Original article

Evaluation of retinal nerve fiber layer thickness parameters in myopic population using scanning laser polarimetry (GDxVCC)

Dada T[1], Aggarwal A[1], Bali SJ[2], Sharma A[1], Shah BM[1], Angmo D[1], Panda A[1]
[1]Glaucoma Facility, Dr. Rajendra Prasad Centre for Ophthalmic Sciences
All India Institute of Medical Sciences, New Delhi 110029, India.
[2]Vision Eye Institute, Chatswood, Australia.

Abstract

Introduction: Myopia presents a significant challenge to the ophthalmologist as myopic discs are often large, tilted, with deep cups and have a thinner neuroretinal rim all of which may mimic glaucomatous optic nerve head changes causing an error in diagnosis.**Objective:** To evaluate the retinal fiber layer (RNFL) thickness in low, moderate and high myopia using scanning laser polarimetry with variable corneal compensation (GDxVCC). **Subjects and methods:** One hundred eyes of 100 emmetropes, 30 eyes of low myopes (0 to - 4 D spherical equivalent(SE), 45 eyes with moderate myopia (- 4 to - 8D SE), and 30 eyes with high myopia (- 8 to - 15D SE) were subjected to retinal nerve fiber layer assessment using the scanning laser polarimetry (GDxVCC) in all subjects using the standard protocol. Subjects with IOP > 21 mm Hg, optic nerve head or visual field changes suggestive of glaucoma were excluded from the study. The major outcome parameters were temporal-superior-nasal-inferior-temporal (TSNIT) average, the superior and inferior average and the nerve fibre indicator (NFI). **Results:** The TSNIT average ($p = 0.009$), superior ($p = 0.001$) and inferior average ($p = 0.008$) were significantly lower; the NFI was higher ($P < 0.001$) in moderate myopes as compared to that in emmetropes. In high myopia the RNFL showed supranormal values; the TSNIT average, superior and inferior average was significantly higher($p < 0.001$) as compared to that in emmetropes. **Conclusion:** The RNFL measurements on scanning laser polarimetry are affected by the myopic refractive error. Moderate myopes show a significant thinning of the RNFL. In high myopia due to peripapillary chorioretinal atrophy and contribution of scleral birefringence, the RNFL values are abnormally high. These findings need to be taken into account while assessing and monitoring glaucoma damage in moderate to high myopes on GDxVCC.

Key-words: myopia, retinal nerve fiber layer, scanning laser polarimetry

Introduction

Glaucoma is a progressive optic neuropathy characterized by irreversible loss of retinal ganglion cells and their axons. Evaluation of retinal nerve fiber layer (RNFL) damage is important to detect progressive structural optic nerve damage in eyes with suspected glaucoma. Myopia presents a significant challenge to the ophthalmologist as myopic discs are often large, tilted, with deep cups and have a thinner neuroretinal rim all of which may mimic glaucomatous optic nerve head changes causing an error in diagnosis.

Received on: 21.03.2012 Accepted on: 12.06.2012
Address for correspondence: Dr Tanuj Dada, Additional Professor, Dr Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi 110029
Tel: +91-11-26593001, Fax: 91-1126588919
E-mail: tanujdada@gmail.com

Scanning Laser Polarimetry (SLP) enables in vivo, accurate and reproducible quantitative assessment of the RNFL thickness by measuring the retardation of the incident polarized light quantified by the phase shift produced as it passes through the birefringent nerve fiber layer. As other structures, viz, the cornea and to a certain extent the lens, also have birefringent properties, the GDx with Variable Corneal Compensation (VCC) employs an anterior segment compensator, that determines the necessary compensation from a scan of the macular area (Bour 1991). This technique has been reported to have good accuracy with respect to the determination of the nerve fiber layer thickness (Greenfield et al 2002; Choplin et al 2003; Weinreb et al 2003).

It has been reported that SLP tends to underestimate the nerve fiber layer thickness and the values tend to decrease with increasing myopia (Ozdek et al 2000; Kremmer et al 2004; Melo et al 2006). This raises questions regarding the reliability of the instrument in detecting glaucoma in this subgroup. It has been suggested that SLP is not sufficiently sensitive to detect glaucoma in high myopes (Dada et al 2009). While the manufacturer recommends that the instrument can internally adjust for refractive error of up to -15D in terms of image acquisition, myopes may not compare well with emmetropes in the values obtained from SLP. Therefore, in the present study, we aimed to evaluate the RNFL thickness in myopic population and compare the findings with those in emmetropic population.

Material and methods

The study was conducted at a tertiary eye care facility of a university hospital between 1st July 2009 and July 2010. A written, informed consent was obtained from all subjects for participation in the study. The study protocol confirmed to the tenets of the Declaration of Helsinki.

The study population comprised of hospital personnel, students, medical faculty, and volunteers attending the outpatient services of our hospital for the correction of refractive errors or other diseases of the external eye, in the age group ranging between 18-40 years.

All subjects underwent a detailed ophthalmic history and examination including determination of visual acuity, refraction, applanation tonometry, anterior and posterior segment evaluation and axial length measurement by A-scan ultrasonography. Participants with corneal opacity, cataract, macular pathology or any ocular disease affecting the optic nerve or RNFL were excluded from the study.

Based on the refraction findings, the study subjects were classified into four groups, namely, emmetropes, low myopes with a spherical equivalent (SE) of 0 to < - 4D, moderate myopes with an SE of - 4.00 to < - 8D and high myopes with an SE of - 8 to < - 15D. Subjects with astigmatism more than 3D were excluded. Visual field analysis was done with the Humphrey Visual Field Analyser using the 30 - 2 SITA standard strategy in all participants. Subjects with unreliable visual fields were called one week later for a second visual field exam. A normal visual field analysis was taken as glaucoma hemifield test within normal limits, pattern and mean standard deviations > 5% and no point within the central 24 degrees in the pattern deviation plot depressed below 5%. Subjects with IOP > 21 mmHg, optic nerve head or visual field changes suggestive of glaucoma were excluded.

Thereafter, all subjects were scanned on the GDxVCC (Carl Zeiss Meditec, Dublin, CA). All examinations were carried out by a single operator (AS). Measurements were done with undilated pupils. The anterior segment birefringence was assessed for each eye. Following this, the fundus was scanned. Both fundi of the same subject were scanned with individual anterior segment compensation. One macular scan was taken followed by three compensated 40^{o} x 20^{o} RNFL scans. All scans were well centered on the optic nerve head and the scan with the best resolution with clearly demarcated retinal vessels was selected as the final image. Only images with a quality score of > 7 were included. Only one eye of each patient was used for analysis.

The major outcome parameters were the temporal-superior-nasal-inferior-temporal (TSNIT) average, the superior and inferior average and the Nerve Fibre Indicator (NFI).

These parameters were compared for statistical significance in all the four study groups. The axial lengths were also compared among the four groups for statistical significance. The statistical analysis was done using the SPSS (version 14.0 for Windows; SPSS Inc., Chicago, IL, USA). The independent sample 't' test was used for comparing the means. A 'p' value of < 0.05 was taken as statistically significant.

Results

A total of 205 subjects comprising of 105 males and 100 females of Indian origin (both emmetropes and varying grades of myopes) were enrolled in the study. The mean age of the study subjects was 29.4 ± 6.8 years (range, 18 - 40 years).There was no statistical difference between the mean age in the emmetropic and myopic population (p = 0.688). The mean values of the various RNFL parameters that were analysed are summarized in Table 1.

We first compared the findings of the different myopic subgroups with those of the emmetropic subgroup. There was a statistically significant difference in the RNFL parameters, TSNIT average, superior average and inferior average in moderate and high myopes when compared to those of emmetropes. The moderate myopes exhibited significantly lower values for each parameter than emmetropes and high myopes showed significantly higher values than emmetropes. However, there was no statistically significant difference in all the parameters measured between emmetropes and low myopes. (Table 1)

When the NFI was compared among the four groups, the findings noted were: there was a statistically significant difference between emmetropes and moderate myopes with moderate myopes showing significantly higher NFI values than emmetropes. When the NFI values were compared between emmetropes and high myopes, the values were still significantly higher for high myopes as compared to emmetropes. There was no statistically significant difference in the NFI values between emmetropes and low myopes (Table 1).

The difference between the axial lengths between the emmetropes and low myopes was not found to be statistically significant. The subjects with moderate and high myopia had a significantly longer axial lengths as compared to emmetropes (p = 0.0001 for both the subgroups).

The data was further analyzed amongst various subgroups of myopia. In high myopes the RNFL parameters, TSNIT average, superior average and inferior average, were significantly higher when compared to low and moderate myopes. The NFI in this subgroup was significantly lower when compared to moderate myopes (Table 2).

However, the difference was not statistically significant when compared to low myopes. There was no significant difference in the TSNIT average between subjects with low and moderate myopia. However, the NFI was significantly higher in moderate myopes as compared to the ones with low myopia. (Table 2)

Table 1: Comparison of RNFL thickness between myopes and emmetropes

GDxVCC Parameters mean ± SD	Emmetropes (a)	Low myopes (b)	Moderate myopes (c)	High myopes (d)	p value (a vs b)	p value (a vs c)	p value (a vs d)
TSNIT	54.21 ± 3.95	53.25 ± 4.24	52.03 ± 5.30	63.58 ± 16.01	0.21	0.009	<0.0001
Superior Average	67.11 ± 7.3	64.07 ± 8.2	63.02 ± 9.9	75.47 ± 8.56	0.32	0.001	<0.0001
Inferior Average	62.8± 7.2	60.37 ± 6.9	55.7 ± 9.9	72.43 ± 8.89	0.44	0.008	<0.0001
Nerve fiber indicator(NFI)	17.43 ± 7.5	20.54 ± 9.3	23.16 ± 8.2	19.58 ± 12.32	0.11	<0.0001	0.04
Axial length in mm	23.12±0.56	24.12±0.83	26.05±1.09	29.08±1.87	0.32	0.0001	0.0001

Table 2: Comparison of RNFL thickness between different grades of myopia

GDxVCC parameters mean ± SD	Low myopia (b)	Moderate myopia (c)	High myopia (d)	p value (b vs c)	p value (b vs d)	p value (c vs d)
TSNIT	53.25 ± 4.24	52.03 ± 5.30	63.58 ± 16.01	0.347	0.0004	0.0001
NFI	20.54 ± 9.3	23.16 ± 8.2	19.58 ± 12.32	0.001	0.861	0.0015
Axial length, in mm	24.12±0.83	26.05±1.09	29.08±1.87	0.0001	0.0001	0.0001

Discussion

As is evident from the analysis of our results, there was no statistically significant difference in any of the GDx VCC RNFL parameters between emmetropes and low myopes. However, the RNFL parameters showed significantly lower values in the moderate myopia group compared to emmetropes whereas the NFI was significantly higher in the moderate myopia group compared to emmetropes. We postulate that these differences between the two groups can be explained by the fact that the subjects in the moderate myopia subgroup would have larger globes compared to the emmetropes thereby allowing a larger surface area for the spatial distribution of the exiting RNFL fibres in the peripapillary region. This would result in a decrease in the density of the RNFL fibres in the peripapillary region in subjects with larger globes resulting in lower RNFL thickness values in these subjects. This hypothesis is corroborated by the comparison of axial lengths between the two groups which showed that the moderate myopes had a significantly higher axial lengths compared to the emmetropes.

On comparing the emmetropes with the high myopes, we found that the RNFL parameters were in the supranormal range and significantly higher than the emmetropes. Using the same hypothesis as stated above, one would have expected these values to be significantly lower than emmetropes. However, the GDx VCC measures the amount of retardation (phase shift) of the light waves by a polar (birefringent material) and extrapolates these to the RNFL thickness in contrast to Optical Coherence Tomography(OCT) which measures the actual RNFL thickness.

As a result, the peripapillary chorioretinal atrophy which is quite pronounced in highly myopic eyes brings into play the scleral birefringence which leads to erroneously high RNFL thickness measurements with the GDx VCC machine. Such abnormal scans should not be used in the interpretation of the RNFL thickness. In eyes with peripapillary atrophy, the default scan diameter may be manually increased such that it falls outside the atrophic area around the disc (Dada et al, 2006).

Previous studies have also revealed conflicting results regarding RNFL measurements

in myopes. It has been shown that there is a significant reduction in all the SLP parameters in

both myopes and hyperopes, which correlated well with the refractive error, though not with the axial length (Kremmer et al, 2004). Myopes have been reported to have significantly thinner RNFL values as compared to emmetropes using the Nerve Fiber Analyser I (NFA I) (Ozdek et al, 2000). Melo et al (2009) showed that the GDx VCC was not sufficiently sensitive to discriminate glaucomatous and non-glaucomatous subjects with high myopia. The authors had also reported a difficulty in obtaining high quality images in patients with high myopia. In another study, it was reported that in both the myopic and the emmetropic group, all the SLP assessments of the RNFL fell within the normal range, with no clinically relevant variations, as assessed with GDx-VCC (Vetrugno, 2007).

We had excluded patients with tilted discs, as it has been shown to adversely influence the reliability of the instrument (Yu et al ,2006). As discussed before, supranormal RNFL thickness in highly myopic eyes needs to be corrected for scleral birefringence (Bozkurt et al, 2002). It is possible that a recalibration of the instrument may be needed to achieve the desired level of accuracy in these patients. A newer version of the instrument is now available with enhanced corneal compensation (ECC) and has been shown to have greater accuracy in patients with atypical birefringence patterns (Sehi et al, 2007).

It has been noted previously that in moderate to high myopes with glaucoma, the mean typical scan score is significantly lower ($p < 0.0001$), and the prevalence of atypical retardation pattern was significantly higher ($p < 0.0001$) by VCC scans than by ECC scans (Morishita et al 2008). Temporal, superior, nasal, inferior, temporal (TSNIT) average and temporal average thickness showed significantly higher values ($p < 0.001$) by VCC than by ECC. They concluded that ECC scans showed a better retardation pattern and structure-function relationship than did VCC, and ECC appeared to be more suitable for RNFL assessment in glaucomatous eyes that are moderately to highly myopic. An optical coherence tomography (OCT) based study on the myopic population did not reveal any statistically different RNFL values in varying grades of myopic population with almost the same range of myopic refractive error as in our study (Hoh et al, 2006).

A limitation of our study is that we did not use a simultaneous OCT evaluation of the subjects to corroborate and compare with their RNFL measurements using GDx VCC.

Conclusion

The results of our study demonstrate that the GDx VCC values begin to significantly alter in the moderate to high myopes but the machine fairs reasonably well when measurements are performed in emmetropes and low myopes. Abnormal RNFL thickness values should be viewed with caution in patients with moderate to high myopia who are being evaluated for glaucoma.

References

Bour LJ (1991). Polarized light and the eye. In: Charman WN, ed. Visual Optics and Instrumentation. Boca Raton, FK: CRC Press: 310-25.

Bozkurt B, Irkeç M, Gedik S, et al (2002). Effect of peripapillary chorioretinal atrophy on GDx parameters in patients with degenerative myopia. Clin Experiment Ophthalmol; 30: 411-414.

Choplin NT, Zhou Q, Knighton RW (2003). Effect of individualized compensation for anterior segment birefringence on retinal nerve fiber layer assessments as determined by scanning laser polarimetry. Ophthalmology; 119:719-725.

Dada T, Gadia R, Aggarwal A, Dave V, Gupta V, Sihota R (2009). Retinal nerve fiber layer thickness measurement by Scanning Laser Polarimetry (GDxVCC) at conventional and modified diameter scans in normals, glaucoma suspects and early glaucoma patients. J Glaucoma; 18:448-452.

Greenfield DS, Knighton RW, Feuer WJ, Schiffman JC, Zangwill L, Weinreb RN (2002). Correction for corneal polarization axis improves the discriminating power of scanning laser polarimetry. Am J Ophthalmol; 134:27-33.

Hoh ST, Lim MC, Seah SK, Lim AT, Chew SJ, Foster PJ, et al (2006). Peripapillary retinal nerve fiber layer thickness variations with myopia. Ophthalmology; 113:773-7.

Kremmer S, Zadow T, Steuhl KP, Selbach JM (2004). Scanning laser polarimetry in myopic and hyperopic subjects. Graefes Arch Clin Exp Ophthalmol; 242:489-94.

Melo GB, Libero RD, Barbosa AS, Pereira LMG, Doi LM, Melo LAS (2006). Comparison of optic disc and retinal nerve fiber layer thickness in non glaucomatous and glaucomatous patients with high myopia. Am J Ophthalmol 142: 858-866.

Morishita S, Tanabe T, Yu S, Hangai M, Ojima T, Aikawa H, Yoshimura N (2008). Retinal nerve fibre layer assessment in myopic glaucomatous eyes: comparison of GDx variable corneal compensation with GDx enhanced corneal compensation. Br J

Ophthalmol; 92:1377-1381.

Ozdek SC, Onol M, Gürelik G, Hasanreisoglu B (2000). Scanning laser polarimetry in normal subjects and patients with myopia. Br J Ophthalmol; 84:264-70.

Sehi M, Guaqueta DC, Feuer WJ, Greenfield DS (2007). Advanced imaging in Glaucoma study group. Scanning Laser Polarimetry with Variable and Enhanced Corneal Compensation in Normal and Glaucomatous Eyes. Am J Ophthalmol; 143:272-279.

Vetrugno M, Trabucco T, Sisto D, Troysi V, Sborgia G (2007). The influence of low to moderate myopia on retinal nerve fiber layer as assessed by scanning laser polarimetry with variable corneal compensator. Ophthalmologica; 221:190-194.

Weinreb RN, Bowd C, Zangwill LM (2003). Glaucoma detection using scanning laser polarimetry with variable corneal polarization compensation. Arch Ophthalmol; 121:218-224.

Yu S, Tanabe T, Hangai M, Morishita S, Kurimoto Y, Yoshirmura N (2006). Scanning laser polarimetry with variable corneal compensation and optical coherence tomography in tilted disc. Am J Ophthalmol; 142:475-482.

Source of support: nil. Conflict of interest: none declared