Impact of Cylinder Axis on the Treatment for Astigmatic Amblyopia

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• PURPOSE: **To compare the effects of oblique astigmatism on refractive amblyopia in children aged 3-7 years with those having orthogonal astigmatism.**

• DESIGN: **A retrospective review of medical records.**

• METHODS: **The medical records of patients attending Tri-Service General Hospital in Taiwan from January 2003 to December 2010 were reviewed and summarized. Seventy-two children with oblique astigmatism–related refractive amblyopia (Group 1) and 82 children with orthogonal astigmatism (Group 2) were chosen. Characteristics such as baseline visual acuity (VA), the time course of VA improvement, refractive error, and family history were assessed.**

• RESULTS: **Group 1 showed a worse baseline mean VA (±SD) of 0.61 (0.13) vs 0.52 (0.16) logMAR (P = .01), a slower rate of amblyopia improvement, and higher prevalence of parental oblique astigmatism (29% vs 5.5%; $P < .01$) than did Group 2. The cylinder power of astigmatism (in D) causing amblyopia in Group 1 of 2.48 (0.82) was lower than that in Group 2: 2.93 (0.71) (P = .006). However, Group 1 achieved a noninferior resolution of amblyopia (mean final VA 0.18 vs 0.16 logMAR) after longer treatment of 6.45 (2.44) vs 5.86 (2.92) months (P = .039).**

• CONCLUSIONS: **A smaller degree of initial oblique astigmatism caused amblyopia than did orthogonal astigmatism. Although the children with oblique astigmatism achieved equal resolution rates after treatment, this took longer. Therefore, we should pay more attention to children with mild oblique astigmatism, as they are more likely to develop oblique astigmatism–related amblyopia. Moreover, early diagnosis and prompt treatment might help visual improvement. (Am J Ophthalmol 2014;157:908–914. © 2014 by Elsevier Inc. All rights reserved.)**

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ASTIGMATISM-RELATED AMBLYOPIA RESULTS FROM an uncorrected cylindrical refractive error and comprises refractive amblyopia with depressed vision in both meridians and meridional amblyopia involving depressed vision in a particular meridian. The brain receives a blurred image from the retina in 1 meridian, leading to the development of meridional amblyopia.[1,2] Uncorrected astigmatism during a critical period of early development can leave visual deficits that cannot be corrected by traditional optical treatment or emmetropization during ocular development.[3] Proper treatment at an early age can improve visual function over time.[4,5]

In school-aged children, the most commonly noted pattern of astigmatism is the with-the-rule (minus cylinder axis 0 degrees ± 15 degrees) form, followed by the against-the-rule (minus cylinder axis 90 degrees ± 15 degrees) form.[6,7] Oblique astigmatism is the least common type of astigmatism, which is seen in about 15% of the population[6] and causes amblyopia in 2%.[8] Despite its lower prevalence, oblique astigmatism is a known risk factor for developing amblyopia.[8] However, there is little information about its impact on refractive amblyopia, such as the dioptric power of astigmatism, age, or the degree and resolution of amblyopia. Besides, we used a traditional definition to ensure good clinical application instead of the modified vector method.[9] In the present study, the results for visual acuity (VA) after treatment for amblyopia were compared between orthogonal and oblique astigmatism–related refractive amblyopia in children aged 3-7 years.

METHODS

THIS RETROSPECTIVE STUDY WAS CONDUCTED TO collate data on astigmatism-related refractive amblyopia in the Tri-Service General Hospital, Taiwan, from January 1, 2003 to December 31, 2010. The study protocol and supporting documents were reviewed and approved by our institutional review board. The study followed the Good Clinical Practice guidelines of Taiwan and was performed in accordance with the Declaration of Helsinki (1964) and later revisions.

All of the patients who were chosen in the study had visited our ophthalmology department for regular follow-ups. Astigmatism was specified in minus-cylinder notation for all subjects. Children were considered to have

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astigmatism-related refractive amblyopia when they had a cylinder power of ≥1.0 diopter (D) in clinical notation and best-corrected visual acuity (BCVA) of worse than 0.1 logarithm of the minimal angle of resolution (logMAR) (Snellen equivalent: 20/25) or worse than 0.2 logMAR (Snellen equivalent: 20/32) if younger than 4 years of age or with at least 2 lines of difference between the eyes. If both eyes met the above inclusion criteria, only the right eye was chosen for analysis. Patients were eligible for inclusion in the study if they were aged between 3 and 7 years at the initial visit; had no history of other ocular disease such as strabismus, cataract, or those that could hinder vision development; and had no history of amblyopia treatment before this study, such as wearing spectacles, atropine penalization, or patching. Patients were excluded from the study if their spherical refractive error was outside the range of −2.00 D to +1.00 D; if they had other concurrent ocular diseases that might result in reduced BCVA, learning difficulties, and presence of strabismus; if they had follow-up of less than 1 year; or if they failed to undergo at least 6 months of proper management for their amblyopia, such as refractive correction and patching or atropine penalization.

Children who met the inclusion criteria were prescribed spectacles in which astigmatism and myopia were corrected fully and in which hyperopia was either fully corrected or undercorrected symmetrically by no more than 1.5 D in both eyes. Additional amblyopia treatment with patching and atropine penalization was started after the patient's monocular VA had stopped improving. Successful treatment of refractive amblyopia with refractive correction and patching or atropine penalization was defined as the resolution of amblyopia (VA of the amblyopic eye ≤0.1 logMAR or ≤0.2 logMAR if younger than 4 years of age). Follow-up examinations were continued for those who did not experience resolution of their amblyopia until the VA of the amblyopic eye had stabilized (no improvement in VA of <0.1 logMAR over 6 consecutive visits).

Detailed information was recorded from the medical records of each patient who underwent ophthalmologic examination during each follow-up visit. Data regarding BCVA, cycloplegic refractive errors including spherical and cylindrical (dioptric power and axis), the characteristics of the amblyopic eye, any family history of amblyopia, and the follow-up period were collected for analysis. The primary BCVA outcomes were recorded by logMAR VA testing (Catalogue 2010; Precision Vision, La Salle, Illinois, USA). Cycloplegic refractive errors were measured with retinoscopic examinations performed by the same ophthalmologist (Chen) after the instillation of 1% cyclopentolate eye drops (Cyclogyl; Alcon Labs, Fort Worth, Texas, USA); this specialist also ensured that the appropriate changes to the spectacle prescriptions were made at each follow-up. The subjects were then stratified into 2 groups according to their astigmatism axis. In Group 1, the study or oblique astigmatism group, the astigmatism axes were in the ranges of 16-74 degrees and 106-164 degrees. In Group 2, the orthogonal astigmatism group, the astigmatism axes were in the ranges of 0 degrees ± 15 degrees and 90 degrees ± 15 degrees.

The astigmatism history of the parents was assessed initially from the medical records of the children chosen in the study. Parents who could not be contacted or were not willing to undergo ophthalmic examinations were excluded from this analysis. A family history was recorded as positive if at least 1 parent experienced astigmatic refractive error.

The data were analyzed using SPSS software (version 16.0 for Windows; SPSS Inc, Chicago, Illinois, USA). All data for each group are presented as the mean ± standard deviation (SD). We used Student *t* test to compare the characteristics of amblyopia between the groups and a mixed model with random effect on age to exclude its confounding effect in evaluating results. $P < .05$ was considered statistically significant.

RESULTS

IN THIS STUDY, 72 CHILDREN WHO HAD OBLIQUE ASTIGmatic amblyopia and 82 children who had orthogonal astigmatic amblyopia met the study criteria. Boys accounted for 39 of the 72 patients (54%) in Group 1 and 46 of 82 (56%) in Group 2. The mean (SD) age was 6.03 (1.6) years in Group 1 and 5.23 (2.3) years in Group 2 (Table 1). The children in Group 1 tended to be older than those in Group 2, although there was no significant difference in mean age. There was a significant difference in the mean baseline VA between the 2 groups ($P = .01$), with 0.61 (0.13) logMAR in Group 1 and 0.52 (0.16) logMAR in Group 2 (Table 2). Of the 72 patients in Group 1, 47 (65%) had moderate amblyopia (≥0.3 but <0.7 logMAR) and 25 (35%) had severe amblyopia (≥0.7 logMAR), whereas the proportions of those forms in Group 2 were 62 of 82 (76%) and 16 of 82 (20%), respectively. Taking refractive error into account, there was no significant difference in spherical equivalent between the 2 groups ($P = .12$). However, the mean (SD) dioptric power of astigmatism was lower in Group 1 at 2.48 (0.82) D than in Group 2 at 2.93 (0.71) D ($P = .006$; Table 1). Figure 1 is a scatterplot showing the baseline VA with dioptric power of astigmatism of each patient. This demonstrates that more patients with low oblique astigmatism had amblyopia than did patients with orthogonal astigmatism and that the greater the degree of astigmatism, the worse the VA for both groups.

All of the patients chosen in this study received standard amblyopic treatment with optical correction with or without patching for at least 6 months, and the mean (SD) follow-up period was 12.3 (3.2) months. The VA changes between the 2 groups are plotted in Figure 2, showing that there was greater VA improvement in Group 1 than in Group 2. However, subjects took longer to