Original Article

DOI 10.3349/ymj.2010.51.1.117
pISSN: 0513-5796, eISSN: 1976-2437

Yonsei Med J 51(1): 117-120, 2010

YMJ

The Prismatic Effect on Stereoacuity in Intermittent Exotropia

Kyoung Sub Choi,[1] Seung Ah Chung,[2] Kyu Sung Lee,[1] and Jong Bok Lee[2]

[1]Department of Ophthalmology, National Health Insurance Corporation Ilsan Hospital, Goyang;
[2]Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, Seoul, Korea.

Purpose: To evaluate the effect of acrylic refractive prism and Fresnel membrane prism on stereoacuity in intermittent exotropia. **Materials and Methods:** Stereoacuities of fifty-two patients (mean age, 12.4 years; range 6 to 45 years) with intermittent exotropia were measured using the Titmus and TNO stereotests, while they wore prisms of varying power on nonfixating eye or evenly on each eye. **Results:** Stereoacuities were significantly reduced with increasing prism power for both prisms, ranging from 8 to 25 prism dipotres. The effects on stereoacuity in single acrylic prism and single Fresnel prism were similar, whereas spilt Fresnel prisms reduced stereoacuity more than spilt acrylic prisms. Spilt prisms were found to have much less effect on stereoacuity than single prisms for both acrylic and Fresnel prisms. **Conclusion:** The use of acrylic refractive prism shared evenly on each eye would be optimal method to minimize the reduction of stereoacuity during the prismatic therapy for intermittent exotropia.

Key Words: Strabismus, stereoacuity, Fresnel prism, acrylic prism

Received: February 3, 2009
Revised: April 11, 2009
Accepted: May 13, 2009

Corresponding author: Dr. Jong Bok Lee,
Institute of Vision Research,
Department of Ophthalmology,
Yonsei University College of Medicine,
250 Seongsan-ro, Seodaemun-gu,
Seoul 120-752, Korea.
Tel: 82-2-2228-3574, Fax: 82-2-312-0541
E-mail: 491209@yuhs.ac

· The authors have no financial conflicts of interest.

INTRODUCTION

Although prisms are widely used diagnostically and therapeutically in orthoptics, the use of conventional glass prism has been decreased because of excessive weight, disturbing reflections, aberrations, and unsatisfactory cosmetics. These disadvantages were overcome by Fresnel membrane prisms, which are based on Fresnel's optic principle that refraction angle of prism is not related with thickness of prism, but related with refraction index of material and surface angle. Fresnel prisms are focused on their cosmetic benefit and less effect on distortion. However, there are some limitations that the visual acuity and contrast sensitivity decrease as the prism power increases. Therefore, Fresnel prisms are used only for diagnosis and temporary treatment of patients when the prism power has to be frequently modified.[1,2]

There are some studies comparing Fresnel prisms with conventional prisms in visual acuity, optical distortions, contrast sensitivity, chromatic dispersion and visual performance,[3-8] however, there have been not enough studies on stereoacuity. Véronneau-Troutman[4] studied the difference in stereoacuity and fusional effect between Fresnel prisms and conventional glass prisms in non-strabismic normal participants, and showed that stereoacuity with the Fresnel prisms is more disturbed than that with the conventional glass prisms of the same power.

This study examined the effect of Fresnel prism and acrylic refractive prism on near stereoacuity of intermittent exotropic patients and determined whether the effects of single prisms are similar to or different from those of spilt prisms.

MATERIALS AND METHODS

Fifty-two patients with intermittent exotropia were enrolled. There were 32 males and 20 females, ranging from 6 to 45 years of age (median, 12.4 years). All patients had normal visual acuity (best corrected acuity 20/20 Snellen or better in each eye; interocular difference of less than or equal to one line) and intermittent exotropia ranging from 4 to 25 prism dioptres (PD) without vertical deviation and paralytic strabismus. Spherical and cylindrical refractive errors of all patients were less than 5.00 and 1.00 dioptres, respectively. Patients were excluded if they had prior history of amblyopia, strabismus surgery, and neurologic component resulting in an inability to complete the stereotests. Informed consent was obtained from each patient.

Acrylic refractive prisms (Luneau, Chartres, France) and Fresnel membrane prisms (3M Health care, St. Paul, MN, USA) were used. Refractive errors were corrected with trial lenses to a visual acuity of 20/20. In acrylic refractive prisms, their back sides were placed parallel to anterior side of orbits by hands and Fresnel membrane prisms were mounted to the test lenses.

Stereoacuity was measured with Titmus test (Stereo Optical Co., Inc., Chicago, IL, USA) and TNO test (Lam Ris Instrument, Groenekan, Netherlands), while patients wore acrylic refractive prisms and Fresnel membrane prisms of their proper angles of near deviation on non-fixating eyes (single stereoacuity). At subsequent step, prism power was equally divided on both eyes and stereoacuities were also measured while wearing prisms on both eyes (spilt stereoacuity). The illumination was 200 lux, and the distance was 40 cm.

Stereoacuity of acrylic refractive prism was compared with that of Fresnel prism according to spilt and single methods with univariate analysis (SPSS 12.0).

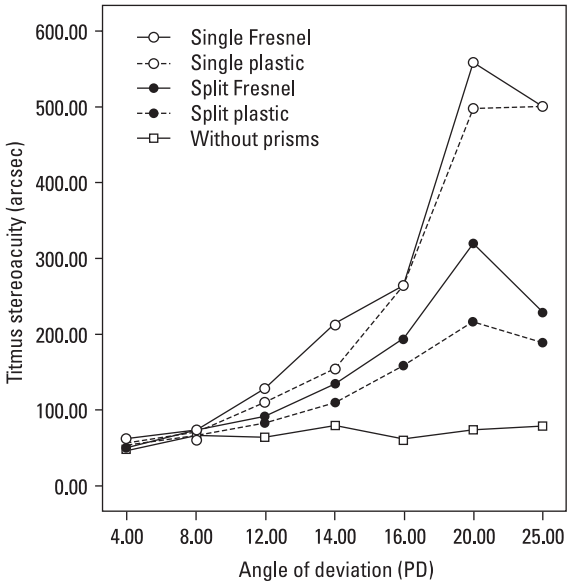

Fig. 1. Titmus steroacutiy for each prism for each prism dipotre.

RESULTS

The mean stereoacuities of exotropic patients were 67.9 arcsec (range, 40 to 140 arcsec), and 83.7 arcsec (range, 60 to 120 arcsec) by Titmus and TNO stereotest, respectively (Table 1).

Overall, the stereoacuities were significantly reduced by prism powers of 8 dioptres or more in both Titmus and TNO stereotests. Below 8 prism dioptres, there was no change in stereoacuity in both plastic and Fresnel prisms (Figs. 1 and 2).

Stereoacuity measured by using Titmus stereotest

The mean stereoacuities were 253.57 arcsec for single Fresnel prisms, 232.85 for single acrylic prisms, 160.85 for split Fresnel prisms, and 126.57 for split acrylic prisms. There was no difference in single Fresnel prisms and acrylic refractive prisms at each prism dioptre. However, spilt acrylic refractive prisms induced less reduction of stereoacuity than spilt Fresnel prism (p = 0.039). In com-

Table 1. Mean Stereoacuity without Prisms

Angle of deviation (PD)	Mean age (yrs)	Titmus (arcsec)	TNO (arcsec)
4 (n = 6)	15.7	48	60
8 (n = 6)	18.5	60	60
12 (n = 8)	13.6	65	86
14 (n = 6)	8.5	80	100
16 (n = 6)	13.0	60	70
20 (n = 10)	19.8	74	96
25 (n = 10)	10.4	78	96
Average ± SD	12.4	67.9 ± 22.7	83.7 ± 30.5

PD, prism dipotres; SD, standard deviation; arcsec, seconds of arc.

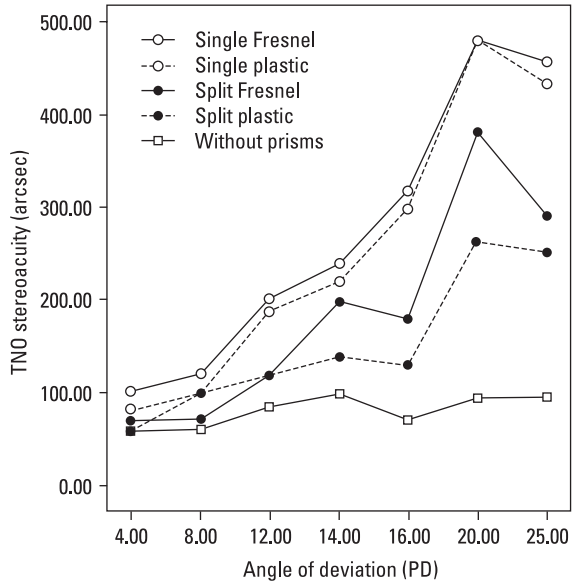

Fig. 2. TNO steroacutiy for each prism for each prism dipotre.

parison of same material prisms, single prisms stereoacuity reduced significantly more than spilt prisms, especially over 16 prism dioptres ($p < 0.000$) (Fig. 1).

Stereoacuity measured by using TNO stereotest

The mean stereoacuities were 273.43 arcsec for single Fresnel prisms, 257.14 for single acrylic prisms, 184.57 for split Fresnel prisms, and 152.28 for split acrylic prisms. Although there was no difference between single Fresnel and single acrylic refractive prisms, spilt Fresnel prisms induced the reduction of stereoacuity more than spilt acrylic prisms ($p = 0.030$). In both acrylic prisms and Fresnel prisms, spilt method preserved more stereoacuity than single method ($p < 0.000$) (Fig. 2).

DISCUSSION

Overall, this study showed that stereoacuities with acrylic refractive prisms and Fresnel prisms decrease with increasing prism power over 8 prism dioptres in intermittent exotropia. These effects of both prisms on stereoacuity in intermittent exotropia were similar to those in non-strabismic participants of Veronneau-troutman study.[5] These reductions in stereoacuity with increasing prism power may be affected by those reductions in visual acuity and contrast sensitivity with increasing prism power. It is of clinical relevance to note that the lower-powered prisms (under 8 prism dioptres) which are commonly used in clinic had a lesser effect on stereopsis.

Some investigators have studied the optical performance of Fresnel prism and conventional prisms. Fauhl, et al.[4] showed that reduction in visual acuity of normal young individuals was proportional to the strength of the prism, and that the rate of reduction in visual acuity with Fresnel prisms was significantly larger than that with conventional glasses prisms [3% per prism dipotres (PD) vs. 2% per PD]. Veronneau-troutman also revealed that visual acuities with Fresnel prisms were more reduced than those with conventional glass prisms, ranging from 12 to 30 PD.[5] Adams, et al.[3] compared the optical distortions between conventional glass and Fresnel prisms, and found that Fresnel prisms cause less over-all magnification than same powered conventional prisms. Woo, et al.[8] studied the effect of chromatic dispersion of Fresnel prisms on the contrast sensitivity function, and found that the reduction in contrast sensitivity and visual acuity with Fresnel prisms is principally due to chromatic dispersion of these prisms. All of these studies were conducted on non-strabismic normal participants who had normal visual acuity, no interocular difference and no previous history of amblyopia. However, Laird, et al.[9] proposed different mechanism for decreased stereoacuity in intermittent exotropia and under conditions of convergence stress in non-strabismic subjects. Therefore, it was necessary to evaluate the effect of prisms on stereoacuity with intermittent exotropic patients, and this study was undertaken to evaluate stereoacuity of intermittent exotropic patients, but not that of non-strabismic normal participants.

In this study, the stereoacuity of intermittent exotropia was reduced more in spilt Fresnel prisms than in spilt acrylic refractive prisms, but similar between single Fresnel prisms and single acrylic prisms. This difference between Fresnel and acrylic prisms which occurred only with split prisms may be related to the facts that single prisms had worse stereoacuity than spilt prisms, that low level stereoacuities such as those with single prisms were measured more roughly than those in high level stereoacuities, similar to those with split prisms,[10] and that fine differences in low level stereoacuities could not be detected. Similar to contrast acuity, more reduction of stereoacuity when wearing Fresnel prisms could be the results of distortion and chromatic aberration.[2,3] The greater reduction of stereoacuity with Fresnel prism is the result of reflection from prism facets, secondary refraction at prism facet base and diffraction of light by grooves.[2]

Moreland and Griffiths[11] found that single Fresnel prisms reduced stereoacuity more than spilt Fresnel prisms with non-strabismic participants. This study also showed that single stereoacuity was much less than spilt stereo acuity in intermittent exotropia. This could be affected by two reasons; one is that single stereoacuity had thicker prisms in equivalent power, therefore, more distortion. Secondly, sharing evenly on each eye reduced interocular disparency.

There are various factors affecting stereoacuity, such as

aniseikonia, anisometropia, accommodation, retinal illuminance, and pupil size.[12,13] In this study, all candidates had pupil sizes 3-4 mm of each eye, and the difference of refraction of both eyes were within 2 dioptres to minimize the factors affecting stereoacuity. Generally, the illumination under 200 lux can decrease stereoacuity, however, over 200 lux there is almost no effect on change of stereoacuity when lightness increases.[14] Therefore, tests were performed under the illumination of 200 lux.

One of the limitations of this study is the evaluation of stereoacuity at near distance of 40 cm. The change of stereoacuity at far distance is more sensitive in evaluation of stereoacuity capacity compared to stereoacuity at near distance.[15,16] Further study by stereotests like Frisby-Davis Distance (FD2) or the Distance Randot (DR) should examine the effect of prisms on distance stereoacuity. Second limitation is that in each prism dioptre, different patients were enrolled, however, comparisons among the methods were made in the same group of patients. Third potential weakness of this study is the use of the Titmus test which has the problems of monocular cues.[17-19] Although patients were checked for using monocular cues by turning the Titmus test book, the results of stereoacuities with the Titmus test trended to be better than those with the TNO test, which has no monocular cues. Nevertheless, most routine clinics still use the Titmus test. We, therefore, believe that the results of this study are applicable particularly to clinical practice. Furthermore, we examined only the proper angles of the deviation, and hope that future study determines how a prismatic overcorrection or undercorrection would affect stereoacuity.

Clinically, the present findings may help orthoptists how to use therapeutic prisms in intermittent exotropia. Reduction in stereoacuity is not a concern with a prescription of prism glasses under 8 PD. However, when it is over 8 PD, the prescription of prism dioptres divided on both eyes is considered to be helpful for the quality of visual acuity and preservation of stereoacuity. Although both prism types reduced stereoacuity over 8 PD, spilt acrylic refractive prisms provided significantly better stereoacuity in intermittent exotropia than spilt Fresnel prisms.

ACKNOWLEDGEMENTS

Presented as a poster at 98th meeting of the Korean Ophthalmological Society November, 2007.

REFERENCES

1. Kim SJ, Park YG. Fresnel prism in Paralytic strabismus. J Korean Ophthalmol Soc 1997;38:129-34.
2. Cheng D, Woo GC. The effect of conventional CR39 and Fresnel prisms on high and low contrast acuity. Ophthalmic Physiol Opt 2001;21:312-6.
3. Adams AJ, Kapash RJ, Barkan E. Visual performance and optical properties of Fresnel membrane prisms. Am J Optom Arch Am Acad Optom 1971;48:289-97.
4. Fauhl GM, Haase W, Rassow B. [Studies on the influencing of distance vision through various prisms]. Albrecht Von Graefes Arch Klin Exp Ophthalmol 1972;185:66-74.
5. Véronneau-Troutman S. Fresnel prisms and their effects on visual acuity and binocularity. Trans Am Ophthalmol Soc 1978;76:610-53.
6. Lee HH, Byun YJ, Lee JB. Prismatic Effect and Visual Acuity Degradation. J Korean Ophthalmol Soc 1995;36:909-14.
7. Flom MC, Adams AJ. Fresnel optics. In: Duane TD, Jaeger EA, editors. Clinical Ophthalmology. Philadephia: Harper & Row; 1982.
8. Woo GC, Campbell FW, Ing B. Effect of Fresnel prism dispersion on contrast sensitivity function. Ophthalmic Physiol Opt 1986;6:415-8.
9. Laird PW, Hatt SR, Leske DA, Holmes JM. Distance stereoacuity in prism-induced convergence stress. J AAPOS 2008;12:370-4.
10. Adams WE, Leske DA, Hatt SR, Holmes JM. Defining real change in measures of stereoacuity. Ophthalmology 2009;116:281-5.
11. Moreland ES, Griffiths HJ. The effect of Fresnel prisms on binocular vision. Br Orthopt J 2002;59:33-7.
12. Lovasik JV, Szymkiw M. Effects of aniseikonia, anisometropia, accommodation, retinal illuminance, and pupil size on stereopsis. Invest Ophthalmol Vis Sci 1985;26:741-50.
13. Menon V, Bansal A, Prakash P. Randot stereoacuity at various binocular combinations of Snellen acuity. Indian J Ophthalmol 1997;45:169-71.
14. Lee CH, Choi DG. Effect of Illunmination on Stereoacuity. J Korean Ophthalmol Soc 2002;43:1963-7.
15. Rutstein RP, Corliss DA. Distance stereopsis as a screening device. Optom Vis Sci 2000;77:135-9.
16. Hammond RS, Schmidt PP. A Random Dot E stereogram for the vision screening of children. Arch Ophthalmol 1986;104:54-60.
17. Levy NS, Glick EB. Stereoscopic perception and Snellen visual acuity. Am J Ophthalmol 1974;78:722-4.
18. Clarke WN, Noel LP. Stereoacuity testing in the monofixation syndrome. J Pediatr Ophthalmol Strabismus 1990;27:161-3.
19. Fawcett SL, Birch EE. Validity of the Titmus and Randot circles tasks in children with known binocular vision disorders. J AAPOS 2003;7:333-8.