Article

Prescribing Vertical Prism: How Low Do You Go?

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Attention to case history combined with careful examination will usually reveal the patients for whom prescription of vertical prism should be considered. Techniques used to determine the amount of vertical prism to prescribe include the magnitude of the vertical heterophoria, the vertical vergence ranges, flip prism tests, or vertical fixation disparity measurements. Determination of the vertical associated phoria at distance and near (and in downgaze when needed) has come to be the most recommended factor in determining the prism to prescribe for correction of vertical heterophoria in everyday clinical practice. What is not currently known is how small a prism might be of clinical use, and what the patient response would be to such a correction. I determined vertical prism based on near vertical fixation disparity measures for 15 patients and provided each of them two sets of glasses, one with prism and one without. Prism prescriptions ranged from 0.5 prism diopters (p.d.) to 2.0 p.d. and the same frame and interpupillary distance was used in each pair of glasses. Neither the patients nor the examiner knew which pair had the prism. Fourteen of fifteen patients preferred the glasses with prism ($p > .01$). With prism, symptoms assessed with a standardized questionnaire improved ($p > .01$) and visual performance determined using a standardized visual task increased ($p > .01$ for near/far copying; $p > .02$ for prolonged testing).

Clinicians become concerned that a vertical prism prescription might be required when a vertical heterophoria co-exists with symptoms such as frequent loss of place while reading or occasional vertical diplopia. Numerous techniques have been used to determine the amount of prism to prescribe in these cases. For example, recommendations have included using one or more of the following factors: the magnitude of the vertical heterophoria, vertical vergence ranges, flip prism tests, or vertical fixation disparity measurements. However, in spite (or perhaps because) of the numerous recommendations, the precise methods used for prescribing vertical prism have not been well defined. As a result, prescription of vertical prism is often deferred in clinical practice because of uncertainty on the part of the clinician as to the best course of action. In this paper I describe research that indicates patient preference for prescriptions containing small amounts of prism determined using fixation disparity testing.

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METHODS OF DETERMINING VERTICAL PRISM CORRECTION

Magnitude of the Heterophoria

The magnitude of the vertical heterophoria may be used to determine the vertical prism prescription. Dissociating techniques available to measure vertical heterophorias include the cover test,[1] Maddox rod,[2] and von Graefe[3] test. The primary advantage of these tests is that they are easily used and familiar to most clinicians. Table 1 lists some advantages and disadvantages of each test.

Unfortunately, there is considerable variation in the recommendations that have been made by clinical researchers as to how dissociated vertical heterophoria findings might influence the amount of vertical prism prescribed. For example, Hansell and Reber[4] recommend prescribing prism to correct one third of the hyperphoria. Emsley[5] and Maddox[6] suggested prescribing prism equal to two thirds of the vertical heterophoria while Giles[7] advised correcting three-fourths of the vertical heterophoria. Duke-Elder[8] and Peter[9] believed that a nearly complete correction (or perhaps 0.5 p.d. less) should be given for hyperphorias greater than 1 p.d. and Hugonnier et al.[10] recommended complete correction when the vertical deviation was small.

Krimsky[11] did not suggest a specific amount but stated that each case should be considered individually and the weakest prism that would relieve symptoms and restore binocularity should be used. The method used to determine the "weakest" prism is not clear, but an anecdotal technique involves placing a prism with its base in the appropriate direction in the trial frame along with the refractive correction and evaluating the patient's visual acuity or comfort. The disappointing lack of standardization and the variety of guidelines for using dissociated vertical heterophoria measurements to prescribe vertical prism indicate the need for a more definitive management regimen.

TABLE 1. Tests of Dissociated Vertical Heterophoria

Test	Advantage	Disadvantage
Cover Test	Rapid, objective	Difficult to see small deviations, requires accurate fixation
Maddox Rod	Rapid, accurate	Suppression invalidates, subjective
von Graefe	Rapid, accurate	Suppression invalidates, subjective

Vertical Vergence Ranges

Methods of determining the amount of prism using measures of vertical vergence ranges vary from balancing the vertical vergence ranges (described below) to that of Tait,[12] who recommended prescribing vertical prism that requires the patient to use one fifth of the vertical fusional amplitude to oppose the deviation. Another method involves prescribing prism to balance recovery values, when they agree with the direction of the heterophoria.[13]

Balancing vertical vergence measurements has probably been the most frequently used method for determining a vertical prism correction. With the patient observing a horizontal line of letters, vertical prism power is slowly increased using base-down prism over one eye (supravergence) until diplopia is reported and then decreased until fusion recovers. The measurement is repeated using base-up prism over the same eye (infravergence). Patients without a vertical heterophoria typically have supravergence and infravergence ranges that are approximately equal[14] (infravergence equals supravergence). Prism that balances the break values may be determined by:

$$\text{Correcting prism} = (\text{base-down to break} - \text{base-up to break})/2$$

If the resultant is plus, prism is prescribed base-down; if minus, it is prescribed base-up. For example, if there is 3 p.d. right hyperphoria and 6 p.d./3 p.d. right supravergence and 4 p.d./2 p.d. right infravergence, then 1 p.d. base-down OD would equalize the break values [(6 p.d. – 4 p.d.)/2 = 2 p.d./2 = 1 p.d.].

A potential problem arises because of variability of vertical vergence measurements. Vertical heterophorias and fusional vergence amplitudes may be affected by residual tonicity[15,16] with a result that vertical vergence re-

sponses are affected by the initial muscles stimulated. For example, if left supravergence is measured first, left infravergence may be reduced by the amount that tonicity is altered by the supravergence stimulation. Vertical vergence measures may also be changed by factors including the speed the prism disparity is introduced,[17] the distance at which the measurement is taken,[18] and the actual vertical deviation.[13a] The dependence of vertical vergence ranges on the measurement technique used, and the possibility that residual tonicity may affect the measurement results, suggests that vertical prism prescription decisions based on the vertical vergence range measurement may not always yield a veridical prism prescription.

Flip Prism

Eskridge[19] suggested that a 3 p.d. handheld prism could be used for determining the amount of vertical prism to prescribe. As the patient observes a horizontal row of 0.75M print, the prism is alternated between base-down to base-up while the patient observes changes in the vertical separation of the images. The direction of the prism base when the images appear closest together should correspond with the direction of the dissociated vertical heterophoria. The prism power prescribed is determined by increasing the power of a diagnostic prism base-down in front of the appropriate eye until the image separation is equidistant for successive presentations.

The flip prism test measures the deviation while the patient is diplopic. Fusion is known to cause changes in the binocular alignment of the eyes because of vergence adaptation.[20] As a result, assessment using diplopic images seen during the flip prism test may overestimate the prism required.

Vertical Associated Phoria/ Fixation Disparity

The principle of fixation disparity testing is to measure the direction and magnitude of the fixation disparity as prism is interposed in various powers and orientations. Because the deviation is measured while the patient is fusing, fixation disparity tests are thought to correlate best with symptoms of vertical heterophorias, just as they do for horizontal deviations.[21,22] The most useful component of fixation disparity testing in diagnosis of vertical deviations is measurement of the vertical associated phoria[23] (prism to reduce the fixation disparity to zero). During most tests the majority of the visual field is visible to both eyes and, thus, can be fused. However, a portion of the central field is only visible to one eye or the other, either because of polarized filters or a septum.

METHODS

In this study I used the technique of Worrell, Hirsch, and Morgan[24] in which they provided 43 patients with two sets of lenses for one week each, and asked them to choose which set was preferred. One set of lenses contained no prism, the other set contained the prism that satisfied Sheard's criterion. This technique has the advantage of combining many possible clinical variables into one subjective decision.

Fifteen patients were selected from my private practice from among patients with near symptoms and a vertical fixation disparity at near. Each was offered the opportunity to participate in an experiment which would involve three subsequent visits along with filling out three visual symptoms questionnaires[25] (Appendix 1) and taking three visual performance tests (Appendix 2). The patients were told that they were to wear one set of lenses continuously for two weeks and another set that would be identical except for one variable for another two weeks. At the end of the fourth week each would decide which set of lenses was preferred and would be given that set to keep. Questionnaires and visual function tests were given at each office visit.

Patients were limited to those who: (a) showed vertical fixation disparity without suppression on the near Mallett unit; (b) reported near symptoms; (c) had not worn prism previously; and (d) had no history of eye disease, eye injury, eye surgery, strabismus, aniseikonia or amblyopia. After noncycloplegic subjective refraction, the minimum amount of prism required to reduce the patient's vertical fixation disparity to zero with the near Mallett unit was determined according to the proce-

dure described below. Vertical vergence ranges were not assessed. The visual function test and the visual symptom questionnaire were filled out. The patient then selected a frame and two sets of lenses were ordered, one containing the correction that was optimum plus (least minus) for best distance visual acuity, and the other containing the same distance correction and the full amount of prism determined using the technique described below. Both sets of lenses had identical base curves recommended by a manufacturer of corrected curve minus cylinder lenses. In order to minimize prism distortions, antireflective coatings were provided on each pair of lenses. A random number table was used to select the order in which each patient received the two sets of lenses. A technician received the lenses from the laboratory, checked them, and inserted the predetermined set in the patient's frame. She gave the spectacles to me to dispense to the patient; neither I nor the patient knew which prescription it was. The patient was instructed to wear the spectacles continuously for distance and near vision. The lenses were exchanged after two weeks and the visual function test and symptoms questionnaire repeated. At the end of the second two-week period, the patient again repeated the visual function test and symptoms questionnaire and chose which lenses were preferred.

Determining Vertical Associated Phoria

To evaluate the vertical associated phoria, the patient observed the horizontally aligned lines on the near Mallett unit and was asked if the lines appeared to be straight across from each other. A base-down prism was placed before the eye that saw the higher line until the lines were aligned. The reverse was true if a line appeared lower. Measurement of the vertical associated phoria was complete when there was stable alignment of the nonius lines through the vertical prism. The amount and direction of the prism was recorded along with information concerning whether one eye or the other tended to deviate (i.e., right or left hyper) and whether more prism was required before one eye or the other to reduce the fixation disparity to zero.

To insure that the endpoint had been reached, vertical prism was interposed until the nonius lines seemed to be stable through the prism. Then the patient closed both eyes for one to two seconds. The patient's task was to notice, when the eyes were first opened, whether the nonius lines were aligned exactly or whether one line or the other moved up or down to become aligned. The open-close eyes procedure was repeated and the prism modified in 0.25 p.d. steps until the lines appeared stable upon opening the eyes and subsequently remained aligned at all times. The prism was prescribed before the appropriate eye (Table 2, minus = base down left, plus = base down right).

RESULTS

Fifteen patients (average age = 29.87 ± 10.21) with vertical fixation disparity participated in the study. Fourteen of the fifteen indicated a preference for the lenses with prism; a result that would have occurred by chance less than one time out of 100 ($X^2 = 7.72$; df = 1, $p > .01$). It is clear that for the patients in this sample, near vertical associated phoria measures provided clinically useful information for determining a vertical prism correction.

Figure 1 indicates that, in most cases, the prescribed prism correction was approximately equal to but slightly smaller than the dissociated phoria, as measured by Maddox rod testing. However, for patients 1 and 8, the prism prescription determined by associated testing was much smaller than the dissociated phoria measure. For patient 15, associated measures indicated a larger prism correction than dissociated phoria measures would suggest (Table 2).

Visual performance increased for all patients when they wore the prism correction, as seen in Table 2. Overall there was a small increase in performance from the initial testing (e.g., 77.13 ± 15.54 to 81.53 ± 12.98 on near/far copying) to the testing without prism which can be attributed to a "practice effect," where performance on the test increases because of familiarity with the test procedures, a common result with many clinical tests. This small increase was neither clinically nor statistically significant. However, both the near/

TABLE 2.

Patient No.	Age	Dissociation Phoria	Prism	Near/Far			Prolonged Teaming			Choose Prism Rx	Symptoms		6 mo FU	Adapt
				Test 1	w/o Prism	With Prism	Test 1	w/o Prism	With Prism		w/o Prism	With Prism		
1	21	–2.25	–1.00	75	81	89	70	79	94	Y	S	S		
2	14	–0.75	–0.75	67	65	82	98	102	120	Y	D	S	–0.75	N
3	18	1.50	1.25	78	87	95	77	88	101	Y	S	D		
4	51	1.50	1.50	81	86	94	81	86	87	Y	I	D	1.50	N
5	35	–0.50	–0.50	68	74	62	95	89	105	Y	S	S	–0.50	N
6	42	–0.50	–0.50	45	55	73	88	89	112	Y	S	S	–0.50	N
7	19	0.50	0.75	106	100	104	73	81	98	N	S	D	No Prism	
8	27	1.75	0.50	98	105	114	70	78	75	Y	S	D	1.00	Maybe
9	30	1.75	2.00	87	90	102	90	93	108	Y	D	D	2.00	N
10	29	–1.00	–1.00	67	81	89	73	84	93	Y	D	D	–1.00	N
11	40	1.00	1.00	71	72	84	74	80	86	Y	S	S		
12	23	1.25	1.00	62	70	80	68	73	84	Y	I	D	1.00	N
13	27	0.75	0.75	93	89	99	71	72	72	Y	S	D	0.75	N
14	34	1.00	0.75	88	87	100	54	61	66	Y	I	D	0.75	N
15	38	0.75	1.25	71	81	95	106	103	99	Y	S	D		
Mean	29.87			77.13	81.53	90.80	79.20	83.87	93.33	14-Y	3-D	10-D		
SD	10.21			15.54	12.98	13.17	13.69	11.07	15.22	1-N	3-I	5-S		
											9 = S			
						T = 2.66			T = 2.41	X = 7.72		X = 6.64		
						P > .01			P > .02	P > .01		P > .01		
						df = 14			df = 14	df = 1		df = 1		

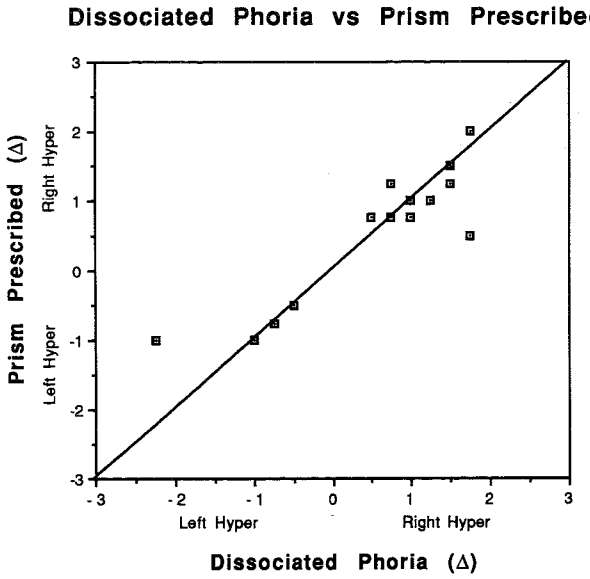

Fig 1. For most patients the prescribed prism correction was approximately equal to or slight smaller than the dissociated phoria, as measured by Maddox rod testing.

far copying (81.53 ± 12.98 to 90.80 ± 13.17; $t = 2.66$, $df = 14$, $p > .01$) and the prolonged testing (83.87 ± 11.07 to 93.33 ± 15.22; $t = 2.41$, $df = 14$, $p > .02$) were significantly improved when prism was worn.

The symptoms questionnaire (Appendix 1) rates symptoms in categories in such a way that a response in any one category suggests a difference in symptoms of 25% when compared to the next category (e.g., a response of 2 on question 4 related to eyestrain indicates 75% frequency of symptoms, while a response of 3 indicates a 50% frequency). Thus a shift from one category to another, which represents a 25% change in symptoms, was considered to be clinically significant. Using this technique 10 patients reported fewer symptoms while wearing prism glasses, whereas only 3 reported fewer symptoms with no prism, a statistically significant decrease in symptoms reported ($X^2 = 6.64$, $df = 1$, $p > .01$).

Long term follow-up (at least 6 months) was available for 10 of the patients. These ten retained their need for vertical prism and continue to enjoy reduced symptoms. The amount of prism required stayed stable for all but one of these patients. The exception was patient 8 who required a small increase in prism (from 0.5 to 1.0 p.d.) after one year of wear.

DISCUSSION

Based on these results, it is prudent to prescribe symptomatic patients prism equal in magnitude to the near vertical associated phoria measure. Prescription of as little as 0.5 p.d. vertical prism seems to have beneficial effects on fusion as well as patient comfort and performance. Because these measures are easily made and successfully reduce symptoms, determination of the prism needed based on near vertical associated phoria measures can be used confidently to decide the amount of prism to prescribe for patients with vertical heterophoria.

Assessment of the vertical associated phoria has been described as a method for the prescribing of prism for vertical heterophorias for more than 30 years. In general, when the lines remain aligned right after the eyes have been opened, the amount of prism that reduces the fixation disparity to zero can be prescribed with confidence that it will dramatically relieve the patient's symptoms. For example, Morgan[26] measured the associated phoria at distance by assessing the patient's ability to detect alignment differences observed in a row of 20/30 letters interrupted by a septum. More than 98.6% of the 215 patients tested noticed the difference created by a 1/2 p.d. prism. Prism based on the perceived vertical misalignment was prescribed for 15% of the patients that Morgan tested and over 90% of them successfully wore the prism. The results of Morgan concerning prescription of vertical prism[26] were supported by Elvin[27] and Tubis.[28] My results confirm those of previous investigators and demonstrate that even very small corrections have significant beneficial effects.

PRISM ADAPTATION

When vertical prism is placed before one eye of a person with normal binocular vision and no vertical heterophoria, re-measurement of the induced vertical deviation after 15 minutes will indicate a resultant deviation that is less than the amount of prism.[29] This adaptation to vertical prism by persons with normal binocularity has been shown by Rutstein and Eskridge[30] and others[17,31] and individual differences in the rate and amount of such prism adaptation have been observed.[32] Nearly 80% of patients with normal binocular vision show these vertical adaptive responses.[33] However, because patients who completely adapt to vertical prism typically have normal binocularity,

they seldom report symptoms of binocular distress.[34] Schor[35] demonstrated that it is the symptomatic patients who do not adapt adequately to prism.

Based on this research in which 9 of 10 patients who had long-term follow-up did not adapt to the small vertical corrections used, it seems prudent to prescribe the prism found on associated phoria testing for symptomatic patients needing small prism prescriptions. It is possible that small increases in prism may be required by some patients.[25,36] However, increases in the prism required are probably not adaptation in the classic sense but rather are similar to clinical observations noted when prescribing plus lenses for patients with latent hyperopia. There is an increase in plus that is not adaptation but rather occurs because the entire correction was not prescribed initially.

SUMMARY

Symptoms of uncompensated vertical heterophoria may be present in up to 20% of patients.[25] Attention to case history combined with careful examination will usually reveal which patients will benefit from prescription of vertical prism. Based on the results presented, determination of the vertical associated phoria at distance and near (and in downgaze when needed) is a viable factor in analyzing the role of vertical heterophoria in everyday clinical practice. Even very small prism prescriptions based on measures of the vertical associated phoria are useful in alleviating symptoms of vertical deviations.

Although the results demonstrate the usefulness of even very small prism prescriptions in improving patient symptoms, they do not test whether a vertical prism prescription determined using associated phoria methods provides better results than that determined using other methods (such as the flip prism test, equalizing vertical vergence ranges, or even simply taking a portion of the vertical phoria). Further, while the results show that patients prefer and perform better with small vertical prism prescriptions, the results do not address the possibility that vertical vergence training might be an equally efficacious treatment. They do, however, indicate that symptomatic patients showing even 0.5 p.d. vertical deviation should have some type of intervention considered.

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APPENDIX 1

Symptoms Questionnaire

1. How long can you do "nearwork"(i.e., reading, writing, sewing, etc.) with no discomfort (e.g. headaches, eye ache, burning, stinging, watering, blurriness, double vision, loss of concentration, tiredness, or falling asleep)?
   a. up to 15min
   b. up to 30 min
   c. up to 1h
   d. up to 2h
   e. at least 3h
2. How often do you get headaches when you do nearwork?
   a. every time (100% of the time)
   b. very often (75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25 % of the time)
   e. never (0% of the time)
3. If you experience headaches during nearwork, how bothersome are these headaches (i.e., the degree to which they interfere with your normal functioning)?
   a. extremely bothersome
   b. very bothersome
   c. moderately bothersome
   d. mildly bothersome
   e. mininally bothersome
4. Do your eyes pull, ache, or water when you nearwork?
   a. every time I read (100% of the time)
   b. very often (about 75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25% of the time)
   e. never (0% of the time)
5. Does the reading material ever become blurred, run together, or jump when you do nearwork?
   a. every time (100% of the time)
   b. very often (about 75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25% of the time)
   e. never (0% of the time)
6. Do you ever skip words or lose your place in the middle of a line while reading?
   a. every time (100% of the time)
   b. very often (about 75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25% of the time)
   e. never (0% of the time)
7. Do you ever read the same line twice while reading (when going back to the beginning of next line you find yourself on the line just read)?
   a. every time I read (100% of the time)
   b. very often (about 75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25% of the time)
   e. never (0% of the time)
8. Do you ever skip a line while reading (when going back to the beginning of the next line)?
   a. every time I read (100% of the time)
   b. very often (about 75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25% of the time)
   e. never (0% of the time)
9. Does the reading material ever become double when you do nearwork?
   a. every time (100% of the time)
   b. very often (about 75% of the time)
   c. often (about 50% of the time)
   d. occasionally (about 25% of the time)
   e. never (0% of the time)
10. Do your eyes feel tired and/or do you lose your concentration when you do nearwork?
    a. every time (100% of the time)
    b. very often (about 75% of the time)
    c. often (about 50% of the time)
    d. occasionally (about 25% of the time)
    e. never (0% of the time)

APPENDIX 2

Visual Performance Test

a b c d e f g h j k l m n o p q r s t u v w x y z

jio nb mic xda npn lkl avx nju bxd ewz skl nvg gfd bdeg	124
uyt dasb kcs far hgec pfnc qwzx opnc hsdr hyw hdf mp	125
hpdm rtoec hiu wiep wxc lkje dhf nbf cxv bedf phr mnt	126
vce cxw opl egq wxu mpm edgu guyc whp yhn exc bvr numu	127
tc uji uy mopl bghei wex cnvr ewr dfs xsd asz zsj f pj	128
swer tfg sxd dju btyn ipjl csk mwr pre dkr wxc mkrt r	129
awe drf gtr mlr tew celb nrel vne mew zxtme wec vmne	130
xrtn xtwp ctyu bnut wrc ctv bon vctr hnt lmbn xt rotg	131
vtn ctop rctp xtyx cty opc pq vt cwed wqn opq svb dru	132
cde frt hnt yru detr cd ghys mupm syn mnu banv stm pom	133
sbr pmtn whtx wnmth mnuc xty puabn rtyu mnwu cbluv xasy	134
myuv cvt xtu plwj hgn cvuw rtn czt plik mxba nhj fxh r	135
wch ctt chu nhg fgw rxv ghyt rtw sedcy mun pumz xty z	136