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The relationship between peripapillary crescent and axial length: Implications for differential eye growth

Toco Y.P. Chui *, Zhangyi Zhong, Stephen A. Burns

School of Optometry, Indiana University, 800 E. Atwater Ave., Bloomington, IN 47405, USA

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A B S T R A C T

We evaluated the relationship between the size of the peripapillary crescent and the axial length (AL) of the eye as well as the fine structure of the peripapillary crescent in selected eyes. Infrared fundus imaging and spectral domain optical coherence tomography (SDOCT) (Spectralis HRA + OCT, Heidelberg Engineering, Germany) centered at the fovea were performed on 72 healthy adults. On the infrared fundus images, we measured (a) the distance between the foveola and the temporal edge of the optic disc (FOD) and (b) the distance between the foveola and the temporal edge of the peripapillary crescent (FOC) (if present). A peripapillary crescent presented at the nasal margin of the disc in 64% of the subjects. The FOD and FOC were 4.22 mm ± 0.46 and 3.97 mm ± 0.25, respectively. Only the FOD was significantly correlated with axial length. As AL increased by 10%, the FOD increased by 13%, the outer neural retina only expanded by 4% (as indicated by the FOC). This result emphasizes that retinal stretching may not mirror scleral growth, and the existence in some eyes of a difference between the photoreceptor margin and retinal pigment epithelium (RPE) margin suggests that within the retina there could be slippage during eye growth.

1. Introduction

The most visible change in the appearance of the myopic fundus is the presence of the peripapillary crescent, which is also known as β-peripapillary atrophy (Curcio et al., 2000; Jonas et al., 1989; Kubota, Jonas, & Naumann, 1993). The bright appearance of the crescent reflects the absence of the retinal pigment epithelium (RPE) and choroid. The presence of an optic disc crescent therefore suggests that the excessive scleral stretching as myopia develops is not mirrored by the RPE and choroid at the region of the crescent.

The structural changes due to the formation of the peripapillary crescent have been studied thoroughly with histological samples. Histological findings have shown that the photoreceptors, RPE, and choroid fall short at the temporal margin of the crescent in myopia (Grossniklaus & Green, 1992) with a partial loss of the photoreceptors and a complete loss of the RPE at the atrophic area (Curcio et al., 2000; Kubota, Jonas, & Naumann, 1993). The sclera underneath the crescent also appears stretched in pathological myopia (Yasuzumi et al., 2003).

Clinically, it has been shown that the frequency of peripapillary crescents increases with increasing axial length (Curtin & Karlin, 1971; Hendicott & Lam, 1991) from 0% in eyes with AL of 20.0–21.4 mm to 100% in eyes with AL of 28.5 mm (Curtin & Karlin, 1971). Although the presence of a crescent is associated with growth of the eye, a previous longitudinal study has shown that the distance between the foveola and the temporal edge of the crescent remains constant as myopia progresses (Nakazawa, Kurotaki, & Ruike, 2008). All these findings suggest that the crescent represents an area where the strain resulting from scleral stretching, is accompanied by a slippage of the major retinal/choroidal layers as myopia progresses. This is also supported by the increase in photoreceptor spacing on all retinal meridians with increasing eye length, except along the nasal retinal meridian (Chui, Song, & Burns, 2008b), presumably due to a separation of the retina from the disc during myopic eye growth.

In the present study, we evaluate the relationship between the peripapillary crescent and axial length in 72 healthy eyes using different imaging techniques. We tested the hypothesis that retinal and choroidal layer slippage is associated with myopic eye growth as reflected in adult eye length measurements.

2. Methods

2.1. Subjects

Seventy-two healthy subjects (35 males and 37 female; age range 20–67 years, mean = 38, SD = ±14) participated in this study. All subjects received a complete eye examination, including a subjective refraction and fundus examination. Exclusion criteria for this study included any evidence of retinal pathology (other than myopia) or systemic diseases. Spherical equivalent refractive

* Corresponding author. Fax: +1 812 855 7045.
E-mail address: ypchui@indiana.edu (T.Y.P. Chui).

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errors ranged from +2.00 D to −13.75 D (mean −2.73 D; SD = ±3.21) with astigmatism less than −2.00 D when referenced to the spectacle plane. All subjects had best corrected visual acuity of 20/20 or better. Only the right eye of each subject was tested in this study. Informed consent was obtained after a full explanation of the procedures and consequences of the study. This study protocol was approved by the Indiana University Institutional Review Board and complied with the requirements of the Declaration of Helsinki.

2.2. Procedures

2.2.1. Axial length measurement

Five axial length (AL) measurements of each eye were made using an IOL Master (Carl Zeiss Meditec, Dublin, California), and we reported the mean AL for each eye.

2.2.2. Infrared fundus imaging and spectral domain optical coherence tomography (SDOCT) imaging

Infrared fundus imaging and SDOCT imaging were performed to obtain both *en face* fundus images and cross-sectional measurements of the posterior pole (Spectralis HRA + OCT, Heidelberg Engineering, Heidelberg, Germany). In this experiment, an infrared fundus image covering 30° of the central retina was obtained for each eye, from which we measured the distance between (1) the foveola and temporal edge of the optic disc (FOD) and (2) the foveola and temporal edge of the peripapillary crescent (FOC) (if present) (Fig. 1) along the horizontal axis. The retinal magnification differences induced by different axial lengths were factored into a calculation of linear retinal units as described by a previous study (Bennett, Rudnicka, & Edgar, 1994).

The foveola was located using SDOCT images obtained using a super luminescent diode with a wavelength of 870 nm as a light source. The axial and lateral resolutions of the SDOCT were approximately 7 μm and 14 μm, respectively. A 15° × 15° raster scan centered at the fovea consisting of 73 horizontal b-scans was obtained in each subject using the manufacturer supplied eye-tracking feature (Automatic Real Time, ART). Each b-scan was composed of 768 equally spaced a-scans. The separation between b-scans was

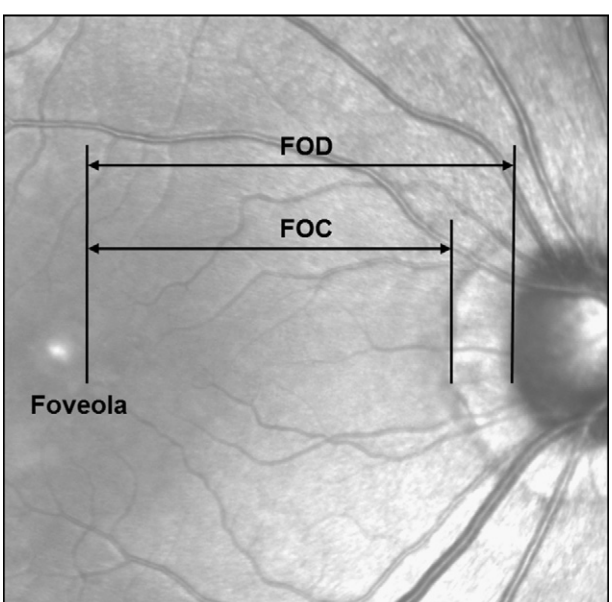

Fig. 1. Retinal distances measured on the infrared fundus image. Both FOD and FOC were measured along the horizontal axis from the foveola to the optic disc margin or the crescent margin.

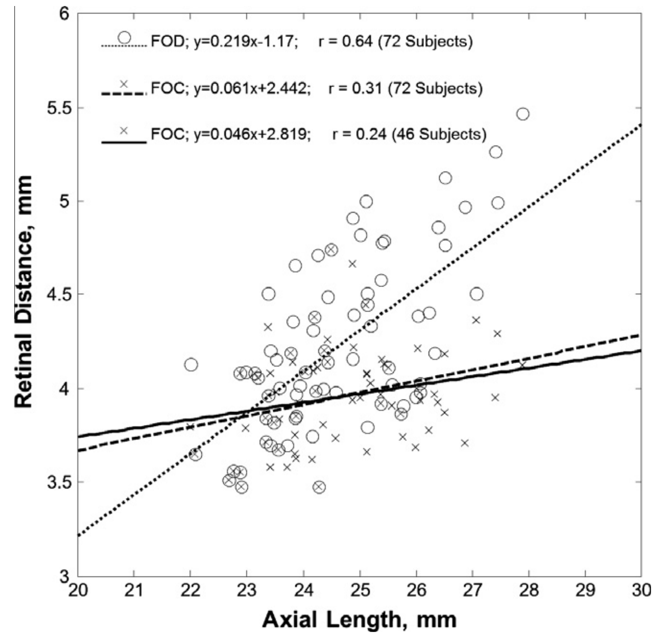

Fig. 2. Variation of retinal distance with axial length. Open symbols represent the retinal distance from the foveola to the temporal edge of the optic disc (FOD). Cross symbols represent the retinal distance from the foveola to the temporal edge of the crescent (FOC). The dotted and dashed lines represent the linear regression fit of the FOD and FOC in 72 subjects, respectively. The solid line represents the linear regression fit of the FOC in 46 subjects who had optic disc crescent.

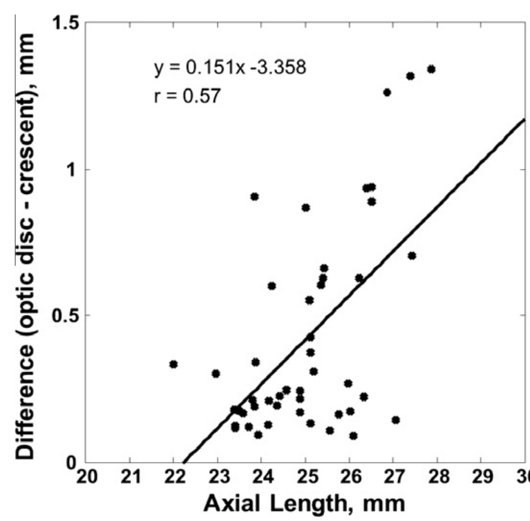

Fig. 3. The difference of FOD and FOC as a function of axial length. Optic disc crescent presents in 64% of the subjects with an average of 0.42 mm in width. Linear regression to the data is showed by the solid line.

Table 1
Demographic data of the six subjects tested with SDOCT and AOSLO.

Subject No.	Age	Rx (D)	AL (mm)	Crescent width (mm)
1	54	+0.50	23.50	0.175
2	31	−6.75	25.42	0.662
3	24	−8.25	26.87	1.263
4	24	−6.00	25.51	0
5	26	−4.75	26.51	0.891
6	43	−4.75	26.23	0.629
Mean ± SD	33.67 ± 12.27	−5.00 ± 3.00	25.67 ± 1.20	0.60 ± 0.46