Article

Prescribing Relieving Prism for Patients with Binocular Vision Disorders

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Patients with strabismus or nonstrabismic binocular disorders can, in certain cases, be managed using spectacle prism that partially or totally neutralizes the ocular deviation. Conditions particularly amenable to relieving prismatic prescription include basic exo- and esophoria, divergence insufficiency, vertical phoria, and strabismus with normal sensory fusion. A prismatic prescription can be determined using Sheard's criterion, Saladin's 1:1 rule, fixation disparity testing, associated phoria measurement, diplopia neutralization, or residual vergence demand criteria. Prescribing prism for patients with noncomitant strabismus requires special diagnostic and management considerations. The likelihood of prism adaptation in certain patients must be considered, and methods of detection are discussed. Two case reports present examples of patients whose management included prescription of relieving prism. **Key Words:** *prism, spectacles, binocular vision, fusion, strabismus, fixation disparity, associated phoria, Sheard's criterion.*

INTRODUCTION

The decision to prescribe spectacle prism for a patient must be made carefully after thorough diagnostic testing. Used wisely, prism can sometimes significantly improve a patient's comfort by relieving diplopia and/or asthenopia. For a patient possessing normal sensory fusion (normal correspondence and little suppression), prism can be used to partially or totally neutralize a phoric or strabismic angle that is too large to allow comfortable and efficient fusion. The minimum amount of prism that allows comfortable fusion should be prescribed. Thus, relieving prism that reduces the demand on the vergence system without eliminating the deviation completely,[1] is often preferred. Whenever possible, the goal should be to reduce the amount of prism worn over a period of time as the patient is able to develop improved motor fusion ability through a vision therapy program. While acknowledging that prism is a very useful tool as part of vision therapy, this review will concentrate on prescription of relieving prism in spectacles.

Obviously, there are certain drawbacks to the use of spectacle prism. First, several conditions are not addressed by a prism prescription. Prism prescriptions do not substitute for vision therapy in treating suppression, oculomotor, accommodative, and vergence facility

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dysfunctions. Second, the issue of prism adaptation is a concern for certain patients. Prism adaptation is an increase in the magnitude of the deviation after a period of prism wear. If a patient adapts to a prismatic prescription, it will take more prism to obtain the initial effect, and symptoms may not be alleviated. These patients are not good candidates for relieving prism wear. Guidelines for predicting prism adaptation are given herein. Third, there is a concern among many practitioners, as well as patients, that the patient will become "dependent" on prism in order to maintain comfortable binocular vision. This is a possibility, but it is not inevitable. If vision therapy is undertaken, if the prism is not worn full-time, or if the prism magnitude is slowly reduced over time,[2,3] the need for prism may be reduced as fusional ranges improve. On the other hand, some patients will need to continue wearing prism if they are unable or unwilling to undergo vision therapy.

Those patients who already wear spectacles full-time may be very accepting of incorporating prism into their prescription provided that image distortion, cosmetic factors, and weight of the spectacles do not preclude their comfortable use. Careful choice of a small frame, plastic (possibly high index) lens material, edge treatments, antireflective coating, and for large magnitudes, Fresnel membrane prisms (Fresnel Prism and Lens Co., Scottsdale, AZ), can decrease distortion and weight, and in many cases, improve cosmesis.[4] Of course, the patient should be informed of all options and their advantages and disadvantages. The patient often will accept some compromise of cosmesis or even clarity of vision in exchange for restoration of comfortable, single binocular vision.

RELIEVING PRISM FOR NONSTRABISMIC PATIENTS

Relieving prism is a good option for symptomatic individuals with certain nonstrabismic binocular vision dysfunctions, although vision therapy is highly recommended if the patient is suitably motivated.[5] Conditions that can be managed with prism include:

- *Basic exophoria,* in which a similar magnitude of exophoria exists at far and near, along with reduced convergence ranges;
- *Basic esophoria,* with a similar degree of esophoria at far and near, and reduced divergence ranges;
- *Divergence insufficiency,* with distance esophoria and a poor compensating divergence range, often with normal exophoria at nearpoint. (An important differential diagnosis is divergence paralysis, which should be suspected if the condition is of recent onset with associated headaches or other neurological symptoms.[6])
- *Vertical phoria,* if it is primary, rather than secondary to a horizontal phoria. A primary vertical deviation manifests a vertical fixation disparity (discussed herein).

In addition, some patients with convergence insufficiency (CI) are good candidates for prismatic prescription, although vision therapy is considered the best option for this condition.[5,7] In CI, there is a larger exophoria at nearpoint than farpoint, poor convergence ability, and frequently associated accommodative problems. Because prism does not address accommodative or vergence facility problems, vision therapy is often required. However, if the CI patient is unmotivated for vision therapy, a prismatic prescription can be tried. Either the prism should be given for near only or the practitioner should determine that the patient can tolerate the prism at all distances before prescribing it for full-time wear. For any of the above conditions, if prism is prescribed to provide immediate relief of symptoms, reducing the need for prism is usually achievable by means of vision therapy.

Methods for Determining Prism Amount for Phoria Patients

A variety of methods are available for prescribing prism. In each case, once a proposed value is obtained, the prism should be trial framed to ascertain patient comfort as well as binocular and accommodative function. Once the patient responds positively to a given prism amount, it can be prescribed in Fresnel form if there is a question of whether prism adaptation will occur. If the practitioner is reasonably confident that this amount of prism will work well, ground-in prism is preferable for long-term wear.

Saladin[7] recommends consideration of Sheard's criterion when prescribing for pa-

tients with exophoria greater than 4^{Δ}, particularly basic exophores. (Patients with smaller, symptomatic exophorias are best treated using vision therapy.) Sheard's criterion states that the compensating vergence range (base-out in the case of exophores) should be at least twice the magnitude of the phoria.[8] In an analysis of 38 exophoric subjects, Sheedy and Saladin[9] found that failure to meet Sheard's criterion was the clinical finding that best differentiated between the symptomatic and asymptomatic subjects. Furthermore, they found the base-our to blur finding more useful than the base-out to break value for this comparison. The amount of base-in prism needed to meet Sheard's criterion for an exophore is equal to: [2(exophoria) – BO to blur]/3.[10]

For example, if a patient has 16^{Δ} exophoria at nearpoint and a near BO range of 18/22/8, the indicated prism would be [2(16) – 18]/3 = 14/3 = 4.67^{Δ}, or approximately 4.5^{Δ} BI. If this same patient has 12^{Δ} exophoria at far and a distance BO range of 15/18/7, the indicated prism for distance viewing would be [2(12) – 15]/3 = 3^{Δ} BI.

Through trial framing of the prisms in the above example to assess comfort and performance, it may be possible to arrive at a compromise prism value for both distance and nearpoint activities (ideally the smallest magnitude that allows comfort and good function). Alternatively, two different pairs of prism lenses can be prescribed to provide a different prism value for reading, computer use, or any other specific task.

When prescribing relieving prism for symptomatic patients with basic esophoria or divergence insufficiency, it is useful to consider Saladin's 1:1 rule. This guideline involves prescribing enough base-out prism to make the esophoria magnitude equal to the base-in vergence recovery value (both measured through the prescribed prism).[7] Justification for this guideline derives from the fact that the base-in recovery finding was found to be an important parameter in analysis of esophoria cases.[7,9] A simple formula may be used to calculate the needed prism value: BO prism = (esophoria – BI recovery)/2.

For example, if a divergence insufficiency patient has 8^{Δ} esophoria at farpoint and a distance BI range of x/4/2, prescribing 3^{Δ} BO should allow an equal phoria and BI recovery magnitude of 5^{Δ} [(8 – 2)/2 = 3^{Δ}]. In other words, when measured through 3^{Δ} BO, the phoria should be reduced to 5^{Δ} eso and the BI recovery value should increase to 5^{Δ}.

If the BI recovery value is negative, the negative value should be used in the formula.

For example, if the esophoria measures 5^{Δ} and the BI range is x/3/–1, the indicated BO prism would be: [5 – (–1)]/2 = 3^{Δ}.

Fixation disparity measures may also be useful in prescribing prisms for some cases of exo- and esophoria, if certain characteristics are revealed (to be described below). A fixation disparity (FD) is an ocular misalignment (usually less than 10 minutes of arc or approximately 0.25^{Δ})[11] present during fusion. It does not result in diplopia because of Panum's fusional area.[12] A small exo FD is present in most patients with normal binocular vision.[11] It has been shown to constitute a stimulus to the disparity vergence system which enables proper innervation to continue flowing to the extraocular muscles. However, a large FD renders the system inefficient and may lead to fatigue or suppression. Such a situation can result from performance of nearpoint work under stress.[13] Exo FD of 10 min. arc or more, or any amount of eso FD, may be associated with asthenopia.[11]

In clinical testing, a horizontal fixation disparity curve (FDC) is used to determine whether a patient might be a good candidate for a prism prescription. The FDC is plotted by measuring the actual amount of FD resulting when the patient fuses through a series of BO and BI test prisms. Prism power is plotted on the horizontal axis and FD magnitude on the vertical. An instrument with polarized vernier lines, one seen by each eye, must be used. Examples of instruments that allow direct measurement of FD are the Disparometer (Vision Analysis, Walnut Creek, CA)) and the Wesson Card (Optometric Extension Program Foundation, Inc. [OEPF], Santa Ana, CA). In addition to measuring FD, this method of testing may also identify subtle suppression that should be treated with vision therapy. A complete explanation of how to plot and interpret FDCs is beyond the scope of this article, and the reader is referred to the instrument manuals and other sources for further information.[5,10,14]

One word of caution is appropriate if FD testing is administered in free space using loose plastic prisms. Some of these prisms (particularly powers of 25$^{\Delta}$ or greater) interfere with polarization of light, potentially altering the patient's monocular views of the test lines. The practitioner should check his/her plastic prisms while wearing polarized filters and viewing a polarized target monocularly through all regions of each prism. If the monocular target's appearance is unaltered by the prism, the prism is safe to use with polarized tests.[15]

Ideally, the FDC reveals a small FD magnitude at the y-intercept of the curve, which is measured through no added prism. It is considered normal for the magnitude of eso FD to increase with increasing BI demand (the patient does not fully diverge to meet the demand) and for exo FD to increase with BO demand. In addition, it is desirable to find a relatively horizontal "flat" slope in the central region around zero prism.[16] Figure 1 shows a typical FDC for an asymptomatic patient.

If a flatter area of the FDC exists off to one side of the y-axis rather than centered about it, a prism prescription may be indicated (Figure 2). The tentative amount of prism to prescribe is obtained by noting the point nearest the y-axis where the curve begins to flatten or change from a convex to a concave shape. One can draw then a vertical line through the point which is 1–2$^{\Delta}$ beyond the point where the flattening begins. The prism value on the x-axis, through which this line passes, represents an amount of prism that generally reduces the magnitude of the FD. It also is the minimum prism power that would allow a portion of the flat region of the FDC to cross the y-axis, because the FDC is essentially shifted laterally when prism is prescribed. It is usually not necessary to reduce the FD completely to zero.[11,13] The proposed prism should be evaluated in a trial frame to check for comfort and prism adaptation.

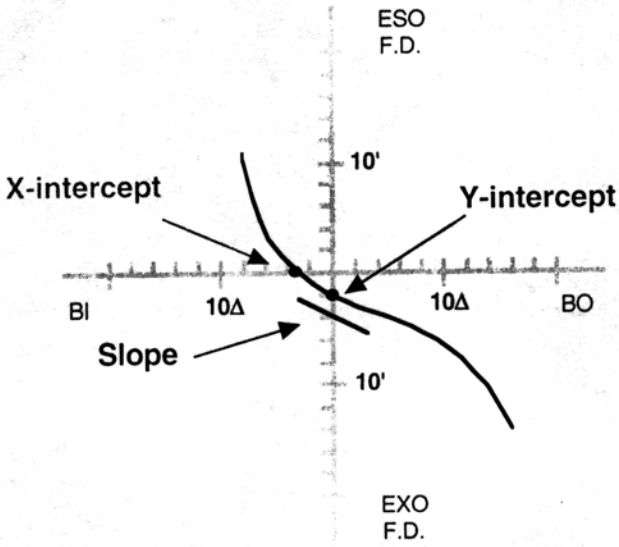

Fig. 1. Generalized normal fixation disparity curve (type 1), showing a y-intercept of 2 min. arc exo, a fairly flat slope in the region of the y-axis, and an x-intercept of 4$^{\Delta}$ BI.

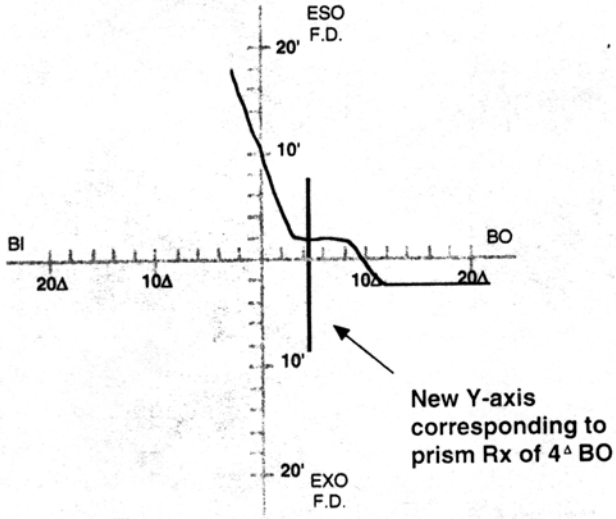

Fig. 2. Fixation disparity curve showing a steep slope in the region of the y-axis, which flattens as BO prism increases. The vertical line drawn through 4$^{\Delta}$ BO indicates the predicted position the y-axis would assume if the patient were prescribed 4$^{\Delta}$ BO. This point is just beyond where the flattening of the curve begins, and corresponds to a smaller fixation disparity (2 min. arc eso) than the habitual 10 min. arc eso (the original y-intercept).

Measurement of the associated phoria (AP), the prism needed to reduce FD to zero, can be performed without plotting a complete FDC. One can measure the AP with less sophisticated equipment than needed for an FDC, because any FD present without test prism must merely be neutralized (once) with prism rather than measured in minutes of arc through test prisms. Examples of instruments that allow AP measurement (in addition to the previously mentioned Disparometer and Wesson Card) are the Bernell fixation disparity slides used with the Bernell lantern, the Mallett units (Bernell Corporation, South Bend, IN), and the Stereo Optical (formerly American Optical/Reichert) vectographic projector slide and Borish Card (Stereo Optical Co., Inc., Chicago, IL). All of the latter instruments con-

tain fixed, polarized, monocularly viewed lines. If the patient perceives misalignment of these lines (indicating a non-zero FD), the examiner adds prism in small steps until the patient perceives that stable alignment has been reached. Two vertically oriented lines are used to measure horizontal AP and two horizontally oriented ones for vertical AP. As with diplopia neutralization, BI prism is used for crossed (exo) disparity, BO for uncrossed, BDOD for right hyper and BUOD for left hyper.

The AP value has been shown to be a useful amount of prism to prescribe for patients with symptomatic vertical deviations.[17] It can also be prescribed for horizontal deviations if an FDC does not reveal a flat zone to move with prism. However, one should be aware that for esophores in particular, the AP may indicate a larger amount of prism than truly needed.[5] In any case, it is not wise to prescribe more prism than the dissociated phoria magnitude, and the lowest possible prism magnitude to stabilize binocularity and provide comfort should be given. Table 1 summarizes the nonstrabismic conditions for which relieving prism might be prescribed, together with suggested methods for determining a prescription.

PRISMATIC PRESCRIPTION FOR STRABISMIC PATIENTS

When treating patients with strabismus, spectacle prism is most effective for those strabismic patients who have normal correspondence and little or no suppression. It can be used to alleviate symptoms either (1) before vision therapy, (2) after maximal progress in therapy is achieved, or (3) in place of therapy if the patient is unable to undertake therapy.

TABLE 1. Suggested Methods of Prescribing Relieving Prism for Nonstrabismic Conditions

Condition	Prism Determination Methods
Basic exophoria	Sheard's criterion, fixation disparity curve
Basic esophoria	Saladin's 1:1 rule, fixation disparity curve
Divergence insufficiency	Saladin's 1:1 rule, fixation disparity curve, associated phoria
Convergence insufficiency	Sheard's criterion, fixation disparity curve
Vertical phoria	associated phoria

Deep suppression and anomalous correspondence must be ruled out or eliminated before either neutralizing or relieving prism is prescribed.

Neutralizing Prism

Prism that fully compensates for the strabismic angle sometimes is necessary to establish or maintain sensory fusion. For example, in a case of recent-onset strabismus in a young child, prompt prescribing of prism can prevent development of adaptations such as suppression, amblyopia, and anomalous correspondence. The amount of prism to prescribe can be determined by neutralization of the alternate cover test. Although ideally patients also receive vision therapy to improve fusion ability, those managed surgically can benefit from prism prescriptions as well.[3]

Zehetmayer et al.[18] studied 178 children under 10 years of age who had constant esotropia of less than 45$^{\Delta}$ and no amblyopia. Those who wore neutralizing prism for 6–15 months before strabismus surgery achieved much better eye alignment and stability following surgery. At 12 months after surgery, the mean ocular deviation remained under 10$^{\Delta}$, and only 8% required reoperation. In contrast, of those who were not prescribed prism preoperatively, 12 months postoperatively the mean deviation was significantly greater than for the prism group, and 25% needed another surgical procedure. One other notable finding was that the Fresnel prisms used were not found to cause any cases of amblyopia in this study.

Another ophthalmologic study involved a nonsurgical treatment approach.[19] Twenty-five children ages 2–8 years participated and all had intermittent exotropia of less than 20$^{\Delta}$. The children were prescribed neutralizing prism, mostly in Fresnel form, as well as full lens correction. Thirteen subjects failed to wear the prisms and showed no improvement in their condition. However, there was a 66% cure rate among the 12 subjects who wore their prisms for at least half their waking hours. The authors defined a "cure" as no strabismus at any distance, 40″ stereopsis on the Wirt circles, and normal convergence and divergence ranges in the major amblyoscope with appropriate diplopia awareness.

Relieving Prism

Relieving prism serves as an aid to fusion, reducing the vergence demand without completely eliminating it.[1] This option should be explored when possible, because it requires that the patient use some of his/her own fusional vergence to maintain fusion and encourages passive development of fusional vergence. Guibor[20] believes that fully neutralizing prism is more than a patient needs when he or she is not tired. He states that a patient is less likely to become "dependent" on prism for fusion if one prescribes relieving as opposed to neutralizing prism. Furthermore, he has found that with relieving prism, the deviation magnitude often decreases over time, thereby allowing the magnitude of the prism to be reduced further.

Several methods can be employed to determine the amount of relieving prism to prescribe. If the patient has diplopia, the prism power that allows elimination of diplopia (i.e., the fusion prism) can be prescribed.[1] A Worth 4-dot flashlight, a red lens and transilluminator, or an object in free space is used to determine this minimum prism power that allows fusion. Testing under conditions that allow the patient to use fusional vergence, rather than testing under fully dissociating conditions, often results in a prism value that is less than the total deviation magnitude.

Another method of establishing a reasonable amount of relieving prism for a strabismic patient is to use the residual vergence demand criteria.[1] The residual vergence demand (RVD) is the amount of fusional vergence (motor fusion) that can be expected from a strabismic patient with normal sensory fusion ability. The values are based upon Caloroso and Rouse's clinical experience with strabismic patients maintaining comfortable binocularity. They state that the RVD is most predictable for patients with esotropia and least predictable for those with exotropia. Refer to Table 2 for the RVD guidelines.

TABLE 2. Residual Vergence Demand Criteria[1]

Direction	Applicable Deviation Size	Residual Vergence Demand
	6–20$^{\Delta}$	4–6$^{\Delta}$
	20–30$^{\Delta}$	10–15$^{\Delta}$
	3–10$^{\Delta}$	2–4$^{\Delta}$

As an example of this prescribing method, consider a patient with a 15$^{\Delta}$ intermittent esotropia at far and near. According to Table 2, the RVD for such a patient is 4–6$^{\Delta}$. This suggests that the patient needs a prescription of 9–11$^{\Delta}$ BO in order to achieve comfortable fusion.

As always, the prism should be evaluated in a trial frame to assess comfort and function. If other tests suggest that less prism would achieve the desired effect, particularly if the patient has well-developed motor fusion ability, the lower amount should be tried initially, and the patient should be counseled that the prism may need to be increased if long-term comfort is not achieved with the initial value.

Additional prism-determination methods are available for patients with intermittent strabismus. If one can obtain vergence ranges on a patient with intermittent exotropia, Sheard's criterion can be considered for prescribing prism, as described previously. Alternatively, for a patient with intermittent strabismus, a horizontal fixation disparity curve or associated phoria measurement could be used to determine a potential prism prescription, as with phoria patients. However, central suppression or instability of fusion sometimes interferes with testing.

For patients with symptomatic vertical deviations, the vertical associated phoria is an excellent determinant of a suitable prism prescription. Strabismic patients with vertical deviations that only occur secondary to their horizontal deviation (e.g., patients with intermittent exotropia who show a hyperdeviation only when dissociated) should not be prescribed vertical prism. Vertical prism should only be considered for those with primary vertical deviations, shown as a non-zero associated phoria (i.e., a vertical fixation disparity) in patients capable of using horizontal fusional vergence to align the eyes. If a patient has constant strabismus with a vertical component, a primary vertical deviation can be distinguished from a secondary one by eliminating the horizontal deviation with sufficient lens power and then checking for residual vertical movement on the alternate cover test. For example, adding sufficient minus lens power bilaterally should stimulate accommodative convergence in an exotrope (of small to moderate magnitude) to eliminate the exodeviation. Only a primary vertical deviation

would still be present on the alternate cover test when the exodeviation is eliminated.[1] If the patient has constant esotropia, the alternate cover test can be performed at the patient's centration point, where the horizontal component is eliminated (using added plus lenses if needed).

For a patient who has both a horizontal and vertical deviation (and resulting oblique diplopia), a Maddox rod can be used to determine the axis of a single oblique prism to correct both components. This enables the examiner to add prism in small increments at the correct orientation until the patient's diplopia is eliminated. As described by Moradiellos and Parrish,[21] the Maddox rod (ideally as a trial lens) is placed before the patient's eye having the poorer vision, while the patient wears the appropriate lens prescription in a trial frame. The patient views a white transilluminator light at distance or nearpoint. The patient should see a red streak with the eye viewing through the Maddox rod. Refer to Fig. 3 for an example of what a patient with left hyperexotropia would see using this procedure. The rod is rotated until the patient sees the streak pass through the white light. The necessary axis of prism correction is read from the trial frame, based on the Maddox streak indicator mark (90° from the orientation of the rods). Next, the Maddox rod is rotated 90° and the patient should perceive that the line and light are separated again. Prism is added at the determined axis (with the base-apex line of the prism parallel to the new position of the rods) until the patient sees the streak pass through the white light again. This value would be the maximum prism needed to eliminate the patient's oblique diplopia. It is sometimes possible to arrive at a lower, but still effective, prism power if smaller amounts of prism are introduced at the appropriate axis while the patient views the light without the Maddox rod. This technique allows a minimum prism prescription to be determined under more natural conditions.

It is important to note that if oblique prism is to be split between the two eyes, the axis must be rotated by 180° for the fellow eye.

For example, if 6^{Δ} is required at an axis if 45° (i.e., BI and BU) when measurements are made before the right eye, splitting the prism equally between the eyes would require a prescription of right eye: 3^{Δ} at 45°, left eye: 3^{Δ} at 225°. Alternatively, this prescription could be specified as right eye: 3^{Δ} BI and BU at 45°, left eye: 3^{Δ} BI and BD at 45°.[22]

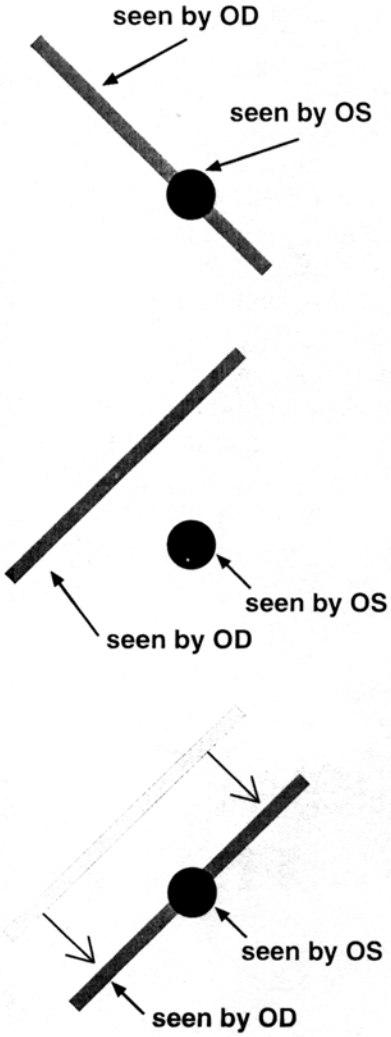

Fig. 3. Maddox rod technique for correcting oblique diplopia, in this case, in a patient with left hyperexotropia. The Maddox rod is before the right eye, while the left eye views the spot of light. The top diagram shows the patient's view after the rod is rotated until the line intersects the light. The orientation of the streak indicates the necessary axis for prism correction. In this case, from the examiner's perspective, the streak is at 45°. The center diagram shows the patient's view after the rod has been rotated by 90°. The bottom diagram shows the patient's perception as prism is added before the right eye, BU and BI at axis 45°, until the line again passes through the light.

Optical laboratories vary regarding whether they wish to have these prescriptions specified using a 180° or 360° system, so it is necessary to communicate with them about this issue the first time such a prescription is ordered.

If subjective methods are not reliable for prescribing relieving prism for a given patient

(e.g., an infant or toddler) or if diplopia is not easily elicited, empirical determination of prism power may be necessary. The initial power selected might be based on the residual vergence demand criteria (Table 2) if the deviation is intermittent. While the prism is held before the patient's eye and the patient fixates an appropriate, interesting target, the unilateral cover test can be used to determine if any strabismus persists. If strabismus is still present, the prism power can be increased until the patient shows no movement on the unilateral cover test. Depending on the patient's responsiveness, it may be possible to perform sensory tests (e.g., stereopsis, Worth 4-dot) to check for fusion through the test prism as well. Table 3 summarizes recommended methods of prescribing prism for patients with strabismus.

Considerations for Noncomitant Deviations

A noncomitant ocular deviation is one that varies by more than 5^{Δ} from one position of gaze to another.[23] Such conditions can result from mechanical restriction or paresis of an extraocular muscle, and if of recent onset, require investigation into the cause. Often this means referral for neurological testing. Meanwhile, the optometrist should prescribe ocular calisthenics to help prevent contracture of the ipsilateral antagonist muscle, if there is a muscle paresis.[23] Although a patient with recent-onset noncomitant strabismus may present for initial ocular examination wearing a patch to eliminate diplopia, frequently prism can be prescribed to restore single binocular vision, enabling the patient to function more satisfactorily. As with comitant deviations, one should prescribe the least amount of prism that eliminates diplopia and allows comfortable fusion. Although for comitant deviations the prism power generally is split equally between the eyes to balance the thickness and weight, for noncomitant strabismus one should prescribe most or all of the prism before the eye with the motility limitation. This allows prescription of less prism than if it were split equally between the eyes. The reason less prism is needed is that when the unaffected eye is allowed to fixate the target directly (without prism), the smaller, primary angle of deviation can be neutralized using prism before the paretic/restricted eye. If instead, relieving prism were placed before the unaffected eye, both eyes would be directed toward the action field of the weakened muscle (due to Hering's law), resulting in a larger strabismic angle. Thus, the least prism is needed when it is placed before the paretic eye.[24]

TABLE 3. Suggested Methods of Prescribing Prism for Strabismic Conditions

Condition	Prism Determination Methods
Constant horizontal strabismus	fusion prism, neutralizing prism
Intermittent exotropia	Sheard's criterion, fixation disparity curve, residual vergence demand criteria
Intermittent esotropia	residual vergence demand criteria, fixation disparity curve
Primary vertical strabismus	associated phoria
Combined horizontal/vertical strabismus	oblique Maddox rod, fusion prism

As an example, consider a patient with a paretic left lateral rectus (LLR) resulting in an esotropia measuring 20^{Δ} BO with the right eye fixating (i.e., right eye aimed straight ahead, prism before left eye). If BO prism instead were placed before this patient's right eye, both eyes would make a version movement to the left. Because of the paretic LLR, the left eye would rotate less than the right for a given amount of innervation, resulting in an esotropia larger than 20^{Δ}.

Fresnel prisms (Fresnel Prism and Lens Co.) should be considered if a large amount of prism is needed, because they add negligible weight to the spectacles regardless of power. They are available in powers up to 40^{Δ}. They also are useful if different prism powers are needed in certain regions of the spectacles to relieve diplopia in specific gaze directions.[4,25] In some cases, resolution of underlying pathology results in a deviation that gradually decreases in magnitude. Fresnel prisms again are ideal for these cases because the power can be changed easily and inexpensively, independent of the spectacle lenses themselves.[4]

In certain cases of noncomitant strabismus, the patient can achieve fusion if the head or eyes are turned so the problematic gaze di-

rection is avoided. Such a patient may develop a compensatory head posture that is unsightly or uncomfortable to maintain. This problem can be addressed by using yoked prism to direct the eyes to a field of gaze where fusion is possible. For example, if the patient has a paretic right lateral rectus muscle and resultant esotropia in primary and right gazes, fusion often is possible in left gaze. Therefore, the patient may present with a head turn to the right so the eyes can rotate to the left to achieve fusion. The head turn can be reduced if the patient is prescribed yoked base-right prisms, which will shift the fixated object toward the patient's left, where fusion can occur. The amount of yoked prism generally is determined empirically, keeping in mind that if more than about 8^{Δ} is needed, Fresnel prisms probably are preferable to ground-in prisms for cosmetic reasons.

PRISM ADAPTATION

A patient who shows an increase in the phoric or strabismic angle after prism is worn may be undergoing prism adaptation. In such cases, the angle often increases by the magnitude of the prism. Thus, a patient who initially showed 10^{Δ} exophoria and was prescribed 4^{Δ} BI may again show 10^{Δ} exophoria through the prism (i.e., a total angle of 14^{Δ} exophoria) after wearing the prism for a period of minutes to days. If this occurs, prism wear is not a helpful option and vision therapy should be performed instead.

It is possible that an increase in the deviation size is caused by the revealing of a latent phoria rather than by prism adaptation. A latent phoria or "partially adapted exophoria" is not initially manifest in its entirety when the patient is dissociated.[26] Thus the phoria may appear larger after some of the compensating fusional vergence has relaxed, as is permitted by prescribing relieving prism. The phenomenon can occur with vertical phorias as well.[5] Although the amount of prism needed by a patient with a latent phoria may at first increase and then stabilize, it is possible that the final amount, particularly for exophorias, will be larger than desirable for long-term wear. As with patients showing prism adaptation, patients with latent exophoria may be better served through vision therapy than spectacle prism.[7]

In general, it has been shown that patients with good sensory and motor fusion (i.e., normal binocular vision) usually exhibit prism adaptation readily.[27] Of course, this is not a concern because relieving prism would not be prescribed for those with normal visual skills. However, those with poor sensory fusion (deep suppression or anomalous correspondence) also may adapt to prism. Therefore, neutralizing or relieving prism is not appropriate for such individuals until sensory fusion is normalized with vision therapy.[1] On the other hand, patients with normal sensory fusion but abnormal phorias/vergences and asthenopia are less likely to show prism adaptation. Additionally, prism adaptation is likely to be weakest at the distance where binocular discomfort is greatest.[28] Therefore, it is likely that asthenopic patients who have normal sensory fusion could benefit from a prism prescription rather than showing prism adaptation to it.

Despite a patient's having asthenopia and an associated binocular vision disorder, it is often wise to investigate whether the patient does, in fact, adapt to prism before prescribing it. One simple method of doing so is to trial frame the proposed prism and have the patient wear it for at least 15 minutes. During this trial period, the patient should read or perform any other visual task likely to be done with the proposed prescription. If after this time period the patient's alternate cover test magnitude or fixation disparity through the prism is larger than what was predicted to be measured through this prism power, prism adaptation is likely to be occurring and the prism probably will not benefit the patient long-term.

Saladin[7] recommends another useful means of detecting prism adaptation (in exophores) or of revealing latent exophoria. This technique is called the forced-vergence cover test, and is performed as follows. First, the distance exodeviation is neutralized using the alternate cover test (ACT). Then the patient holds the neutralizing prism and fuses through it for 20 seconds, gazing around the room. (Binocular viewing without prism is not allowed during the entire test.) The ACT is repeated through this prism. If either additional exophoria or no movement is seen, an additional 2^{Δ} BI is added and the patient

again views the room through the increased amount of prism for 20 sec. The ACT/adding 2^{Δ} BI/fusing process should be repeated until eso movement is seen on the ACT. At this point the preceding prism value, which most recently neutralized the ACT, is compared to the original exophoria measurement. If the patient's exodeviation has increased by more than 4^{Δ} over the original amount of exophoria, the patient is likely to show prism adaptation rather than benefit from prescribed prism. Vision therapy is indicated instead.[7]

When one is unsure about the possibility of prism adaptation, temporary Fresnel prism is useful. If prism adaptation is evident at a progress evaluation 1–2 weeks later, the prism can easily be removed and the angle generally returns to its original magnitude in minutes to (less commonly) weeks.[1]

CASE REPORT 1: SYMPTOMATIC NEARPOINT EXOPHORIA

A 53-year-old woman complained of frequent frontal and temporal headaches after 20 minutes of reading. The problem was particularly troubling in her work as a clinical psychologist because she needed to perform a great deal of near work. Review of previous clinical records indicated the headaches had existed to some degree for at least 14 years, along with the diagnosis of convergence insufficiency, and the patient had tried numerous prescriptions already. Some of these had included small amounts of BI prism. Vision therapy had never been attempted. The patient's ocular health was unremarkable, her systemic conditions were hypertension, fibromyalgia, and osteoarthritis secondary to a neck injury, and she took Cardizem and ibuprofen. Although some patients with fibromyalgia experience muscular pain, including headaches, the history suggested this patient's headaches were strongly associated with use of her eyes for close work.

The patient's preferred pair of glasses (based on optimal visual acuity and comfort) had a prescription of: OD – 2.25 – 1.50 × 095, OS – 1.50 – 1.75 × 105, with a +2.00 add OU and no prism. With these glasses her acuities were 20/20 in each eye, far and near. The cover test through this prescription showed orthophoria at far and 10^{Δ} exophoria at nearpoint through the add. She was orthophoric vertically. Her near point of convergence was to the nose initially, receding to 8 cm with a 10 cm recovery later in the examination. Stereopsis was 30 sec. arc. Nearpoint vergence ranges were x/12/8 BO and x/20/16 BI. A horizontal fixation disparity curve revealed no FD without prism (zero *y*-intercept) and a suitably flat curve, but great variability as BO prism power increased. There was no vertical fixation disparity, and ocular health was unremarkable.

My diagnoses were compound myopic astigmatism with presbyopia and convergence insufficiency (CI). It seemed likely that the CI accounted for the patient's headaches, and vision therapy was recommended. The patient subsequently underwent 5 months of vision therapy, which emphasized convergence and divergence ranges and facility. The therapy program consisted of weekly in-office therapy combined with home therapy 4–5 days per week.

Despite compliance with home and office therapy procedures, the patient's headaches were only partially relieved. She showed obvious gains in vergence ability, with a sustainable near point of convergence to the nose and near ranges of >45 BO and 16/30/18 BI. Her near phoria at that time measured 8^{Δ} exo. Because therapy was not continuing to alleviate her symptoms, and sometimes aggravated them, we decided to terminate the program. In an attempt to determine whether her remaining headaches were truly caused by her binocular condition, the patient experimented with reading while one eye was occluded, and found that it took much longer for a headache to develop. Thus, binocular use of the eyes contributed at least partially to the headaches. She described them as a tenderness around her eyes, similar to the fibromyalgia soreness she experienced. She decided to go for a period of time without therapy, to determine if her improved skills would give her sufficient relief if she wasn't regularly putting the demands on her extraocular muscles that therapy can involve. There was no indication for a change in spectacle prescription at that time.

The patient returned 1 year later, reporting that the headaches with near work were recently even more of a problem. Clinical examination showed orthophoria at far and 16^{Δ}

exophoria at near. Near vergences were x/24/16 BO and x/32/24 BI. Fixation disparity testing revealed acceptable findings. The patient did not desire to pursue further therapy. Because her convergence ability had dropped so much that Sheard's criterion was no longer met, I believed that her large near phoria was demanding too much fusional effort for this patient with chronic pain. Sheard's formula (using the BO break because there was no blur finding) predicted that approximately 3^{Δ} BI would restore balance. I had the patient read for 20 minutes using this prism power over her prescription. She did not show prism adaptation nor did she develop a headache within this time, and expressed the desire to try such a prescription. After using a 3^{Δ} BI Fresnel prism for 2 weeks on a pair of near-only spectacles, she felt this was an effective prescription for reducing the frequency of her headaches. When she did develop a headache, she nevertheless could read comfortably for a longer period of time before its onset. Thus, she opted for ground-in prism, and I prescribed 1.5^{Δ} BI OU in her habitual near-only prescription.

It is notable that this patient had tried several BI prism prescriptions before vision therapy without positive results. Also, vision therapy alone did not satisfactorily relieve her headaches. The combined effects of vision therapy and BI prism for nearpoint use produced the most favorable results in this patient with both CI and fibromyalgia presumably contributing to her pain.

CASE REPORT 2: NONCOMITANT VERTICAL DEVIATION

A 59-year-old woman reported intermittent vertical diplopia, with a slight torsional component. The diplopia was relieved by covering or closing one eye. She had noted this problem for approximately 4 months. At first she had noticed diplopia only in the morning, but more recently it was present constantly with distance fixation, and occasionally with near fixation. There was a larger separation between the two images with distance compared to near fixation. The patient had recently been diagnosed as having hyperthyroidism, for which she was taking Tapazole.

The patient's visual acuities through her habitual progressive addition lens prescription were 20/20 OD/OS at distance and 20/20– OD, 20/25– OS at near. The current prescription was: OD +1.75 – 0.50 × 005, OS +2.00 – 0.50 × 120, with a +2.25 progressive add OU. Refraction yielded no significant change. Pupils, confrontation fields, and internal ocular health were normal. External structures were also normal, with the exception of superior and inferior lid edema, greater on the right side. Exophthalmometry readings were 18 OU, which was within the normal range.

On extraocular muscle testing, full movement of the left eye was possible, but the right eye could not elevate above primary position. A forced duction test (attempting to elevate the topically anesthetized eye using forceps) was positive OD, indicating a restrictive cause of the upward gaze limitation. Cover testing at far, with the patient instructed to fixate the left eye's image when diplopia was present, showed constant right hypotropia and a slight eso component. The deviation measured 15^{Δ} BUOD with 2^{Δ} BO (OS fixating). When she attempted to fixate with her right eye, the patient was very uncomfortable because it took great effort to elevate that eye to primary position. As predicted by Hering's law, the left eye received excessive innervation as well, increasing the magnitude of the resulting left hyperdeviation. A near cover test in the reading position revealed left hyperphoria measuring 2^{Δ} BUOD. The double Maddox rod test measured a 10° right excyclodeviation, which explained why the patient reported that the diplopic images were slightly rotated with respect to each other.

Subjective testing to determine the minimum amount of prism that would allow fusion was performed using a transilluminator as a target and a red lens before one eye. For distance viewing, the patient preferred 15^{Δ} BUOD and no horizontal prism. For near viewing in the reading position (through the appropriate area of her progressive lenses), she preferred no prism. Despite the neutralization of her diplopia with prism, the patient did not have perfect fusion because of the torsional component of the deviation.

An MRI confirmed that the upward gaze limitation OD and the resulting vertical devia-

tion were secondary to Graves' ophthalmopathy affecting the right inferior rectus muscle. The lid edema was also a sign of Graves' ophthalmopathy. Because of the nature of this disease, there was a strong possibility of the strabismus changing in magnitude. The patient had adequate visual acuity with her habitual spectacles, therefore, I elected not to prescribe new lenses at that time. Instead, I applied 15$^{\Delta}$ BU in Fresnel form to the top half of the right lens.

One advantage of using a Fresnel prism is that it could be changed easily if the deviation were to change. Use of Fresnel prism also made it easy to prescribe prism for the top half of the lens only, and allowed a relatively large amount of prism to be used over just one eye. Monocular use prevented bilateral reduction of visual acuity and contrast sensitivity that can result from Fresnel prism. It would not have been advantageous to apply base-down prism to the left lens instead, because more prism would have been necessary to compensate the larger strabismic angle that resulted when the restricted right eye was forced to fixate. No specific treatment was advised for the torsional component; this problem cannot be addressed using prism. However, the patient could compensate adequately for this component when the vertical one was neutralized. Cyclovertical vergence therapy was a future option.[5] However, the patient's consulting neuro-ophthalmologist had advised her not to try to force the right eye to elevate while orbital inflammation persisted, possibly because of the increase in intraocular pressure that might result.[29] Further, the patient experienced significant discomfort when attempting to move her right eye upward, so vision therapy to improve vertical vergence ability was not a viable option at that time.

The patient declined occlusion as a temporary option for eliminating the diplopia, although she occasionally shut her right eye when performing certain visual tasks such as inserting a key into a lock (to avoid transient diplopia that occurred in all but the specific gaze position for which prism had been prescribed). She generally preferred having some unstable binocular vision to the total lack of stereopsis and reduced peripheral field that resulted from monocular occlusion. The patient also voluntarily (but reluctantly) gave up driving and biking because she lacked consistent fusion. Fusion was particularly difficult to regain when saccades were required in various directions away from primary gaze.

One month later, the patient reported that the diplopia was worsening at both far and near, despite her prism. At this point, her condition had progressed to the degree that she required 20$^{\Delta}$ BUOD for far and 2$^{\Delta}$ BUOD for reading. It is not likely that prism adaptation was occurring because, first, there was an unresolved disease process causing the diplopia, and second, patients with symptomatic binocular disorders tend to have reduced ability to adapt to prism.[28] I thus prescribed sector Fresnel prisms: 20$^{\Delta}$ BUOD on the upper part and 2$^{\Delta}$ BUOD on the lower portion of the right lens, with the prisms meeting just above the near vision area of the lens.

One month later, the patient was again experiencing diplopia, but only in the reading position. At this time, she needed 8$^{\Delta}$ BUOD on the lower part of the right lens, along with the 20$^{\Delta}$ BUOD on the upper part. Six weeks later, the diplopia in the reading position required 12$^{\Delta}$ BUOD for neutralization, as the deviation continued to become more comitant. The distance deviation remained neutralized by 20$^{\Delta}$ BUOD. The patient had recently undergone successful radioactive iodine treatment for the hyperthyroid condition, and no longer needed to take Tapazole. With return to a euthyroid state, there was hope that the muscle restriction might regress over time. Meanwhile, the patient was pleased with the binocular vision afforded by easily changed Fresnel prisms.

The patient returned in 2 months, suspecting that she might actually need less prism because she was aware that her right eye could now elevate slightly and she was experiencing diplopia at distance with her current prism. Cover test measurements were 12$^{\Delta}$ BUOD at distance and 10$^{\Delta}$ BUOD in the reading position. She subjectively preferred 10$^{\Delta}$ BUOD for all distances, and fusion was stable in all gazes. At this time, I prescribed a 10$^{\Delta}$ BUOD Fresnel prism over the entire right lens. This prism power could easily have been ground into the patient's spectacles, but we decided to wait for stabilization at a (hopefully) lower power. At this point, the patient

felt confident enough about her binocularity that she could cautiously resume biking and driving a car.

Two months later, the right eye showed additional elevation ability and the patient preferred 8^{Δ} BUOD for all distances. In another 2 months, the deviation measured 7^{Δ} BUOD and the patient preferred 5^{Δ} BUOD for constant wear. Thus, she was using her own vertical vergence ability to supplement the prism. Rather than continuing to improve, however, the patient then experienced fluctuations in prism power needed, and was able to apply the 5^{Δ} or 8^{Δ} prisms as needed. She also went without prism on occasion, as she could sometimes compensate for the deviation on her own. Her progress has reached a plateau, and she may soon be willing to try vision therapy. Because of the fluctuating nature of Graves' disease, the prognosis for total resolution is guarded. Meanwhile, the patient remains grateful for the option of changing Fresnel prism powers.

CONCLUSION

Prism is a powerful tool in the management of certain cases of strabismus as well as nonstrabismic binocular disorders. Numerous methods are available to determine a useful prism prescription for a patient, depending on the patient's specific condition. Prismatic prescription is only one of several possible treatment modalities, and is often used as a temporary measure to allow comfortable fusion until appropriate skills are developed through vision therapy or until a health problem has stabilized (e.g., Graves' disease). However, an optimal prismatic prescription can be a permanent means of alleviating discomfort for some patients, particularly if vision therapy is not possible for these individuals.

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VISUAL VIGNETTE

PEOPLE WITH SPECTACLES SEEM DULL AND INTELLIGENT

Research has shown that faces with spectacles are perceived as less attractive, less friendly, shyer, and meaner than those without them. These results are consistent with the physical attractiveness stereotype, according to which positive evaluations for personality and intelligence are more likely to be given to attractive than unattractive faces. However, somewhat paradoxically, spectacles have also been linked to intelligence, honesty, and reliability.

In our experiment, college undergraduates judged that faces with spectacles were most frequently perceived as dull, intelligent, and shy, whereas faces without glasses were most often perceived as friendly and untrustworthy.

Perceptual and Motor Skills
Stuart J. McKelvie