Title: Is the Tilt of The Optic Disk Different in Myopia? Optic Disc Tilt Measurement by Three Different Methods in Myopic Eyes

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Abstract:

The prevalence of myopia is a major concern worldwide. Optic disc tilt (ODT), Peripapillary atrophy (PPA) and abnormally large or small optic discs are the earliest known changes occurring in myopic eyes and may precede the development of pathological myopia. Increasing ODT and distance between the macula and optic nerve head have been reported being associated with progressive myopia. Therefore, it is important to segment and quantify the ODT accurately. Using a new automated image processing method, we measured the ODT in both myopes and emmetropes.

We determined the ODT from myopic (n= 24) and compared the results with emmetropia (n=18). All 42 optical coherence tomography (OCT) images had dimensions of 200x200 pixels corresponding to 6mm x 6mm. The myopic OCT images were labelled based on a severity scale as mild, moderate and high using standard refractive error classifications. Each OCT image was manually segmented by a clinician as well as, by the new automated method. The OCT images were 8-bit grayscale images of sizes ranging from 400 to 600 pixels in width and 700 to 900 pixels in height. These images were preprocessed by convolving with a Gaussian kernel to remove noise followed by a Contrast Limited Adaptive Histogram Equalization based thresholding to determine the white bands, the region of interest. The white band represents….

The thresholded image was split into two halves about a point to fit two lines separately for each half. Morphological transforms are applied to the resulting image to remove any artefacts or noisy points. The operations used were erosion and dilation. These operations were performed by convolving a 5x5 kernel with the image for a single iteration. In erosion, the pixels were retained white only when all the pixels of the convolution are white, otherwise, all were made black. In dilation, the pixels were retained black only if all the pixels of the convolution are black, otherwise, all were made white. The images were tested with three combinations of erosion and dilation iterations, the first set with no erosion and dilation, the second with 1 iteration of erosion followed by 2 iterations of dilation, and the last being 2 iterations of erosion followed by 3 iterations of dilation. Following this we fit a line for the white band on each half of the image

using a univariate linear regression model separately on each half. From this the slopes of the lines and hence the angle between the lines were determined. The maximum (mean ± SD) horizontal ODT values for both emmetropes and myopes was by method II (17.54° ± 2.92 & 19.11° ± 12.77) and minimum ODT was by clinical expert method (14.95° ± 4.20 & 15.76° ± 7.12). The myopes showed a higher tilting angle than emmetropia in both horizontal and vertical. However, it was an insignificant one ($p>0.05$). All four methods showed a more horizontal ODT than vertical in both normal and myopia. Both vertical and horizontal ODT was higher in myopic eyes.

100-word summary

We investigated the characteristics of the optic nerve head in subjects with emmetropia (n=18) and myopia (n=20). We quantitatively measured the optic disc tilt in 3 automated methods and also by a clinical expert method. The horizontal optic disc tilt was noted both in emmetropic and myopic eyes. The typical average value of tilt was: A significant difference between emmetropic and myopic eyes observed by all four methods. However, the maximum horizontal tilt was noted in method III between emmetropic and myopic eyes.

Extended Abstract:

The prevalence of myopia is a major concern worldwide. Optic disc tilt (ODT), Peripapillary atrophy (PPA) and abnormally large or small optic discs are the earliest known changes occurring in myopic eyes and may precede the development of pathological myopia. [1] This paper investigates the optic nerve head characteristics in both emmetropic and myopic subjects. We quantitatively measured three different newly developed image processing techniques and clinical expert methods too. The optic disc tilt was calculated both in horizontal and vertical.

We determined the ODT from myopic (n= 24) and compared the results with emmetropia (n=18). All 42 optical coherence tomography (OCT) images had dimensions of 200x200 pixels corresponding to 6mm x 6mm. The myopic OCT images were labelled based on a severity scale as mild, moderate and high using standard refractive error classifications. Each OCT image was manually segmented by a clinician as well as, by the new automated method. The OCT images were 8-bit grayscale images of sizes ranging from 400 to 600 pixels in width and 700 to 900 pixels in height. These images were preprocessed by convolving with a Gaussian kernel to remove noise followed by a Contrast Limited Adaptive Histogram Equalization based thresholding to determine the white bands, the region of interest. The white band represents….

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using a univariate linear regression model separately on each half. From this the slopes of the lines and hence the angle between the lines were determined.

The myopic images were labelled using a standardized severity scale from 1 to 3, 1 representing low (> ± 0.5D to ± 3.00D Spherical Equivalent), 2, Moderate (>±3.00 D to ±6.00 D SE) and 3, high (>±6.00 D SE) respectively. Table 1. shows the demographic details and clinical profile of study subjects. The mean ± standard deviation of optic disc tilts in the emmetropic and myopic eye were listed in Table 2. The maximum (mean ± SD) horizontal ODT values for both emmetropes and myopes was by method II (17.54° ± 2.92 & 19.11° ± 12.77) and minimum ODT was by clinical expert method (14.95° ± 4.20 & 15.76° ± 7.12). The myopes showed a higher tilting angle than emmetropia in both horizontal and vertical. However, it was an insignificant one ($p>0.05$). All four methods showed a more horizontal ODT than vertical in both normal and myopia. Both vertical and horizontal ODT was higher in myopic eyes.

Table 1. Demographic and clinic data of study subjects

Groups	n	Age in years	SE (D)	BCVA
Emmetropia	18	29.78±15.24	-0.03±0.16	0.01±0.02
Myopia	25	25.28±3.74	-4.59±2.06	-0.01±0.06
*p-Value**		*0.186*	*0.000*	*0.118*

SE- spherical equivalent, BCVA – Best Corrected Visual Acuity *Mann-Whitney U test

Table 2: A comparisons of optic disc tilting angle between emmetropic and myopic eyes

	Method I	**Method II**	**Method III**	**CE Method**
Horizontal Optic Disc Tilt				
Emmetropia	15.95° ± 5.97	17.54° ± 2.92	16.58° ± 2.81	14.95° ± 4.20
Myopia	17.57° ± 12.44	19.11° ± 12.77	18.22° ± 9.45	15.76° ± 7.12
p-Value	*0.740*	*0.863*	*0.658*	*0.902*
Vertical Optic Disc Tilt				
Emmetropia	10.63° ± 7.31	11.47° ± 5.26	15.79° ± 11.85	13.74° ± 3.34
Myopia	13.96° ± 7.91	15.46° ± 8.05	15.80° ± 8.03	14.87° ± 6.90
p-Value	*0.052*	*0.048*	*0.314*	*0.802*

An important shortcoming of this study was a small number of fundus images that were available for analysis. We are in the process of collecting additional images to further quantify these results. We will also extend these studies to anomalous states of the eye.

Reference:

1. Ang M, Wong CW, Hoang QV, Cheung GC, Lee SY, Chia A, Saw SM, Ohno-Matsui K, Schmetterer L. Imaging in myopia: potential biomarkers, current challenges and future developments. British Journal of Ophthalmology. 2019;103(6):855-62.

Keywords:
1.) Optic Nerve Head
2.) Optic Disc Tilt
3.) Myopia
4.) OCT
5.) Image Processing