Myopia-Related Optic Disc and Retinal Changes in Adolescent Children from Singapore

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Purpose: To examine early myopia-related optic disc and retinal changes in a Singapore Chinese adolescent sample without confounding ocular or systemic disease.

Design: Population-based cross-sectional study.

Participants: Children aged 12 to 16 years at a follow-up visit for Singapore Cohort Study of Risk Factors for Myopia.

Methods: Detailed eye examinations, including cycloplegic autorefraction and contact biometry, were performed. Retinal photographs were acquired using nonmydriatic retinal photography among children who attended follow-up examinations in 2006, and were graded for myopia-related optic disc signs and macular changes by a single experienced grader. Optic nerve head parameters were measured adjusting for camera and ocular magnification with appropriate formulae.

Main Outcome Measures: Optic disc changes (tilt, beta peripapillary atrophy [β-PPA], and optic nerve parameters) and macular changes (staphyloma, lacquer cracks, Fuchs' spot, and chorioretinal atrophy).

Results: Retinal photography data were available for 1227 children (median age, 14 years; range 12–16). Tilted optic discs were found in 454 subjects (37%), and were associated with myopic spherical equivalent refractions (−3.6 diopters [D] vs −1.3 D; $P<0.0001$), higher cylindrical error (0.9 vs 0.7 D; $P = 0.0001$) and longer axial length (24.93 vs 23.96 mm; $P<0.0001$). The pattern of distribution of the axes of the tilted discs and corneal curvature were similar ($P = 0.4$). All linear optic nerve parameters, except vertical disc diameter ($P = 0.15$), were significantly smaller in eyes with than without tilted discs ($P <0.001$) after adjusting for confounders. Apart from 20 cases, all eyes with tilted optic discs had associated β-PPA. We identified only 1 case each (0.1% prevalence) of staphyloma and lacquer cracks in this sample.

Conclusions: In this Asian adolescent population, tilted optic discs were highly prevalent, in contrast with the lower prevalence reported in Caucasian populations. Eyes with tilted discs tended to have smaller optic cups with smaller cup-to-disc ratios, and were associated with myopic refraction, higher astigmatism, and longer axial length. There were similar patterns of distribution between the axis of disc tilt and the axis of corneal curvature, which could have embryologic origins. In contrast with optic disc changes, myopic macular changes were rare in this age group, suggesting that these changes may develop later in life.

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Myopia is an increasing public health concern, with prevalence estimates as high as 80% in selected regions of East Asia among younger persons.[1–7] High myopia can lead to many ocular complications, such as myopic macular degeneration and retinal detachment.[8,9] Identifying and treating patients at risk of the complications from high myopia may be useful, given recent data suggesting that modifiable environmental factors (such as outdoor activity) could help to ameliorate the development or extent of myopia.[10,11]

A tilted optic disc is a relatively common finding in eyes with myopia, and represents the oblique insertion of the optic nerve into the globe. Eyes with tilted optic discs have been shown to have greater levels of astigmatic error.[12–14] Furthermore, the presence of a titled disc may be a risk factor for glaucoma, and frequently complicates assessment of glaucoma, which has been shown to be associated with myopia.[12,15] Other fundus features found more frequently in cases of high myopia include myopic macular degenerative changes, such as staphyloma, lacquer cracks, Fuchs' spot, chorioretinal atrophy, and optic nerve crescents (beta peripapillary atrophy [β-PPA]).[16] These features are thought to be caused by excessive elongation of the eye and signify that chorioretinal tissue is undergoing degenerative change,[16–18] and their presence may indicate an eye at increased risk of visual impairment from myopia. However, it is unclear when these degenerative changes develop (i.e., early in life with the onset of myopia or years later with age).

The prevalence of optic nerve and macular signs associated with myopia have been reported in limited series,

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largely in adult subjects,[12,17,19,20] with very little documentation of these changes in children. Myopia is common in urban Asian cities such as Singapore, where the prevalence of myopia is 28% in 7-year-old children, 34% in 8-year-old children, and 43% in 9-year-old children,[21] making this an ideal population to examine myopia-related optic disc and macular changes. Additionally, identifying these features in children is important in understanding the natural history of high myopia, and the chronological pattern of the development of myopic maculopathy. Children further offer the unique advantage of having minimal ocular (e.g., cataract) and systemic (e.g., diabetes) diseases that could potentially confound analyses of myopia related fundus changes.

In our study, we examined the entire sample of Asian adolescents aged 12 to 16 years from the Singapore Cohort Study of Risk Factors for Myopia (SCORM) population using fundus photographs, and report the prevalence and associations of early optic disc and macular signs with myopia.

Methods

The SCORM performed a detailed examination of 1979 children, whose ages at the baseline examination were 7 to 9 years, attending 3 elementary schools in Singapore. The study was approved by the Ethics Committee of the Singapore Eye Research Institute and adhered to the tenets of the Declaration of Helsinki.

Detailed study methods have been described previously.[22,23] In brief, all children aged 7 to 9 years from 2 elementary schools (Eastern and Northern provinces) were invited to participate in 1999 (n = 1683). A third school (Western province) was enrolled in 2001 (n = 1230). The total number of eligible students was 2913, of whom 1979 (67.9%) agreed to participate. Annual follow-up visits were conducted in the schools and 1227 children, who were now aged 12 to 16 years with a median age of 14 years, remained in follow-up. They underwent repeat retinal eye examinations, which included retinal photographs. These were available for 1227 children of the original cohort, who were now aged 12 to 16 years, with a median age of 14 years. Written informed consent was obtained from all parents before each child's examination.

Questionnaire Data

Parents completed detailed questionnaires at baseline that encompassed topics including demographic information, the child's previous medical/ocular history, and socioeconomic status. Ethnicity was determined by using the father's self-reported ethnicity as per the definitions adopted by the Singapore Population Census 2000.[24]

Examinations

A thorough ocular examination was conducted on all adolescents by trained staff in the schools. Cycloplegia was induced with 3 drops of cyclopentolate 1% 5 minutes apart. At least 30 minutes after the last drop, autorefraction and keratometry were measured with an autokeratorefractometer (model RK5; Canon, Inc., Ltd., Tochigiken, Japan). Five consecutive measurements were obtained and the mean was used for analyses. Axial length was measured using a contact biometry ultrasound unit (Echoscan model US-800, probe frequency 10 mHz; Nidek Co., Ltd., Tokyo, Japan) after the instillation of 0.5% proparacaine (1 drop). The mean of 6 measurements was used for analyses if the standard deviation was <0.12 mm. Standing height, in meters (m), was measured for each child without shoes, and weight, in kilograms (kg), was measured using a standard, calibrated, portable weighing machine. Body mass index was calculated as weight divided by height squared (kg/m^2).

Retinal Photography

Results of retinal photography from SCORM have previously been published.[25,26] Methods to measure and summarize optic nerve head (ONH) parameters from the digitized retinal photographs used the same protocols as described in previous reports of childhood populations.[27] Briefly, after cycloplegia, digital retinal photographs centered on the optic disc and macula were obtained from both eyes using standardized settings with a non-mydriatic retinal camera (Canon CR6-45NM retinal camera, EOS-D60 digital camera; Canon, Inc.).[28] Optic disc and cup dimensions were measured by a single experienced grader (CS) from these stereoscopic retinal photographs using National Institutes of Health image-analysis software (ImageJ 1.40; available from http://rsb.info.nih.gov/ij/index.html; accessed October 10 2008; developed by Wayne Rasband, National Institutes of Health, Bethesda, MD). The halo surrounding the optic disc was identified but not included in the measurements. A calibration factor of 6.42 μm/pixel was used to compensate for the effect of magnification from the fundus and digital camera (Nightingale N, Canon, Technical Memo, personal communication, 2003). The Bengtsson formula[29] was used to correct for the effects of ocular magnification. Spherical equivalent refraction (SER) was defined as sphere + ½ negative cylinder, measured in diopters (D). Astigmatism was defined as cylinder ≥1.00 D.

Optic disc tilting was diagnosed when 1 margin of the optic disc was raised above the opposite margin as seen from stereoscopic photographs using a stereoscopic viewer. The axis of tilt was also identified and defined as the deviation of the long axis of the optic disc from the vertical meridian, and measured when the torsion was >15° as per standard definitions for cyclotorsion.[12] The tilt ratio, defined as the ratio between the longest and shortest diameters of the optic disc, was calculated in all cases of tilted optic discs as a further measure of tilting. Myopic retinopathy was defined to include staphyloma, lacquer cracks, Fuchs' spot, chorioretinal atrophy and optic disc crescent, as defined by Curtin.[16] All retinal images were graded by a single experienced grader (CS) according to previous grading techniques,[17] and adjudication was performed by an experienced ophthalmologist (PM). One month later, 100 images were regraded by the same grader to assess repeatability, with a kappa for the diagnosis of tilted optic discs of 0.84, and a correlation coefficient of 0.73 for the direction of disc tilt and 0.89 for the tilt ratio. Optic disc crescents were defined as the presence of β-PPA for the purposes of this analysis.

Statistical Analysis

Because results were largely similar in both eyes, only analyses from right eyes are presented. Chi-square tests were used to compare gender, ethnicity, and position of β-PPA in those with and without tilted optic discs, and the Student *t* test was used to compare age, mean SER, cylinder, and axial length of subjects with and without tilted optic discs. The Student *t* test was also used to determine the influence of tilted optic discs on ONH parameters. Regression analysis was used to determine the *P* value for trend for the prevalence of tilted optic discs and β-PPA across SER categories. General linear models adjusted for the influences of age, gender, ethnicity, axial length, and cylindrical error when determining the effect of a tilted optic disc on SER. The Kolmogorov-