

Article ▶ Axial Length and Corneal Curvature in Anisometropic Amblyopia in Nepalese Children

Safal Khanal, B Optom, Southwestern University, Cebu City, Phillippines

Himal Kandel, B Optom, MSc PHEC, International Centre for Eye Health, London School of Hygiene and Tropical Medicine, London, UK

ABSTRACT

Background: Purpose/Aim: To assess ocular parameters in Nepalese children with severe anisometropic amblyopia.

Methods: This was a hospital-based cross-sectional analytical study conducted in a tertiary eye center in Nepal. Twenty-one children aged 7-12 years with severe anisometropic amblyopia ($>3D$ of anisometropia) were included in the study. Relevant demographic and clinical data were obtained. Axial length, corneal curvature, and anterior chamber depth were measured in both the amblyopic and fellow eye, along with detailed anterior and posterior segment evaluation.

Results: In anisomyopia, amblyopic eyes had longer axial length than the fellow eyes ($p<.05$), while in the cases with anisohyperopia, amblyopic eyes had shorter axial lengths than the fellow eyes ($p<.05$). The difference in corneal astigmatism between the amblyopic and fellow eye in children with anisoastigmatism was clinically and statistically significant ($p<.05$). However, there was no significant difference between the axial lengths in the amblyopic and the fellow eyes ($p=.84$).

Conclusion: Difference in axial length was responsible for the difference in spherical refractive error in children with anisometropic amblyopia with no significant difference in corneal astigmatism, whereas corneal curvature was the significant factor responsible for amblyopia resulting from anisoastigmatism.

Keywords: anisometropic amblyopia, anterior chamber depth, axial length, corneal astigmatism, cycloplegic refraction

Introduction:

Amblyopia is a disorder of reduced visual function from abnormal visual experience caused by strabismus, anisometropia, or visual form deprivation during the critical period of visual development. Anisometropia is a condition in which the two eyes have disparate refractive power by an amount equal to, or greater than, 1D in one or both meridians.¹ It is known to be the primary risk factor for the development of amblyopia.² The child with anisometropic amblyopia has a refractive error (RE) with normal vision in one eye with or without correction and a significant RE with substantially reduced corrected acuity in the other.³ The amblyopia results from cortical image blur in the affected eye and the resulting inter-ocular competition or inhibition.⁴ The inhibition of the amblyopic eye during development results in changes throughout the visual pathway which account for the reduced visual acuity.⁵ These changes occur because the parvocellular layers of the lateral geniculate nucleus, which respond to high spatial frequency stimulation, are ineffectively driven by the blurred eye. Low spatial frequencies may be driven by either eye through the more robust magnocellular layer.⁶ Other aspects of amblyopic loss are seen in the form of reduced contrast sensitivity, which is uniformly depressed across the visual field of the amblyopic eye, along with poorer monocular fixation.⁷ Anisometropic amblyopia generally occurs in the more ametropic eye, whether it is more hyperopic, myopic, or astigmatic than the non-affected fellow eye. Asymmetric

hyperopia and inter-ocular differences of greater than or equal to 3.0 D of refractive error are especially prone to cause anisometropic amblyopia.⁴

In a study done in rural and urban parts of eastern Nepal, the prevalence of RE was 19.8%, including hyperopia greater than or equal to +0.50, myopia greater than -0.50, and any cylindrical error as astigmatism.⁸ In another study performed by Nepal et al. to determine the ocular morbidities in school children in Kathmandu, RE was the most common type of ocular morbidity (8.1%).⁹

In a report produced by the Ministry of Health and Population in Nepal,¹⁰ uncorrected RE was found to be the most common cause of ocular morbidity and visual impairment. Although children constitute 34.5% of the Nepalese population, less than 15% of eye care services are provided to children. Around one million children under 16 years of age have uncorrected refractive error, which accounts for an estimated 10% prevalence in that age group. This indicates high vulnerability of Nepalese children to developing amblyopia.

Prevention and management of amblyopia in Nepal has been affected by two main developments. First, uncorrected RE has recently been recognized as an important cause of visual impairment. This was accomplished after incorporating the use of presenting vision for the definition of low vision rather than the best corrected visual acuity, which was used previously. Second, due to the unilateral nature of amblyopia

Table 1. Clinical Findings at the Time of Study

Patient	Age	Sex	Visual Acuity		Refractive Error		Amblyopic eye
			RE	LE	RE	LE	
1	9	F	6/6	6/18	+0.25/-0.50×180	-6.00/-2.00×160	LE
2	10	F	6/6	3/60	+0.75	+8.50/+1.00×90	LE
3	12	M	4/60	6/6	+8.00/-1.00×10	none	RE
4	8	F	6/6	6/18	none	-4.00×170	LE
5	10	M	6/6	6/36	none	+4.00	LE
6	10	M	6/6	6/9	-1.00/+1.00×90	-4.00/+1.00×90	LE
7	7	F	6/6	6/18	+0.25/-0.50×180	-5.75×10	LE
8	12	M	6/6	6/60	+1.00	+8.50/+0.75×90	LE
9	11	M	6/6	6/24	+0.75	+4.50	LE
10	10	F	6/36	6/6	+8.00/-1.00×130	+1.75/+0.50×60	RE
11	12	M	6/60	6/6	+4.75/+1.75×60	+1.00/+0.50×130	RE
12	10	M	6/6	6/24	+0.25	+4.00/-6.00×170	LE
13	8	M	6/60	6/6	+4.75/+1.50×150	-0.25	RE
14	10	M	6/6	6/24	+0.75/+0.50×180	+4.00/-6.00×5	LE
15	10	M	6/6	6/36	+1.25	+3.75/-0.50×120	LE
16	10	M	4/60	6/6	-9.00/-1.00×180	-1.00/-0.50×180	RE
17	12	M	6/24	6/6	+3.75	+0.75	RE
18	9	F	6/6	6/36	+1.00/-0.50×90	+4.75/-1.50×90	LE
19	10	F	6/60	6/6	+5.25/-2.00×70	+0.75/-0.50×160	RE
20	9	M	6/6	6/18	+2.50	+6.00/-0.50×180	LE
21	12	M	6/6	6/60	+0.50	+5.50	LE

and with the goal of eliminating avoidable bilateral blindness, amblyopia and its potential effects on a child's vision, as well as impact on his quality of life, have been neglected.

Although the development of anisometropia is often thought to have a genetic component, the mechanisms are not clear.¹¹ Tong et al.¹² reported that anisometropia was the result of differences in axial length rather than differences in corneal refractive power. The relative contribution of axial or refractive factors in the development of anisometropic amblyopia is still not well known. We were interested to determine the role of axial length, corneal curvature, and anterior chamber depth in anisometropic children of Nepal with severe refractive imbalance between the two eyes.

Methods

This hospital-based cross-sectional analytical study included pediatric patients aged 7 to 12 years presenting to the pediatric outpatient department of B. P. Koirala Lions Center for Ophthalmic Studies with anisometropic amblyopia. During the course of 12 months, 79 children were diagnosed as having amblyopia by either a pediatric ophthalmologist or an optometrist. Out of 79 cases, none of these children had strabismus, and two had a history of preterm birth. Twenty-one children had at least 3 D difference between the eyes in cylindrical power or spherical equivalent on cycloplegic refraction and were included for further analysis. Written

consent was taken from both the subjects and their parents. All the procedures carried out in the study conformed to the Declaration of Helsinki, and the permission to conduct the study was obtained from the Institute of Medicine. Information on age, sex, visual acuity at first presentation, and course of treatment undergone was collected. Cycloplegic refraction and best corrected visual acuity at the time of the study, along with other associated findings from a complete ophthalmological examination, are shown in Table 1.

The cycloplegic refraction was performed by an optometrist (SK) after instillation of one drop of 1% cyclopentolate three times at ten minutes interval and 30 minutes after the last installment of the drop. The subjective refraction was three days post cycloplegia based on the hospital protocol. The keratometric readings were obtained using a keratometer based on doubling principle, and the corneal astigmatism was obtained as the difference between the two principal meridians. A topical anesthetic (lidocaine 1%) was instilled in each eye, and axial length, as well as anterior chamber depth measurements, were taken using Quantel MedicalAxis II PR. For each of these, 10 valid values were taken, and the mean was noted. The right eye of each patient was tested first for all parameters. All data were analyzed in SPSS 19.0 software.

Results

Out of 21 cases who met the inclusion criteria, 14 (66.67%) were males and 7 (33.33%) were females. The age range of the patients was from 7 to 12 years with a mean age of 10.05 years (95% CI = 9.40 to 10.70 years). Out of 21 patients, 3 (14.28%) had anisomyopia, 14 (66.67%) had anisohyperopia, and 4 (19.05%) had anisoastigmatism.

The range of difference in axial length between the amblyopic and normal eyes was 0.49 to 2.98 mm with a mean of 1.56 mm (95% CI = 1.19 to 1.92 mm). Difference in corneal astigmatism varied from 0.12 to 2.50 with a mean of 0.73 (95% CI = 0.35 to 1.19 D), and difference in anterior chamber (AC) depth ranged from 0.06 to 1.89 mm with a mean of 0.46 mm (95% CI = 0.23 to 0.69 mm). The mean axial length, corneal astigmatism, and AC depth in each group of anisometropia along with their 95% CI of mean are shown in Figures 1, 2, and 3, respectively.

The mean axial length in amblyopic eyes of the anisomyopia group was 24.33 mm (95% CI = 21.23 to 27.44 mm), and that of non-amblyopic eyes was 22.20 mm (95% CI = 20.77 to 23.62 mm). The difference between the mean was statistically significant (95% CI = 0.32 to 3.95; paired t test, $p=0.03$) with the amblyopic eyes having longer axial lengths than the non-amblyopic eyes. Similarly, the mean axial length in amblyopic eyes in anisohyperopes was 21.60 mm (95% CI = 21.12 to 22.07 mm), and that of non-amblyopic eyes was

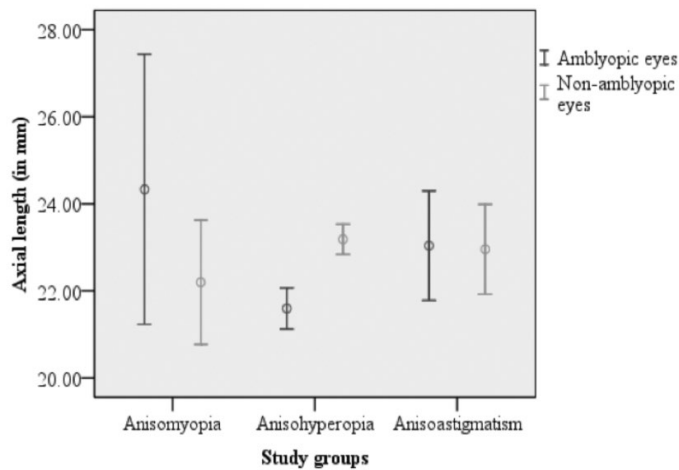


Figure 1. Axial length between amblyopic and non-amblyopic eyes in different groups of anisometropia. Error bars = 95% CI of mean.

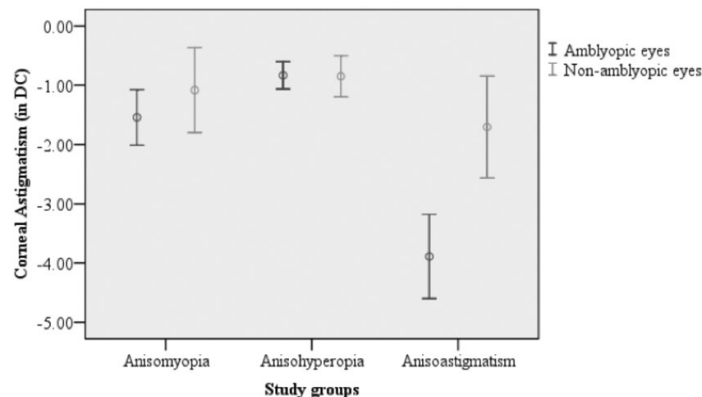


Figure 3. Axial length between amblyopic and non-amblyopic eyes in different groups of anisometropia. Error bars = 95% CI of mean.

Discussion

For years, the axial length has been considered the major determinant of the magnitude of the refractive error in both myopic and hyperopic eyes. This has also been shown to be true in cases of anisometropia. In cases of myopic or hyperopic anisometropia, antimetropia, or anisometropia associated with amblyopia or strabismus, the interocular difference in refractive error has been attributed to interocular difference in axial length.

The inclusion criteria for age in this study was set, as it was difficult to carry out complete biometric and keratometric examinations in the office setting without sedation. Our study showed that greater than 3D of anisohyperopia and anisomyopia were associated with significant differences in axial length, thereby establishing axial length as the primary factor for the development of anisometropia. Subsequently, amblyopia was manifested due to cortical blur and inhibition with no significant contribution from corneal astigmatism or AC depth in the amblyopic eye. However, this was not the case with anisometropic amblyopia resulting from significant differences in refractive astigmatism between two eyes. The difference in corneal astigmatism was significant between the two eyes in patients with anisoastigmatism with no significant difference in axial length. Therefore, it is reasonable to say that the amblyopia resulting in the patients with anisoastigmatism was attributed solely to corneal astigmatism.

Patel et al.¹³ showed similar results obtaining oculometric measurements with the IOL Master. Similar findings were also reported by Cass and Tromans,¹⁴ who showed that children with amblyopia resulting from anisohyperopia had significantly shorter axial lengths in the affected eye. However, this study performed A scans through the lids and only included mild hyperopia in their analysis. We attempted to define the ocular parameter responsible for different types of anisometropia and included children aged 7-12 years with more reliable and accurate measuring protocols and instrumentation.

The discrepancies seen in Nepalese children with severe anisometropic amblyopia in this study indicate the possible role of genetics. We did not sub-analyze the data into

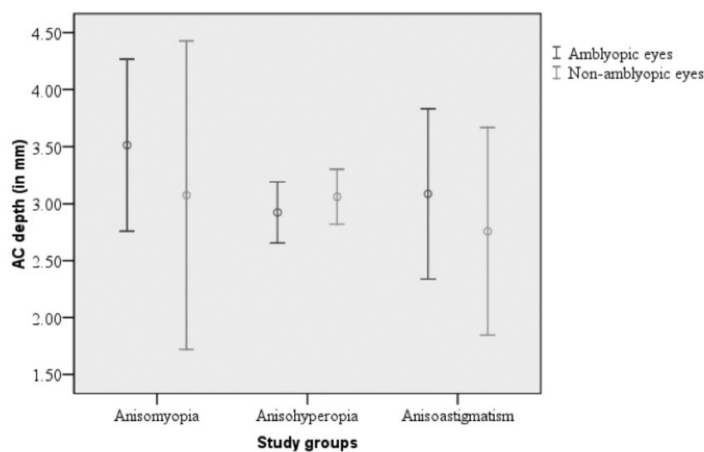


Figure 2. Corneal astigmatism between amblyopic and non-amblyopic eyes in different groups of anisometropia. Error bars = 95% CI of mean.

23.19 mm (95% CI = 22.84 to 23.53 mm). The difference between the mean was again statistically significant (95% CI = -2.13 to -1.05; paired t test, $p < 0.001$) with the amblyopic eyes having shorter axial lengths than the non-amblyopic eyes. Other parameters were statistically similar between eyes, including corneal astigmatism (paired t test, $p = 0.13$ for anisomyopia and $p = 0.90$ for anisohyperopia) and anterior chamber depth (paired t test, $p = 0.16$ for anisomyopia and $p = 0.39$ for anisohyperopia).

In the anisoastigmatism group, the mean corneal astigmatism in amblyopic eyes was -3.89 D (95% CI = -4.60 to -3.18 D), and that of the non-amblyopic eyes was -1.70 D (95% CI = -2.57 to -0.85D). The difference between the mean was statistically significant (95% CI = -2.80 to -1.56; paired t test, $p = 0.001$) with the corneal astigmatism being greater in the amblyopic eyes than the non-amblyopic eyes. Other parameters were statistically similar between eyes, including axial length ($p = 0.84$) and anterior chamber depth ($p = 0.29$).

different ethnic groups due to relatively small sample size. We recommend a larger study to explore the possible differences in the origin of anisometropia in amblyopic children from different ethnic groups. As severe refractive amblyopia is a relatively rare condition and mostly unilateral, it may not be a public health problem in the Nepalese setting. However, it has tremendous detrimental effects on the education of the child and may affect him into his adulthood. Moreover, Nepal being an agricultural country with rapid industrialization, ocular trauma is quite common, making even the non-amblyopic eye more vulnerable to loss of sight.

Conclusion:

Axial length was responsible for the difference in spherical refractive error in Nepalese children with anisometropic amblyopia with no significant difference in corneal astigmatism and AC depth. However, corneal curvature was the significant factor responsible for amblyopia resulting from anisoastigmatism.

References

1. Benjamin WJ. Patients with anisometropia and aniseikonia. In: Borish's Clinical Refraction, 2nd ed. St. Louis: Butterworth-Heinemann, 2006; 1482. <http://amzn.to/1g5LYNd>
2. Vital-Durand F, Ayzac L. Tackling amblyopia in human infants. Eye 1996;239-44. <http://bit.ly/1k0LRNu>
3. Benjamin WJ. Patients with amblyopia and strabismus. In: Borish's Clinical Refraction, 2nd ed. St. Louis: Butterworth-Heinemann, 2006; 1462. <http://amzn.to/1g5LYNd>
4. Simon JW. Amblyopia. Anisometropic amblyopia. In: American Academy of Ophthalmology Basic and Clinical Science Course 2006-2007, Section 6: Pediatric Ophthalmology and Strabismus. San Francisco (CA), American Academy of Ophthalmology; 2006, 69. <http://bit.ly/1v46fT2>. (no longer in print, unable to find any copies being sold online, 2013-2014 edition is available for purchase from the link above) Amos IF. Refractive Amblyopia. Diagnosis and Management in Vision Care, Boston: Butterworth, 1987; 369-407.
5. Livingstone M, Hubel DH. Segregation of form, color, movement, and depth: Anatomy, physiology, and perception. Science 1988;240:740-9. <http://amzn.to/QICqa3>

6. Kirschen DG, Kandall IH, Riesen KS. An evaluation of the accommodative response in amblyopic eyes. Am J Optom Physiol Opt 1981;58:597-602. <http://1.usa.gov/1iLqhIr>
7. Pokharel A, Pokharel PK, Das H, Adhikari S. The pattern of refractive errors among the school children of rural and urban settings of Nepal. Nepalese J Ophthalmol 2010;2:114-20. <http://1.usa.gov/1mXF1YD>
8. Nepal BP, Koirala S, Adhikari S, Sharma AK. Ocular morbidity in school children in Kathmandu. Br J Ophthalmol 2003;87(5):531-4. <http://bit.ly/RQaIcA>
9. Upadhyay M, Gurung R, Shrestha B. Mid Term Review Vision 2020: The Right to Sight, Nepal 2011 Apex Body for Eye Health, Ministry of Health and Population, Kathmandu, Nepal. 2012 Oct. <http://bit.ly/1jzPkj>. Last Accessed November 19, 2013.
10. Duke-Elder S. System of Ophthalmology. Vol 5. St. Louis: CV Mosby, 1970. <http://bit.ly/QIGTcK>
11. Tong I, Saw SM, Chia KS, Tan D. Anisometropia in Singapore school children. Am J Ophthalmol 2004;137:474-9. <http://bit.ly/1iSQfxZ>
12. Patel VS, Simon JW, Schultze RL. Anisometropic amblyopia: Axial length versus corneal curvature in children with severe refractive imbalance. JAAPOS 2010;14:396-8. <http://bit.ly/1k0Tkw6>
13. Cass K, Tromans C. A biometric investigation of ocular components in amblyopia. Ophthal Physiol Opt 2008;28:429-40. <http://bit.ly/1sNoJFj>

Correspondence regarding this article should be emailed to Safal Khanal, B. Optom at safaladarsha09@gmail.com. All statements are the authors' personal opinions and may not reflect the opinions of the the representative organizations, ACBO or OEPE, Optometry & Visual Performance, or any institution or organization with which the author may be affiliated. Permission to use reprints of this article must be obtained from the editor. Copyright 2014 Optometric Extension Program Foundation. Online access is available at www.acbo.org.au, www.oepf.org, and www.ovpjournal.org.

Khanal S, Kandel H. Axial length and corneal curvature in anisometropic amblyopia in Nepalese children. Optom Vis Perf 2014;2(3):142-5.

***The online version of this article
contains digital enhancements.***