Haase found that there is "a critical value

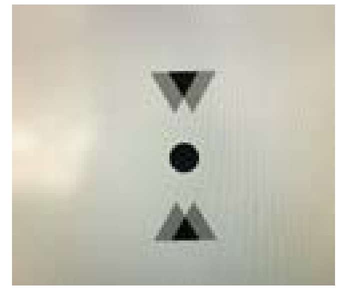

Figure 9. *Haase Stereo Balance test for vertical disparity, as seen on the AOC Polar chart*

of at least a 20 arc minutes distance to eliminate the perceived depth… and allow it to be seen at its approximately true position".[15]

The third step to refinement of the Haase method is to refine vertical prism, unless it is primary, in which case it might be measured before the Pointer test. Secondary vertical prism often goes away when the horizontal angle is neutralized, so prism prescribing is sometimes an iterative technique, testing horizontal, then vertical, then horizontal again, etc., until stability in both measurements is reached. In the case of the so-called Rectangle test, it is actually a square made of brackets that appear to each eye and form a rectangle when vertical misalignment of the eyes occurs (Figure 8).

There are two more steps to the Haase method. Step 4 involves vergence facility, or speed of fusion. It is my understanding that the Stereo Balance test helps to break ties between acceptable combinations of prism in the first three steps. The Stereo Balance test appears in Figure 9. Here's how it works: after the Cross, Pointer, and Rectangle tests, the patient should have prism in place that is very close to, if not exactly, what is needed. At this point, the Stereo Balance test presents an upper and lower triangle that have relative convergence demands compared to the central circle. Therefore, the fused triangles allow the

Video 1. *Haase method stereo acuity test for vertical disparity, similar to the Landolt ring version seen on the AOC Polar chart*

clinician to measure speed of distance stereopsis and to fine-tune horizontal and vertical prism in order to optimize performance. The Stereo Balance test should be repeatable and help further to refine the prism prescription.

The final step in the Haase technique is the measurement of distance stereo acuity. In the past, when available, we would use anaglyphic Lea, Landolt ring, or random dot stereoacuity on the M&S charts. Decreased stereo acuity was usually an indication for prism but was not always used as a performance measure at far. Part of the reason was the availability of the M&S charts, but part was the reduced contrast of anaglyphic presentation compared to polarized targets. Experience from using this with students in teaching over the past few years has indicated that many otherwise-asymptomatic young adults have reduced distance stereopsis through anaglyphic (red-blue) filters, often by hundreds of arc seconds.

The Haase stereo acuity test uses only Landolt rings, but these are at high contrast due to circular polarization on the 3D TV display. The target is chosen from a total of five per line, as shown in Video 1.

As a final test of what prism to prescribe, it is expected that the patient's stereoacuity would be improved from previous prescriptions. The AOC Polar chart can measure distance stereopsis from 300 to 30 arc seconds.

Despite its popularity in central Europe, there is a paucity of data published on the Haase technique. One of the larger studies was a symptom survey from 36 private practices in Germany and Switzerland.[15] This study examined the partial or total resolution of symptoms from Haase-method-prescribed prism for each of the following:

1. Visual acuity
2. Photophobia
3. Headaches/migraines
4. Attention
5. Dry eye
6. Ability to write
7. Fine motor skills
8. Tenseness in neck/shoulders
9. Near work complaints
10. Coarse motor skills

With a large number of subjects (n=857), this study showed overwhelming subjective preference for the Haase-method prisms compared to previous eyeglasses, with or without prism. Whether these results can be replicated, or even improved upon, remains to be seen.

Conclusions

Prism prescribing for symptomatic patients should not just include minimum prism to fusion for those who see double with the red lens test. Other reasons to prescribe prism include optimizing visual acuity, contrast sensitivity, and stereopsis. Prism can be prescribed using objective, motor-based strategies and subjective, sensory-based responses. If prism is prescribed judiciously to symptomatic patients, adaptation should not be a concern, especially for patients who have not adapted to their symptoms.

Future studies are needed to discover what is the expected ratio between traditional dissociated and associated phorias; that is, between alternate cover test, Maddox rod, or von Graefe dissociated phorias and those measured with anaglyphic or polarized-filter methods. When measuring associated eye posture through filters, many more patients may be orthophoric, more than what would be expected with careful dissociated measurements, such as von Graefe. For those who are not orthophoric on associated methods, but who remain symptomatic, many may be prism candidates. This is despite generally smaller phorias measured with associated techniques.

Lastly, the most obvious missing piece to prism research is objective measurement of subtle ocular misalignment. For all of the advances in autorefractive technology for optical defocus, there remain relatively few ways to make automated vergence measures. The most user-friendly option currently on the market may be the Power Refractor, the most recent version of which is the PowerRef 3 by PlusOptix. Using instruments like this one, objective verification of ocular misalignment may be possible, accurate to 1.0 prism diopter or less. If so, this would allow optimization of visual performance through ophthalmic prism prescription, even for patients who cannot subjectively respond to traditional sensory or motor prism targets. Alternately, structural imaging like optical coherence tomography angiography (OCT-A) shows promise to demonstrate the structural asymmetries that may lead to sensory degradation and motor misalignment. Someday, off-label use of these instruments may lead to an objective test for aniseikonia.

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