1040-5488/09/8602-0153/0 VOL. 86, NO. 2, PP. 153–156
OPTOMETRY AND VISION SCIENCE

ORIGINAL ARTICLE

Effectiveness of Base in Prism for Presbyopes with Convergence Insufficiency

Bruce Teitelbaum*, Yi Pang†, and Joseph Krall*

ABSTRACT

Purpose. Although the treatment of symptomatic convergence insufficiency (CI) with base-in (BI) prism in adults has a strong theoretical foundation, there have been very few studies addressing its efficacy. The purpose of this study was to investigate whether the application of BI prism, using a novel progressive addition lens design which incorporates BI prism in the near portion only, could help alleviate the symptoms in presbyopes with CI.

Methods. A total of 29 symptomatic CI subjects aged 45 to 68 years were examined. All subjects took the CI Symptom Survey V-15 (CISS) and scored ≥16 points. Each subject was assigned two pairs of progressive addition glasses made by the same manufacturer in a randomized sequence, one with BI prism and one with the same lens prescription but no prism (placebo). Subjects wore each pair of glasses for 3 weeks and completed the CISS at the end of the 3rd week. Symptom level measured with CISS was the major outcome measure.

Results. The mean (standard deviation) CISS score was 30.21 (9.30) at baseline and decreased to 13.38 (9.44) with the BI-prism glasses, vs. 23.62 (10.76) with the placebo glasses. There were significant differences between the baseline survey score and the score with the BI-prism glasses ($p < 0.0001$) and between the score with placebo glasses and the one with BI-prism glasses ($p = 0.001$).

Conclusions. The progressive addition glasses with BI-prism were found to be effective in alleviating symptoms of presbyopes with symptomatic CI.

(Optom Vis Sci 2009;86:153–156)

Key Words: convergence insufficiency, exophoria, associated phoria, prism, presbyopia

The treatment of convergence insufficiency (CI) by orthoptics/vision training has been well accepted by optometrists. Grisham[1] reviewed the literature and reported a combined improved and cure rate of 93%. For those patients who are unable to avail themselves of this treatment because of time or financial constraints, the prescribing of base-in (BI) prism has served as an alternate form of management.[2]

The treatment of convergence disorders using prism was proposed over100 years ago by Percival[3] who developed a treatment algorithm based on the heterophoria measurement and its compensating vergence. Sheard[4] modified the algorithm using the same measurements and proposed that the fusional reserve must be twice the amount of the heterophoria. The amount of prism to be prescribed was further refined when the concept of fixation disparity was introduced. This method differed from the previous two in that the measurement of the deviation was defined in minutes of arc and the measurement was taken while the patient was binocular. Mallett[5] proposed the neutralization of the fixation disparity with prism (associated phoria), whereas Sheedy and Saladin[6] proposed a prism correction that would place the patient demand on the flat portion of the forced vergence fixation disparity curve. Regardless of the method chosen, there have been very few clinical studies to assess the efficacy of BI prism in the treatment of CI and most have focused on a pediatric population.[7–9]

Stavis et al.[7] concluded that BI prism improved reading ability and comfort in a group of children between the ages of 8 and 18 with "mini-CI," which was defined as having an exophoria at near of at least 4Δ greater than the exophoria at distance. Lie and Opheim[8] also found a decrease in subjective complaints in a group of heterophoric subjects corrected with prism. Their patient population was overwhelmingly pediatric in the age range of 10 to 18 years. Scheiman et al.,[9] in a randomized double-blind study of CI found no difference in CI symptoms between subjects wearing BI reading glasses and placebo reading glasses. Once again, the study

*OD, FAAO
†PhD, OD, FAAO
Illinois College of Optometry, Chicago, Illinois (BT, YP) and Private Practice, Mitchell, South Dakota (JK).

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.optvissci.com).

was confined to children whose ages ranged from 9 to 18 years. Finally, Worrell et al.[10] compared the responses of 43 patients with heterophoria, who did not meet Sheard criterion, by having them compare spectacles with and without prism. The amount of prism prescribed allowed the patients to satisfy Sheard criterion. There was no significant difference in CI symptoms when wearing prism vs. no prism in the 24 patients with CI. Five of the 24 patients in the study were presbyopic and all but one of the five preferred the prism prescription.

The purpose of this study was to investigate whether or not prescribing BI prism was successful in alleviating symptoms in presbyopes with CI. We used fixation disparity and specifically the associated phoria to determine the amount of prism to be prescribed. Previous studies[11,12] have found this measurement to be superior to heterophoria in the correlation of symptoms in patients with convergence disorders.

METHODS

Twenty-nine subjects from a private optometric practice in South Dakota were recruited for the study. The study protocol (see Appendix A, available online at http://links.lww.com/A663) and informed consent forms were approved by the Illinois College of Optometry Institutional Review Board and followed the tenets of the *Declaration of Helsinki.* Informed consent was obtained from all subjects in the study.

Potential subjects in the practice whose age was ≥45 years were asked to complete the CI Symptom Survey-V15 (CISS-V15), which was developed and validated by the Convergence Insufficiency Treatment Trial Study Group and consists of 15 questions which are scored from 0 to 4 based on the severity of the symptoms.[13] (see Appendix B, available online at http://links.lww.com/A664) The survey was self administered. A comprehensive eye examination including refraction was performed for the patients whose CISS-V15 score was higher than 16 to select the subjects who met the inclusion criteria. To be qualified for the study, patients had to have an exophoria at near of at least 4Δ greater than at distance. The detailed inclusion and exclusion criteria for the study are listed in Table 1. The diagnostic data for the 29 subjects in the study were collected by one of the authors (JK) and included:

- Dissociated heterophorias at distance and near by cover test.
- Dissociated heterophorias at distance and near by the Modified Thorington method.
- Associated phoria at near tested with the Bernell binocular refraction slide.
- The break and recovery value of the near point of convergence using accommodative target.
- Positive fusional vergence at near measured with Risley prisms.

Patients were assigned two pairs of progressive addition lenses (PAL) fabricated by Signet Armorlite with an updated lens prescription, in a randomized sequence. Prism was prescribed in only one pair of glasses with other pair serving as a placebo. The study had a double-blind design as neither the examiner nor subject was aware of the glasses assignment. The amount of prism prescribed was based on the associated phoria and was always within 0.75Δ of the associated phoria value. The amount of prism was split equally between the two eyes. The treatment PAL was a novel design, not commercially available, that confines the prism to the near portion only. This lens uses the design platform of the company's commercially available PAL with the exception of BI prism. The amount of prism that can be incorporated in the near portion of this PAL is dependent on base curve and add power and can range from 0.375 to 0.75Δ per lens. The prism power is gradually introduced along the corridor of the PAL and reaches its maximum power at the point of maximum add power. Because of the limitations on the magnitude of prism that could be incorporated in this design, additional prism was added to both the distance and near prescriptions if needed. If additional prism was needed, an associated phoria at distance was measured through the tentative prescription. To minimize symptoms unrelated to the CI, an ortho fixation disparity at distance was necessary for the subjects to continue in the study. Subjects wore one pair of PAL for 3 weeks and completed the CISS-V15 at the end of the 3rd week. They were then given the other pair of PAL to wear for 3 weeks after which the survey was completed again. Therefore, a baseline, placebo, and treatment symptom score was tabulated. The CISS-V15 score was the primary outcome measure. An analysis of variance was performed to make comparisons within the CI symptom scores of the baseline, placebo, and treatment groups. Statistical sample size calculation was performed using the pilot data (the first 18 subjects) to determine the number of subjects required in the study to detect differences in CI symptom scores. A sample size of 21 would be required to give 80% power at the 0.05 level, and 28 subjects are needed to give the 90% power. Hence, a sample size of 29 subjects was determined to be adequate for this study.

TABLE 1.
Eligibility and exclusion criteria

Eligibility criteria
Age ≥45 yr.
Best-corrected visual acuity of 20/25 or better in each eye at distance and near.
Currently wearing progressive addition lenses.
A minimum of +1.50 add in subjects' habitual prescription.
A minimum of 2 h spent on reading or close work on a daily basis.
Associated phoria at near ≥1Δ BI.
No associated phoria with the potential BI prism at distance.
Exophoria at near at least 4Δ greater than at distance.
CI symptom score ≥16.
Willingness to participate in the study and wear two pairs of eyeglasses consecutively.
Exclusion criteria
Constant strabismus at distance or at near.
CI previously treated with prism.
Vertical heterophoria greater than 1Δ.

RESULTS

The baseline characteristics of the subjects are displayed in Table 2. The characteristics of the clinical measurements are listed in Table 3. Nine patients had prism confined to the near portion

TABLE 2.
Demographic characteristics of study subjects (n = 29)

Characteristic	Number	Mean	SD
Gender			
Female	25		
Male	4		
Race			
White	29		
Age (yr)		54.14	5.90

SD = standard deviation.

TABLE 3.
Characteristics of clinical measurements on study subjects

Characteristic	Mean	SD
Exophoria (Δ)		
Distance	2.24	1.75
Near	11.17	3.49
Associated phoria at near (Δ)	2.29	1.31
NPC break value	21.52	6.11
Positive fusional vergence at near break value	14.79	7.23
Prism power to be prescribed (Δ)	1.97	1.29
Prism in distance portion	1.15	1.26
Power of add (D)	2.04	0.30
Refractive error (spherical equiv.) (D)		
Right eye	−0.51	2.00
Left eye	−0.66	2.00

SD = standard deviation; D = diopter; Δ = prism diopter.

TABLE 4.
Comparison of CI symptom scores in baseline, placebo, and treatment groups

CI symptom score	Mean	SD	95% Confidence interval for mean	
			Lower	Upper
Baseline	30.21	9.30	26.67	33.75
Placebo	23.62	10.76	19.53	27.71
Treatment with prism	13.38	9.44	9.80	16.97

SD = standard deviation.

only, whereas the remaining 20 patients had some BI prism in both the distance and near portions. The mean total prism prescribed for all 29 patients was 1.97 ± 1.29Δ, whereas the mean prism at distance was1.15 ± 1.26Δ. The CI symptom scores for the three groups are displayed in Table 4. The mean (standard deviation) CI Symptom Score for the baseline group was 30.21 (9.30), for the placebo condition was 23.62 (10.76), and for the treatment (prism) condition was 13.38 (9.44). An analysis of variance showed a statistically significant difference in the CI Symptom Score between the treatment group and both the baseline group ($p < 0.0001$) and the placebo group ($p = 0.001$). There was also a statistically significant difference between the baseline and placebo groups ($p = 0.044$). Twenty-five of 29 subjects reported a lower CI symptom score with the prism glasses. Of the four subjects who had lower symptom scores with the placebo glasses, three complained of distance vision problems with the prism glasses.

DISCUSSION

The results of our study support the efficacy of BI prism in the management of CI in the presbyopic population. The statistically significant difference between the baseline CI symptom score and the placebo is not surprising given the often powerful effect of a placebo treatment. Interestingly, the CI Symptom Score for the treatment group probably overrepresents subject symptoms and therefore reduces the treatment effect of the prism glasses. This is due to the fact that the prism at distance is capable of inducing some asthenopia even though the subjects demonstrated no fixation disparity through the prism glasses.

The use of fixation disparity/associated phoria to determine eligibility and magnitude of prism in this study was selected instead of Sheard criterion, which uses the heterophoria and its compensating vergence. Although the work of Sheedy and Saladin[6,14] has demonstrated that heterophoria and Sheard criterion were important discriminators of asthenopic symptoms, all of their subjects were optometry students (non-presbyopes). In addition, Sheedy and Saladin[15] found in a previous study that, although there were significant differences in the heterophorias and vergences between the presbyopic and non-presbyopic groups, there were no differences between the asthenopic symptoms in each group. They suggested that the heterophoria and vergence measurements in presbyopes do not give a true picture of the binocular status of the patient. Yekta et al.[11] also addressed this issue and reported that the fixation disparity and associated phoria are both better predictors of nearpoint symptoms than the heterophoria in both presbyopic and non-presbyopic populations. This was confirmed by Jenkins et al.[12] who concluded that a 2Δ associated phoria is the minimum prism to best differentiate symptomatic from asymptomatic patients. However, there were many symptomatic patients with an associated phoria of 1Δ in their study. Therefore, on the basis of the previous studies, we used the associated phoria as one of our study's inclusion criteria and to determine the amount of prism prescribed for our subjects.

Our study results regarding use of BI prism in the treatment of CI are not in agreement with the study by Scheiman et al.,[9] which evaluated children ages 9 to <18 years in contrast to our presbyopic population and used Sheard criteria instead of the associated phoria used in our study. Another possible explanation for this difference is the issue of the impact of accommodation on the source of symptoms. Marran et al.[16] found accommodation as the primary cause of nearpoint symptoms in a study of 299 elementary school children. Whereas Scheiman et al.[9] excluded subjects with accommodative insufficiency, their exclusion criteria of having an amplitude of accommodation <4 D tested with the push-up method in a pediatric population, could still include subjects with mild to moderate accommodative insufficiency. Marran et al.[16]

used a more liberal threshold for diagnosis and included subjects with an amplitude of accommodation 2 D below Hofstetter[17] age-based norms. If some of the subjects in the Scheiman et al.[9] study had a mild accommodative insufficiency, the effect of the prism on the CI would be minimized and a significant change in the CI Symptom Score would not be expected. Irrespective of the possible influence of accommodation, other attributes of an adult population, such as the type of near activities and the sophistication in responding to the questionnaire, could lead to the disparity in the results.

There are also limitations to the study as the amount of prism in the near portion of the PAL was limited by the lens design. As a result, additional amounts of prism were prescribed in both the distance and near portions to closely approximate the near associated phoria. As previously indicated, the prism at distance may have induced some asthenopia which could have led to higher CI symptom scores associated with the BI prism glasses. This would underestimate the efficacy of BI prism for management of CI but would not affect the ultimate conclusion. An additional observation from the study is the positive acceptance of small amounts of BI prism at distance by patients who wanted to wear a correction full time instead of separate pairs of distance and reading glasses. Although technology exists for incorporating small amounts of BI prism in only the reading portion of PAL, it is not commercially available at this time. If a currently available PAL is used, one can initially prescribe prism in the traditional manner (same prism power for distance and near) assuming the associated phoria is ortho at distance through the prism, and be optimistic that symptoms can be reduced in patients with CI.

Finally, the possible effects of prism adaptation were not controlled in this study. However, North and Henson[18] found that subjects with binocular anomalies which result in nearpoint symptoms display reduced prism adaptation and therefore are unlikely to influence the results of our study. In fact Brautaset and Jennings[19] specifically studied prism adaptation in patients with symptomatic CI and also found reduced prism adaptation at distance and near. Because associated phoria measurements were not taken after the glasses were worn, we cannot comment on the degree of prism adaptation that occurred and the assumption that fixation disparity is a sign of decompensation of the binocular vision process. Nonetheless, our double blind study design with a control group attempted to isolate the affect of the prism and therefore did not require subsequent associated phoria measurements to assess prism adaptation to substantiate the affect of the prism on the CI.

CONCLUSIONS

Our study found BI prism to be effective in alleviating symptoms of CI in presbyopes. More research is needed to determine the optimal prism to be prescribed in this condition and the adaptability of patients to BI prism prescribed at distance.

ACKNOWLEDGMENTS

We thank Signet Armorlite who funded the study and provided the spectacle lenses and Jeff Krall, OD, and Kelly Frantz, OD, for their assistance in the preparation of the manuscript.

Portions of this paper were presented at the American Academy of Optometry annual meeting, October 24, 2007, Tampa, Florida.

Received March 26, 2008; accepted July 10, 2008.

REFERENCES

1. Grisham JD. Visual therapy results for convergence insufficiency: a literature review. Am J Optom Physiol Opt 1988;65:448–54.
2. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric. Accommodative and Eye Movement Disorders, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2002.
3. Percival AS. The relation of convergence to accommodation and its practical bearing. Ophthal Rev 1892;11:313–28.
4. Sheard C. Zones of ocular comfort. Am J Optom 1930;7:9–25.
5. Mallett RF. The investigation of heterophoria at near and a new fixation disparity technique. Optician 1964;148:547–51.
6. Sheedy JE, Saladin JJ. Association of symptoms with measures of oculomotor deficiencies. Am J Optom Physiol Opt 1978;55:670–6.
7. Stavis M, Murray M, Jenkins P, Wood R, Brenham B, Jass J. Objective improvement from base-in prisms for reading discomfort associated with mini-convergence insufficiency type exophoria in school children. Binocul Vis Strabismus Q 2002;17:135–42.
8. Lie I, Opheim A. Long-term acceptance of prisms by heterophorics. J Am Optom Assoc 1985;56:272–8.
9. Scheiman M, Cotter S, Rouse M, Mitchell GL, Kulp M, Cooper J, Borsting E. Randomised clinical trial of the effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. Br J Ophthalmol 2005;89:1318–23.
10. Worrell BE Jr, Hirsch MJ, Morgan MW. An evaluation of prism prescribed by Sheard's criterion. Am J Optom Arch Am Acad Optom 1971;48:373–6.
11. Yekta AA, Pickwell LD, Jenkins TC. Binocular vision, age and symptoms. Ophthal Physiol Opt 1989;9:115–20.
12. Jenkins TC, Pickwell LD, Yekta AA. Criteria for decompensation in binocular vision. Ophthal Physiol Opt 1989;9:121–5.
13. Borsting EJ, Rouse MW, Mitchell GL, Scheiman M, Cotter SA, Cooper J, Kulp MT, London R. Validity and reliability of the revised convergence insufficiency symptom survey in children aged 9 to 18 years. Optom Vis Sci 2003;80:832–8.
14. Sheedy JE, Saladin JJ. Phoria, vergence, and fixation disparity in oculomotor problems. Am J Optom Physiol Opt 1977;54:474–8.
15. Sheedy JE, Saladin JJ. Exophoria at near in presbyopia. Am J Optom Physiol Opt 1975;52:474–81.
16. Marran LF, De Land PN, Nguyen AL. Accommodative insufficiency is the primary source of symptoms in children diagnosed with convergence insufficiency. Optom Vis Sci 2006;83:281–9.
17. Hofstetter HW. A comparison of Duane's and Donders' tables of the amplitude of accommodation. Am J Opt 1944;21:345–63.
18. North R, Henson DB. Adaptation to prism-induced heterophoria in subjects with abnormal binocular vision or asthenopia. Am J Optom Physiol Opt 1981;58:746–52.
19. Brautaset RL, Jennings JA. Distance vergence adaptation is abnormal in subjects with convergence insufficiency. Ophthal Physiol Opt 2005;25:211–4.

Bruce Teitelbaum
Illinois College of Optometry
3241 S. Michigan Avenue
Chicago, IL 60616
e-mail: bteitelb@ico.edu