

Research Article

Optic Disc Parameters by Spectral Domain Optical Coherence Tomography: Normative Values and Associations in Adult Emmetropic, Myopic and Hypermetropic Population

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Abstract

Objectives: To study the optic disc parameters in adult emmetropic, myopic and hypermetropic pakistani eyes using Topcon spectral domain optical coherence tomography (SD-OCT) and its variation with refractive error and axial length.

Methods: This cross sectional study was carried out in Ophthalmology Department of Shifa Foundation Falahee Clinic after approval from Ethical Committee and IRB, over a period of one year starting from January 2016. A total of 93 eyes (including 35 myopes 29 emmetropes and 29 hypermetropes) of 93 patients were enrolled, and autorefraction, axial length measurements and optic disc analysis done. Various optic disc parameters were obtained using Topcon SD OCT. A definable optic cup was absent in 9.68% (n=9) of the patients so they were excluded. One-way ANOVA was applied to compare the variables amongst three groups after adjustment for ocular magnification by using Littman's formula. Pearson correlation coefficients (r) were measured to establish the relationship of the optic disc parameters with axial length and disc area.

Results: The study included 51.2% males (n=43) and 48.8% (n=41) females. Mean age was 30.82±8.01years. Mean±SD of cup-disc ratio was 0.33±0.14 and disc area was 2.24±0.44mm². Statistically significant difference was found among the three groups in disc area (p=0.001). No correlation was observed between disc parameters and axial length except for the linear and vertical CDR. Positive correlation was observed between disc area and various disc parameters.

Conclusions: This study provides normal values for the optic disc parameters in healthy adult Pakistani eyes as measured by OCT. We also report that optic disc parameters are significantly associated with refractive error, axial length and disc area.

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Introduction

The importance of optic disc assessment in diagnosis of optic neuropathies cannot be overlooked. The quantitative parameters of optic disc including cup-disc ratio, area and volume of cup and disc are valuable for early detection of glaucoma thus helping

us to identify diseased nerves and those at risk of disease.¹

Optical coherence tomography (OCT) is an imaging modality whose value for diagnosing and monitoring the diseases related to optic nerve and retina cannot be under estimated². With newer spectral domain SD-

OCT, it is now possible to get rapid and reproducible measurements of the optic disc.^{3,4} However it is known that certain factors related to ocular structure and demographic factors can affect the ability of OCT to quantify disc parameters.^{5,6}

Optic disc parameters measured in various groups have shown racial differences.^{7,8} However, there is limited information of these parameters in Pakistani population and variations with refraction and axial length of the eye have not been studied as yet. Influence of refractive status and axial length on optic disc may be relevant for managing different optic nerve pathologies including glaucoma.

We aim to find out the normal values of optic disc parameters in a healthy non-glaucomatous Pakistani population and their variation with refractive state and axial length using Topcon SD 1-maestro OCT in our clinical setting.

Methods

This cross sectional study was started after approval from Institutional Review board and Ethics Committee. Patients were recruited from eye clinic of Shifa Falahee Community Health Centre over a period of 1 year from January to December 2016 using convenience sampling technique. A total of 93 eyes of 93 patients (including 29 emmetropes, 29 hypermetropes and 35 myopes) older than 18 years of age, both males and females and having best corrected vision 6/6 were included. Eyes having astigmatism >2.00 dioptre, amblyopia, strabismus, corneal, retinal and optic nerve pathologies (including glaucoma and ocular hypertension) and prior history of ocular surgery or trauma were excluded. Verbal Informed consent was taken from all the patients. After detailed history, visual acuity, auto refraction, applanation tonometry and complete examination of anterior and posterior segment (using slit lamp) was done.

Refractive errors were measured by spherical equivalent (SE) via autorefraction. Axial lengths were noted using A-scan (Quantal medical axis-11). An average of 3 measurements was taken. Various optic disc parameters like area of disc, cup and rim, cup to disc area ratio (CDR), vertical and horizontal CDR, cup and rim volume, vertical and horizontal disc diameter were obtained using Topcon SD OCT. All OCT examinations were performed by single

examiner. We used Littmann's formula^{9,10} to correct ocular magnification induced by refractive error.

Statistical analysis was done using SPSS 20.0. Frequency and percentage was calculated for gender and was compared by Chi square test. After applying Kolmogorov-Smirnov test for normal distribution, mean \pm SD was calculated for age, SE, axial length and parameters of disc. Levene's test was applied to evaluate the homogeneity of the variances. One-way ANOVA was applied to compare the variables amongst three groups. A p-value of <0.05 was taken as statistically significant. Pearson correlation coefficients (r) were measured to establish associations of disc parameters with axial length and area of the disc.

Results

A total of 93 eyes of 93 patients were enrolled in the study, 9.68% (n=9) of the patients were excluded as a definable optic cup was absent in these patients. Remaining 84 eyes [42(50%) right & 42(50%) left eyes] were analysed. The study population included 36.9% (n=31) myopes, 29.8% (n=25) hypermetropes and 33.3% (n=28) emmetropes.

Mean age of study population was 30.82 \pm 8.01 years (range 17-47 years). The mean age in the emmetropic group was significantly younger than the other 2 groups. The difference of age between the myopic and hypermetropic group is not significant (p=0.397).

Table 1 shows the demographic and clinical variables of the groups.

Mean value of axial length was 23.15 \pm 1.13mm.

Table 1: Demographic and Clinical Variables of the Groups (Mean \pm SD and Percentages)

Characteristic	Myopic eyes (n=31)	Hypermetropic eyes (n=25)	Emmetropic eyes (n=28)
Age (years)	31.87 \pm 7.01	33.80 \pm 9.86	27.00 \pm 5.61
Gender Male	45.2%(n=14)	32.0%(n=8)	75.0%(n=21)
Female	54.8%(n=17)	68.0%(n=17)	25.0%(n=07)
SE (diopters)	-3.58 \pm 1.86	2.37 \pm 2.28	-0.17 \pm 0.23
Axial length(mm)	24.48 \pm 0.85	22.71 \pm 1.01	23.16 \pm 0.66
Intraocular pressure IOP (mmHg)	12.45 \pm 1.43	11.92 \pm 1.78	12.14 \pm 1.33

Table 2: The Mean Values of the Optic Disc Parameters of the Groups (Mean±SD) (After Applying Littmann's Formula)

Optic Disc Parameters	Total (n=94)	Myopia (n=31)	Hyperopia (n=25)	Emetropia (n=28)	p-value
Disc area (mm ²)	2.24±0.44	2.05±0.37	2.23±0.37	2.47±0.44	0.001
Cup area (mm ²)	0.81±0.50	0.77±0.58	0.67±0.35	0.98±0.49	0.060
Rim area (mm ²)	1.53±0.69	1.55±1.03	1.56±0.38	1.48±0.37	0.894
Cup to disc area ratio(CDR)	0.33±0.14	0.33±0.15	0.28±0.12	0.37±0.14	0.072
Linear CDR	0.56±0.14	0.57±0.14	0.51±0.13	0.59±0.13	0.062
Vertical CDR	0.56±0.14	0.58±0.12	0.51±0.13	0.59±0.15	0.068
Cup volume (mm ³)	0.16±0.13	0.15±0.15	0.13±0.11	0.20±0.13	0.118
Rim volume (mm ³)	0.47±0.26	0.46±0.30	0.53±0.24	0.43±0.22	0.379
Horizontal disc diameter (mm)	1.61±0.31	1.62±0.46	1.57±0.20	1.64±0.17	0.655
Vertical disc diameter (mm)	1.80±0.26	1.78±0.37	1.76±0.19	1.87±0.16	0.288

Mean intraocular pressure was 12.19±1.51 mmHg. The difference in IOP between three groups is insignificant statistically (p=0.420). SE and axial length were statistically different between the three groups (p-value 0.000 for both).

Table 2 shows Mean±SD of the optic disc parameters.

Mean CDR was 0.33±0.14 and mean disc area was 2.24±0.44mm² (ranging from 1.29-3.61mm²) for total population.

The disc area did not show statistically significant difference with age on an independent sample t-test (p=0.290) and with gender on Chi square test (p=0.265).

We observed statistically significant difference among the three groups for disc area (p=0.001) after applying Litmann's formula (table 2). All other optic disc parameters were found to be similar in the three groups.

No correlation between optic disc parameters and axial length was established in our study except for the linear and vertical CDR (table 3). Positive correlation was found for the linear and vertical CDR with axial length. The disc area was positively correlated with the cup area (r=0.467, p=0.000), linear CDR (r=0.296, p=0.006), vertical CDR (r=0.253, p=0.020), cup disc area ratio (r=0.327, p=0.002), cup volume (r=0.459, p=0.000) and horizontal (r=0.371, p=0.001) and vertical diameter of the disc (r=0.517, p=0.000).

Discussion

In the present study, we document normal values for

Table 3: Correlations between Optic Disc Parameters and Axial length in Study Subjects after Applying Litmann's Formula

Optic Disc Parameters	Axial length Correlation coefficient r	p-value
Disc area (mm ²)	-0.114	0.300
Cup area (mm ²)	0.090	0.415
Rim area (mm ²)	0.039	0.722
Cup to disc area ratio(CDR)	0.141	0.200
Linear CDR	0.254	0.020
Vertical CDR	0.302	0.005
Cup volume (mm ³)	0.002	0.988
Rim volume (mm ³)	-0.032	0.772
Horizontal disc diameter (mm)	0.182	0.097
Vertical disc diameter (mm)	0.112	0.309

optic disc parameters using Topcon SD-OCT in healthy non-glaucomatous Pakistani eyes. We found that the optic disc parameters were normally distributed. Dagdelen K¹¹ assessed optic disc parameters of patients with primary open angle glaucoma and ocular hypertension and compared them with healthy individual using Cirrus OCT. Their values for healthy eyes (mean age 59.10±10.41 years) were disc area 1.98±0.33 mm², rim area 1.40±0.28mm² and CDR 0.50 ± 0.15. Another study¹² using Cirrus OCT examined 51 healthy eyes and found mean value of 1.89 ± 0.36 mm² for disc area. These values are lower than our values which may be due to difference in age group studied and OCT used.

According to Kiziloglu OY¹³ mean disc area was 2.30 ± 0.42 mm² and cup to disc area ratio was 0.20 ± 0.13. These values agree closely with our study although their age group was younger.

In another study by Mansoori T et al.¹⁴, their mean

values were disc area $3.36 \pm 0.64 \text{ mm}^2$ (range 2.13–5.08 mm^2), rim area $2.49 \pm 0.58 \text{ mm}^2$ (range 1.20–3.62 mm^2), and cup area $1.10 \pm 0.75 \text{ mm}^2$ (range, 0–3.07 mm^2). These values are higher than our study and the study by Dacosta S¹¹ which can be attributed to include a large number of eyes having large disc areas in their study as shown by the range.

In another study¹⁵ optic disc parameters were measured in myopic subject (SE $-4.91 \pm 2.03\text{DS}$), mean values were disc area $1.98 \pm 0.50 \text{ mm}^2$ and rim area $1.49 \pm 0.30 \text{ mm}^2$. These values agree closely with our values for myopic patients with similar SE.

Studies that used Cirrus OCT for measuring optic disc parameters have reported different values. Most likely these variations are due to different scan patterns, software algorithms and display scans of Topcon OCT as compared to Cirrus OCT.

Knight et al.⁸ reported: Mean disc area 1.81 mm^2 and rim area 1.32 mm^2 , these values are less than our documented values. This may be possible due to difference in age (18–84 years) and use of different OCT (Cirrus OCT). Value for CDR (0.47) was however higher to our study.

AttaAllah¹⁶ analysed optic discs of 86 myopic and 92 healthy eyes using Cirrus OCT. They reported lesser values for disc and rim areas ($1.83 \pm 0.35 \text{ mm}^2$ and 1.27 mm^2 respectively) and greater values for CDR (0.51 ± 0.16) as compared to our study.

In the present study positive correlation was observed between disc area and other disc parameters. This is in accordance with Knight et al.⁸ where rim area ($r = 0.15$), average CDR ($r=0.33$), vertical CDR ($r=0.33$), and cup volume ($r=0.37$) were moderately associated with disc area.

Mansoori T¹⁴ found that the disc area was positively correlated with other parameters like the rim and cup area, cup disc area ratio, both vertical and horizontal, mean and maximum cup depth ($P < 0.001$).

We did not observe any correlation between optic disc parameters and axial length (after correction for magnification effect). This is in agreement with other studies like Savini G¹⁷ who measured disc and rim area in 45 eyes with Cirrus OCT and documented that disc ($r=-0.74$, $r^2=0.54$, $p<0.0001$) and rim area

($r=-0.41$, $r^2=0.17$, $p=0.0051$) decreased with increased axial lengths. But this relationship disappeared after applying Littman formula. Studies discussed below did not correct the parameters for effect of ocular magnification and found a negative correlation of optic disc parameters with axial length. Knight et al.⁸ found weak but statistically significant correlations of axial length with disc parameters. Disc area ($r=-0.29$; $P<0.001$) and rim area ($r=-0.24$; $P<0.001$). Nagaoka N¹⁸ reported that disc and rim area increased significantly with axial length (correlation coefficient: 0.45).

In the present study we did not find significant effect of gender or age on disc area and this is in accordance with Knight et al.⁸ Zeried FM noticed similar results for age of normal patients.¹⁹ However Mansoori¹⁴ and Poon et al reported that optic disc parameters varied with age.

The strengths of our study include the use of a spectral domain OCT, standardized examination protocols, a relatively uniform sample and use of Littman's formula. Possible limitations include relatively small sample size and limited range of spherical equivalent considered. However, the study provides baseline data on optic disc measurements in Pakistani eyes. Therefore, it is recommended that studies with larger sample size and with a wider range of spherical equivalent be conducted in future.

Conclusion

We have reported normal values for optic disc parameters in healthy Pakistani eyes as measured by Topcon SD-OCT. We further document that optic disc parameters are significantly associated with axial length, refractive error and disc area. The latest available OCT devices have built-in software to correct the effect of refractive error and axial length which should be taken into account to enhance the diagnostic accuracy of these devices.

Ethical Approval: Given

Conflict of Interest: None

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