RESEARCH ARTICLE

Optic Nerve Head Parameters in Saudi Male Young Adults Using Swept-source Optical Coherence Tomography

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Abstract

Purpose: To assess the optic nerve head (ONH) parameters in normal male Saudi eyes using swept-source optical coherence tomography (SS-OCT).

Materials and methods: The study included 86 healthy men with a mean age of 23.6 ± 4.82 years. The metrics collected using SS-OCT from each individual was disk area (DA), rim area (RA), cup volume (CV), linear cup–disk ratio (LCDR), vertical cup–disk ratio (VCDR), and total retinal nerve fiber layer (RNFL) thickness, superior RNFL thickness, and inferior RNFL thickness. All the metrics were correlated with the DA. The right eye data were used for the correlation analysis.

Results: The mean DA in OD was 1.78 mm^2 (range 1.09–2.70 mm^2). The mean RA was 1.28 mm^2 (range 0.72–2.47 mm^2). The DA showed a significant positive correlation ($p < 0.05$) with RA, cup area (CA), CV, VCDR, LCDR, and total RNFL thickness.

Conclusion: For the first time, using sweeping source OCT (DRI OCT Triton, Topcon Corporation), a normative database of ONH parameters was made accessible to the Saudi male population. While assessing the optic disk for progressive optic neuropathies like glaucoma, disk size should be taken into consideration since the optic DA affects ONH topography, especially in Saudi eyes.

Keywords: Cup to disk ratio, Optic nerve head parameters, Retinal nerve fiber layer thickness, Swept-source optical coherence tomography.

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Introduction

For the diagnosis and treatment of glaucoma and other optic nerve anomalies, an examination of the optic nerve head (ONH) is crucial.[1] ONH's appearance does not match up with the normal population but rather exhibits extraordinary diversity.[2] Understanding the normal topography of the optic disk serves as a benchmark for assessing glaucomatous pathologic alterations, particularly in the early stages.[1,3]

The anatomic layers of the retina and ONH can be assessed using *in vivo*, high-resolution cross-sectional pictures produced by the noncontact, noninvasive optical coherence tomography (OCT) imaging technology.[4] OCT instruments have evolved over years and the most advanced OCT technologies now being used in ophthalmic contexts are spectral domain OCT and swept-source optical coherence tomography (SS-OCT), both of which are Fourier-domain OCT versions.[5] SS-OCT has improved sensitivity and can run at higher speeds with good reproducibility of the data.[5,6] High prices and lack of normative data prevent the current commercial acceptability of SS-OCT devices.[5] There are limited attempts to measure the ONH parameters in different races using SS-OCT.

Although there are previous reports that have described the morphology and measurement of ONH parameters using OCT across different races,[3,4,7–11] limited data is available from Saudi Arabia. There is only one study[12] that specifically aims to measure the ONH parameters in the healthy Saudi male population, however, the individuals' mean age was above 50 years old in that study. Another study evaluating the ONH parameters in healthy Saudi females was recently published.[13] To the best of our knowledge, there is no normative database of ONH parameters using SS-OCT in Saudi young male subjects. In this work, SS-OCT was used to evaluate ONH topography in the Saudi male population in normal eyes. The investigation was further extended to see whether there is any influence of age on ONH parameters.

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Materials and Methods

A total of 86 male participants (the university staff and students) who had visited the university eye clinic for refractive error correction or for general eye examination between January and May 2022 were included in this prospective study. The investigations followed the Declaration of Helsinki's guidelines. All the participants were Saudi nationals and were included in the study following the collection of written informed consent.

Each participant has undergone a comprehensive eye examination that included Snellen visual acuity, slit lamp examination, ophthalmoscopy, intraocular pressure, refractive error, and visual fields. All participants who had a normal ocular examination, intraocular pressure of <21 mm Hg on Goldman applanation tonometry, Snellen visual acuity of 6/6, refractive error of <± 3 D, clear ocular media, normal visual fields, and normal optic disk appearance (intact neuroretinal rim, free from optic neuropathy, free from notches, hemorrhage, pallor of the disk, and no vertical CDR asymmetry of greater than 0.2 between both eyes) were included in the study.

Subjects with any ocular pathology such as corneal, uveal, or retinal pathology, undergone any intraocular surgery, had any neurological disease, have shown abnormal disk appearances such as tilted disk or peripapillary atrophy, and any family history of glaucoma was also excluded from the study.

Acquiring the OCT Images

Swept-source OCT (SS-OCT) (Topcon DRI OCT Triton plus) was used to measure the ONH metrics in all participants. Topcon DRI OCT Triton Plus is a noncontact, high-resolution, tomographic, and microscopic imaging device with a scan speed of 1,00,000 A-scan/second allowing a clear B-scan image along with a fundus image in a single capture. A three-dimensional disk scan pattern (6.0 × 6.0 mm) was used to measure the ONH parameters. Subjects were asked to look at the internal fixation target and the examiner observed the position of ONH to properly align the scan over ONH. During the scan, the patient is advised to blink normally to get a clear image. Stereoscopic disk images were constructed in all the subjects. The green box in the scan helps to find the area of the scan (6.0 × 6.0 mm) and the red box allows us to measure the RNFL thickness extracted from data points in a 3.4 mm peripapillary circle centered on the optic disk. The metrics collected from each individual were DA, CA, CV, LCDR, VCDR, total RNFL thickness, superior RNFL thickness, and inferior RNFL thickness.

Sample Size Calculations

Previous research[12] has estimated that the average optic disk size using OCT in the Saudi population is 1.92 ± 0.45 mm^2. The sample size was calculated using the following assumptions—a significant difference (d) of 0.5 mm^2, a power of 90% (Zb = 1.282), and a significance level of 0.01 (Za = 2.576).

$n = 2\,(Za + Zb)^2\, S^2/d^2$ was used to calculate the sample size. The minimum sample size calculated was 24, based on the standard deviation (SD) of 0.45 mm.

Before analyzing the data, all of the information was entered into Microsoft Excel and exported to Statistical Package for the Social Sciences (version 25). The Pearson correlation coefficient and linear regression were determined to report the effect of age and refractive error and ONH parameters.

Results

A total of 172 scans of 86 subjects (both eyes) were analyzed for the ONH parameters (i.e., DA, CA, CV, LCDR, VCDR, and RNFL thickness). The mean age of the study cohort was 23.6 ± 4.82 years. The mean spherical equivalent of the right eye and left eye were −0.58 ± 1.01 D and −0.53 ± 0.97 D, respectively. Out of 87 subjects, 26 subjects were emmetropic, 49 subjects were myopic and 11 subjects were hypermetropic.

The mean disk area (DA) of the right and left eye were 1.77 ± 0.36 mm and 1.78 ± 0.35 mm, respectively. Since right and left eye DAs have shown a high positive correlation (0.75, $p < 0.01$) (Fig. 1), only right eye data were used for correlation analysis. The mean and SD of all the ONH parameters with 95% confidence intervals (CI) were summarized in Table 1.

Correlations among ONH parameters were presented in Table 2. The correlation between DA and other ONH parameters were presented in Figure 2. DA had a significant positive correlation ($p < 0.01$) with rim area (RA) ($r = 0.53$), linear cup disc ratio (LCDR) ($r = 0.37$), vertical cup disk ratio (VCDR) ($r = 0.34$), cup volume (CV) ($r = 0.50$), total retinal nerve fiber layer (RNFL) thickness ($r = 0.24$, $p < 0.05$), Superior RNFL thickness (r = 0.2, $p < 0.05$). Similarly, RA has a significant ($p < 0.01$) negative correlation with LCDR ($r = -0.51$), VCDR ($r = -0.40$), CV ($r = -0.33$), and significant ($p < 0.01$) positive correlation with total RNFL thickness ($r = 0.36$,), superior RNFL thickness ($r = 0.45$).

Age did not show a significant ($p > 0.05$) correlation with DA, RA (Fig. 3), and other ONH parameters. The degree of myopia has a significant positive correlation ($p < 0.05$) with RA ($r = 0.36$), total

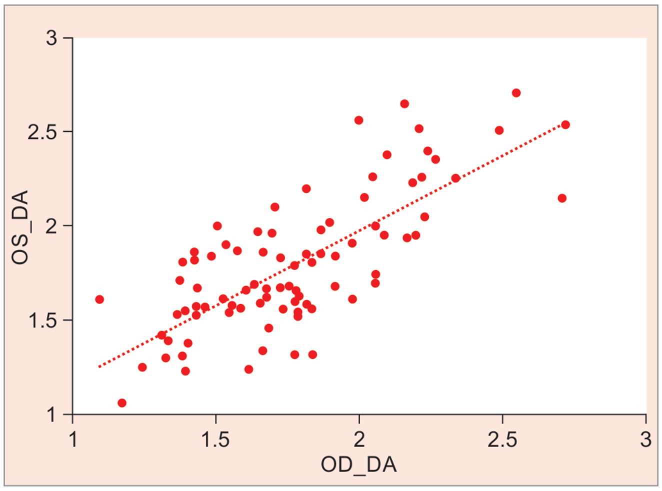


Fig. 1: Shows a significant positive correlation between the right and left eye DA

Table 1: Shows the mean, 1st, 5th, 50th, and 95th percentiles of several ONH metrics as well as the SD, range, and 95% CI for each. This data is from the right eye of the study participants

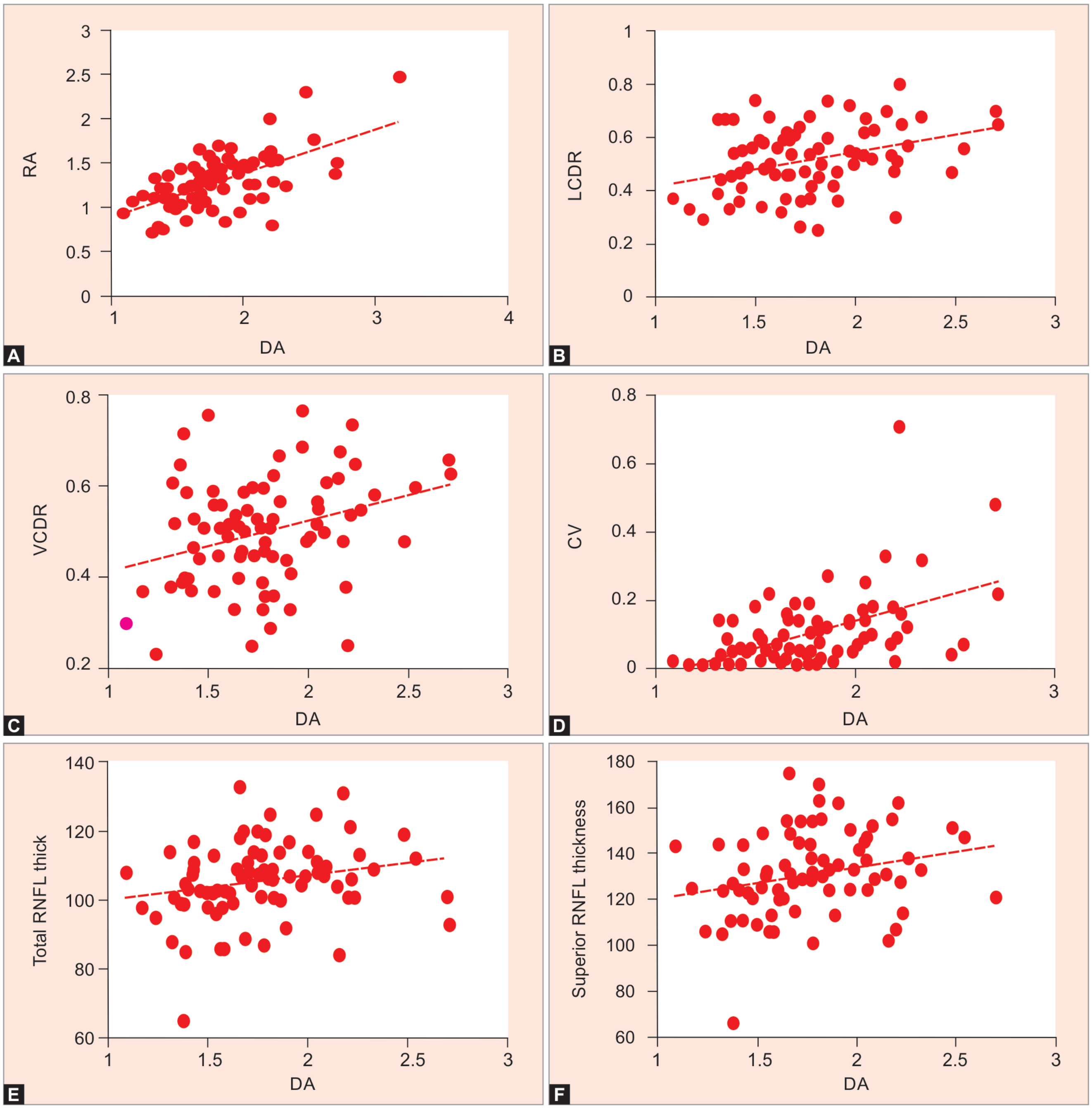
ONH parameters	*Mean ± SD*	*Range*	*95% CI of mean*	*1st percentile*	*5th percentile*	*50th percentile*	*95th percentile*
DA	1.76 ± 0.34	1.09–2.71	1.70–1.86	1.09	1.31	1.74	2.43
RA	1.26 ± 0.27	0.72–2.30	1.21–1.34	0.72	0.81	1.25	1.67
LCDR	0.52 ± 0.12	0.25–0.80	0.49–0.54	0.25	0.31	0.52	0.71
VCDR	0.50 ± 0.12	0.23–0.77	0.47– 0.52	0.23	0.29	0.51	0.71
CV	0.09 ± 0.09	0.01–0.71	0.07–0.11	0.01	0.01	0.07	0.33
Total RNFL thickness	10.5.59 ± 10.66	65–133	103.51–108.12	65	86	107	125
Superior RNFL thickness	130.82 ± 17.72	66–175	127.02–134.62	66	105	129	162
Inferior RNFL thickness	133.28 ± 16.78	73–163	129.68–136.88	73	105	132	160

LCDR stands for linear horizontal cup disk ratio

Table 2: Effect of the optic DA area on other optic disk variables

ONH parameters	*Correlation coefficient (OD)*	*Significance (OD)*	*Equation (OD)*
DA vs RA	0.53	0.0001**	Y = 0.75 + 0.81 X
DA vs LCDR	0.37	0.0001**	Y = 0.10 + 0.32 X
DA vs VCDR	0.34	0.0001*	Y = 0.08 + 0.35 X
DA vs CV	0.50	0.0001*	Y = 0.14 – 0.15 X
DA vs total RNFL thickness	0.24	0.029**	Y = 90.5 + 8.56 X
DA vs superior RNFL thickness	0.25	0.019*	Y = 107.38 + 13.30 X
DA vs inferior RNFL thickness	0.15	0.170	Y = 120.1 + 7.46 X

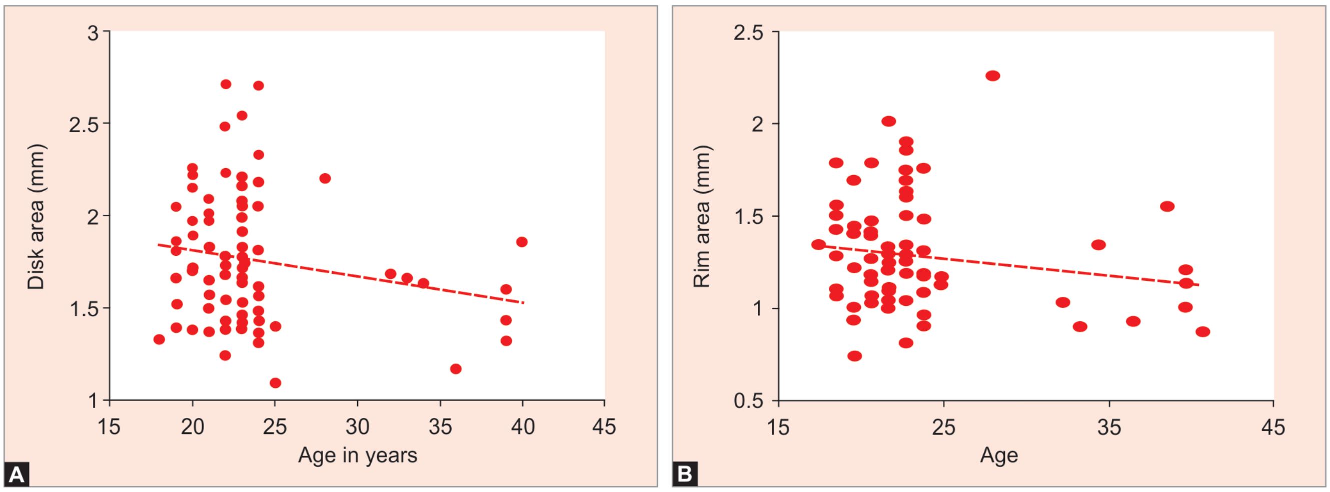
**Correlation is significant at the 0.01 level; *correlation is significant at the 0.05 level



Figs 2A to F: Shows the correlation between DA and other ONH parameters of the right eye. The dotted line in each graph shows the best-fitting line of the data. RNFL thickness is in μm

Table 3: Disk area in normal eyes of various ethnicities according to various studies

Author	*Ethnicity*	*The instrument used for disk examination*	*Sample size*	*DA in mm² (mean ± SD)*
Current study	Arabian	SS–OCT	86	1.78 ± 0.35
Marsh et al.[2]	Whites Hispanic African–American	Stratus OCT	212	2.17 2.33 2.49
Zhang et al.[3]	Chinese	HRT-II		2.28 ± 0.43
Mansoori et al.[4]	Indian	Spectral-domain OCT	157	3.36 ± 0.64
Ramrattan et al.[7]	Dutch	Stereoscopic disk images with image analyser	5114	2.42 ± 0.47
Medeiros et al.[11]	Caucasian	Stratus OCT	78	2.35 ± 0.51
Almarzouki et al.[12]	Arabian	Cirrus HD-OCT	416	1.92 ± 0.45
Ocansey et al.[14]	African	Cirrus HD-OCT 5000	100	2.08 ± 0.40
Varma et al.[15]	Western	Stereoscopic photographs	1853	2.63
Funaki et al.[16]	Japanese	Scanning laser polarimetry	60	2.20 ± 0.55
Dacosta et al.[17]	Indian	Stratus OCT	156	2.63 ± 0.55
Zeried et al.[20]	Arabian	Stratus OCT	65	2.52 ± 0.09



Figs 3A and B: The left graph shows the correlation between age and DA and the right graph shows the correlation between age and RA. The dotted line in each graph shows the best-fitting line of the data

RNFL thickness ($r = 0.32$), and superior RNFL thickness ($r = 0.46$) but not with DA, CV, and inferior RNFL thickness, however, the degree of hyperopia has not shown any significant correlation ($p > 0.05$) with any of the ONH parameters.

Discussion

The current study assessed the ONH characteristics in healthy Saudi male eyes using SS-OCT. Depending on the race, the optic disk's size varies. The optic disk sizes measured in the current study in the Saudi male population are quite smaller than that measured in Hispanic,[2] Chinese,[3] Dutch,[7] Caucasian,[11] African,[14] Western,[15] Japanese,[16] and Indian populations.[4,17,18] There are two studies that reported the DA in the male Saudi population.[12,19] The mean DA in the current study was 1.78 mm, which is less than (2.50 mm) what Zeried et al.[19] but comparable to the study done by Almarzouki (1.90 mm).[12] This difference in disk size in Zeried et al. study[19] might be brought on by the instrument employed and the variation in a sample's mean ages. In Zeried et al., study[19] the mean age of the sample was 50.7 ± 7.1 years and the instrument used was Stratus OCT, whereas in the current study, the samples mean age was 23.6 ± 4.82 years and the instrument used was Topcon DRI OCT Triton plus (Table 3).

The DA (1.78 ± 0.36 mm) of Saudi male participants in the current study is smaller than the measured DA (2.22 ± 0.48 mm) of the female participants in the Elagamy et al., studies.[13] Given that subjects in both studies were of the same age range, it could be interpreted that Saudi females have larger disk sizes than Saudi males. Regarding gender, a large population-based survey[15] pointed out that males have a considerably larger DA than females, On the contrary, conclusions drawn from the current study and Elagamy et al.,[13] studies show that Saudi females have a larger DA than Saudi males.

In relation to age and ONH parameters, the current study has shown there is no statistically significant ($p > 0.05$) relationship between the age of the subjects and the ONH parameters. This result was consistent with the findings of the Ramrattan et al.,[7] and Singapore Malay Eye[20] studies and conflicts with the Blue Mountains

Eye Study,[21] Garway-Heath et al.,[22] and Mansoori et al.[4] study who found a significantly weak correlation between age and the C/D ratio.

In terms of the relationship between age and RNFL thickness, no significant correlation ($p > 0.05$) was found in our study for either the superior or inferior RNFL thickness. This result was in line with that of Balazsi et al.[23] In contrast, studies by Lee et al.[24] and Cheung et al.[25] have shown that RNFL thickness significantly decreased with advancing age. Furthermore, Parikh et al.[26] have shown that the inferior quadrant RNFL is more resistant to thinning with age than the superior quadrant RNFL. However, the correlation between age and ONH parameters in the current study should be interpreted with caution since >90% of the sample's age range is between 19 and 26 years.

In the current study, a significant positive correlation between the DA and the CDR (both linear and vertical) was observed. The clinical significance of this finding is that optic nerve damage in small optic disks with relatively small cups may go unnoticed in early glaucoma if one fails to consider that small optic disks typically have small or no optic cups and that large optic cups can be physiological in eyes with large ONH that may be mistaken for glaucoma. As the current study found small DA in Saudi eyes, more careful evaluation is needed in these subjects.

The main limitation of the current study is the constrained age range. Hence the relation between age and ONH parameters have to be interpreted with caution. We cannot extrapolate the data presented in this study to the general population as females were not included in this study.

For the first time, the current study used SS-OCT to establish a normative database for ONH parameters in healthy Saudi male eyes. Optic disk sizes measured in the current study are small in the Saudi eyes compared to Western, South Asian, and African eyes. Age has no association with ONH parameters. While assessing the optic disk for glaucoma and other progressive optic neuropathies, Saudi eyes should be screened more carefully as the disk size is small, to avoid misdiagnosis of optic neuropathies.

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