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A consideration of binocular parameters in the spectacle correction of anisometropic amblyopia: A Case Report

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ABSTRACT

Background: Recent evidence points to the use of spectacles alone in the treatment of anisometropic amblyopia. However, the impact of this treatment on the restoration of binocular vision is often not considered. **Case Report:** Patient M.Z., aged 7 years, showed 3.5D of anisometropia which was coupled with a best corrected visual acuity of 6/38 in the more hyperopic eye (6/6 in the non-amblyopic eye). Spectacle lenses were prescribed using specially designed software to alter the spectacle frame and lens parameters to theoretically reduce the static and dynamic aniseikonia to 1% and 3.8% respectively. Four subsequent follow up visits were conducted over a 2 year period where standard clinical measures of refraction, visual acuity, and binocular vision were conducted. The spectacles were worn consistently over this time. Single letter acuity normalized by 5 months while crowded acuity took longer. Improvements of binocular vision resulted concomitantly. However, improvement in suppression and stereo acuity continued for 2 years following the initial spectacle correction. **Conclusions:** This case exemplifies how the prescribing of spectacle lenses with consideration of, and correction for, predicted optical aniseikonia allowed the amelioration of amblyopia without patching and the provision of significant levels of binocular vision within a 1 year period. However, the time course for the development of binocular vision well exceeded that for the amelioration of amblyopia.

Keywords: amblyopia, aniseikonia, anisometropia, binocular vision, hyperopia, spectacle correction, stereo acuity, visual acuity

Background

Evidence is building in the form of clinical research[1-3] that effective treatment of refractive (deprivation) amblyopia in young children can be achieved by spectacle correction alone without patching. The amblyopia arises primarily due to differences in the magnitudes of their hyperopia and sometimes astigmatism.[4,5] The success with spectacles without patching would in part relate to the impact of the refractive correction on the previously uncorrected amblyopic eye (spectacle adaptation).[6] However, there may in fact be a relationship between the amelioration of amblyopia and the development of binocular vision.[7] To date the restoration of binocular vision which is predicted in clinical texts[8] has not been directly sought in clinical trials of anisometropic children.[1,2] A reanalysis of several clinical trials conducted by the Pediatric Eye Disease Group (PEDIG) which targeted the spectacle correction of anisometropic amblyopia found a significant correlation between the improvement of visual acuity and that of stereo acuity (SA).[9] However, even when the amblyopia was ameliorated, the SA was reduced in comparison to non- amblyopic children.[9]

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When clinical trials[1,2] have examined the amelioration of amblyopia following spectacle correction of non strabismic anisometropic children between the ages of 3 to 7 years, refractive amblyopia showed its greatest rate of reduction within 4 to 12 weeks following wear, after which the rate of amblyopia reduction changed slowly. Successful amelioration was significantly less as the magnitude of the initial anisometropia became large (e.g. 4D or greater).[1,2] It has been postulated that this may be due to aniseikonia since no adjustment was attempted for magnification differences induced by the spectacles.[2] The point is well warranted since spectacle corrections will induce aniseikonia of both a static and dynamic component.[10]

The following case report illustrates an associated improvement of binocular vision with amelioration of the refractive amblyopia (difference in SE = 3.5D) through spectacles alone. The report will introduce the use of purpose designed software (OptometricaTM - Lens Wizard) that can provide spectacle designs which minimize aniseikonia and thereby would enhance binocular vision.

Case Report

Subject M.Z. aged 6, attended the Paediatrics and Special Needs Clinic in the School of Optometry University of Waterloo, over a 2 year period from 2010 to 2012. At his initial visit (Jan. 2010), he presented with one of his parents, where it was reported that he had difficulty seeing out of his "lazy" left eye. There were no other visual concerns or complaints. His birth history was normal and no developmental delays were reported. He was not taking any medications. No significant ocular or medical family history was initially reported, but later, his father reported that he suffered from keratoconus.

Ocular health both external and internal was unremarkable. Keratometry readings were 46.75 @180 and 44.25@ 90 OD and OS. Details of the ocular findings and spectacle treatment over a 2 year period are summarized in Table 1. M.Z. presented as a non-strabismic anisometrope where the difference in spherical equivalent between the eyes was found to be 3.5D. The initial visit showed results expected with a history of uncorrected anisometropia. Amblyopia was found where the best corrected VA in the more hyperopic eye was reduced to 6/18. Suppression was found in tests of W4D and when stereo acuity was attempted at 40cm.

Once a spectacle frame was selected, lenses were designed in order to reduce the relative spectacle magnification differences (aniseikonia). This process was conducted using an ophthalmic lens design software application, currently marketed as Optometrica.™

Optometrica™ modeled the effect of the spectacle system at the position of wear upon the binocular vision system using an iterative ray tracing method. It permitted a rapid and accurate calculation of the resultant static and dynamic aniseikonia resulting from the spectacle correction of the anisometropia. Following the input of standard spectacle design information (vertex distance, eye size, lens material etc.), a design wizard rapidly computed optimized lens parameters in order to reduce the predicted degrees of static and dynamic aniseikonia. The resulting lens shapes were then graphed and modifications could be made to lens thickness and/or base curve should cosmesis be an issue.

Trivex lenses were prescribed. (OD plano ct 4.5; BC 9.00; OS. +4.00-1.00x005; ct 4.4; BC 4.75) (Table 1). The values for center thickness (ct) and base curve (BC) were obtained following inputting of the spectacle system (frame specifications and vertex distances) into the Optometrica™ program. Lens specifications were determined which balanced the degree of predicted aniseikonia with cosmetic considerations. The specifications above limited the predicted static aniseikonia to 1.1 % and the dynamic aniseikonia to 3.8%. The spectacles were then dispensed several weeks later. M.Z. was then followed up over a 2 year period through 5 subsequent examinations which along with the initial visit, are summarized in Table 1. The first two follow up examinations were targeted at 2 to 3 month intervals which were then broadened to approximately 6 month intervals. His parents reported rapid acceptance of the spectacles and full time wear was reported throughout the 2 year period. Actual measures of static aniseikonia could not be made; however, dynamic aniseikonia was estimated in a manner described by Remole and Robertson[10] where the prismatic effect of looking binocularly through the superior part of the spectacles is compared to that looking through the optical centers. In this case the Maddox rod measures are nulled by the application of size lens magnifiers before the right eye instead of prisms.

Outcomes Following Spectacle Wear

Amblyopia: Amblyopia is defined as a group of visual deficits[11] which includes reduced visual acuity as well as a crowding effect where visual acuity is

Table 1: Summary of ocular findings over a 2 year follow up.

TEST	INITIAL VISIT	2-MONTH FOLLOW-UP	5-MONTH	1 YEAR	17 MONTHS	2 YEARS
Habitual	No Rx	Regular Rx wear	Full-time wear happy with Rx	Wearing Rx full time	Wearing Rx full time	Wearing Rx full time
VA CCC single (S) 3m	OD 6/6; OS 6/60	OD 6/4; OS 6/9	OD 6/4; OS 6/6	6/4 6/4	OD 6/4; OS 6/6	OD 6/4; OS 6/4
VA CCC crowded	OD 6/6; OS 6/36	OD 6/6; OS 6/9	OD 6/6; OS 6/9	6/4, 6/6	OD 6/6; OS 6/6	OD 6/4; OS 6/6
Motility	Unrestricted					Unrestricted
CT 3m	NS ortho		NS ortho	NS ortho	NS ortho	NS ortho
0.4m	NS ortho	NS ortho	NS small exo	NS ortho, small eso?	NS ortho	NS ortho
NPC	3cm					
W4 dot in light At 6m 0.81 deg W/4 Dot in light at 0.40m 1 deg sub tense	OS suppression	Fused some suppression	No suppression		OS suppression Fused with 1.5% size lens	Fused at distance with some intermittent diplopia Fused
Stereo acuity Randot	OS suppression	<2000	70 sec	50 sec	80 sec Not improved with size lens	40
Monocular fix	OD steady, foveal OS unsteady		OD steady OS steady			
Stereo/suppression 6m (AO Vectographic Projector Slide)				Poorer than 260" Letter supression reduced with 1% size sens	Achieved 260" facilitated with 1.5% size lens Letter suppression not consistently reduced with 1.5%h size lens	n/a
Refraction	OD: plano 6/6 (S)	No sig change either eye	No sig change		Cyclo tropicamide OD + 0.50 - 0.50 x 005 6/6 (S)	No
	OS: +4.00 - 1.00 x 005 6/18 (S)				OS: +4.00 - 1.00 x 005 6/6 (S)	
Amp	OD 9.5D OS n/a					12D
Dynamic aniso		1%	1%	0	0 to 1%	1%
Rx prescribed	OD. Plano BC 9.00; CT 4.5mm					
	OS +4.00 - 1.00 x 005 BC 4.75 ct 4.4mm Trivex lens material (1.53 index)					

reduced when competing contours surround the target letter.[11] The Cambridge Crowding Cards (Clement Clarke, U.K.) were used in the initial and follow up assessments. These acuity charts have been normed on a large sample of preschool children. The norm for both the single letters and that of the crowded design would be 6/6 for a child of 6 years. We defined amblyopia as a 2 line difference or more between the eyes. Based on this criterion, amblyopia for single letters was ameliorated after 5 months while that for crowded letters took between 5 to 12 months. The time line for amelioration of anisometropic amblyopia with spectacle lenses when single letters were used, agreed with that found in the majority of

similarly aged children followed up in clinical trials.[1,2] The crowding effect appears to have taken a few months longer to ameliorate.

Binocular Vision: Suppression of the left eye in room lit conditions was measured by Worth 4 Dot (W4D) tests. Since smaller displays will elicit more central vs. peripheral measures,[12] the angular subtense of each W4D used throughout is included in Table 1. W4D measures showed an initial constant suppression which changed to intermittent and then to a predominantly fused response for subtenses close to 1 degree at both 6m and 40cm by 2 years of age. Randot stereo acuity showed a strong improvement over the first 5 months. However, improvement continued up to 2 years until a normal level of performance for his age was found at 13 years. The value of 80 seconds found at 17 months however falls outside of defined confidence levels[13] for 7 years of age suggesting that in this case, full development of stereo acuity required a time course between 17 and 24 months. Reduced stereo performance (below 260 seconds of arc) was observed using the AO vectographic chart at 6m. Visual acuity testing with the same vectographic chart identified central suppression of the left eye which was present at 17 months. Presumably, these findings indicated that peripheral suppression but not central suppression has declined since, the W4D dot target subtended the much larger angle than the letter test (0.81 degrees at 6m). At the 12 month visit this central suppression could be corrected with a further reduction of magnification using a 1% size lens. However this could not be consistently repeated at 17months. At the latter visit, gross stereo acuity may have been assisted with a further increased magnification of the right eye. The reduction in peripheral and central suppression was accompanied by a steady increase in stereo acuity. At the final 2 year visit, even though stereo acuity had reached normal values there was still intermittent diplopia on W4D testing at distance but not at near with targets close to 1 degree in subtense. Letter suppression testing was not possible.

Conclusions

This case illustrates how the wearing of a spectacle correction in anisometropic amblyopia provides amelioration of refractive amblyopia without the need for patching. Further, as amblyopia reduced there was a concomitant increase in the quality of the patient's binocular vision. Classic clinical thinking would suggest that spectacles have improved the quality of the image in the left eye leading to amelioration of the amblyopia. However, recent evidence suggests it may be the restoration of the binocular vision which improves the amblyopia. Further while we have not compared with and without aniseikonia correction, the justification of the consideration of spectacle induced aniseikonia is reflected in the fact that in some measures small letter (foveal) suppression and stereo acuity were improved by further reduction in magnification differences. However, it is clear that the development of binocular vision appears to have a longer time course than the amelioration of amblyopia (as defined by improved single and crowded letter acuity). This would agree with the results of the PEDIG clinical trial[9] discussed above. This case shows however that reduced SA found when amblyopia has subsided does reach normal levels at a later time. Certainly the use of a more iseikonic spectacle design that enhances binocular vision is preferred to patching as a first step in the treatment of anisometropic amblyopia. Hopefully future studies on anisometropic amblyopes will consider the impact of iseikonic designs in their spectacle prescriptions.

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