Original Article

Variations in Optic Cup to Disc Ratio Due to Refractive Errors and Smoking

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Abstract

Objective: To evaluate the deviation of Optic Cup to Disc Ratio with refractive errors and smoking status.
Methodology: This was a cross-sectional observational study carried out from January to October, 2016 at Dr Akil bin Abdul Kadir Institute of Ophthalmology, Karachi, Pakistan. A total of 300 eyes of 300 patients were included in the study and divided according to the error of refraction into emmetropic (n=135), hypermetropic (n=77) and myopic (n=88) eyes for Cup to Disc Ratio measurements. To assess the effect of smoking, emmetropic eyes were further divided into smokers (n=23) and nonsmokers (n=112). Independent T test and ANOVA was used to analyze the differences in the mentioned groups. P value <0.05 was taken as significant.
Results: The optic Cup to Disc Ratio in emmetropic eyes was found to be 0.27 ± 0.03. It was found to be significantly decreased in myopic eyes (0.24 ± 0.05) and significantly increased in hypermetropic eyes (0.31 ± 0.07) with p value = 0.01. CDR was significantly increased in smokers (0.31 ± 0.07) than nonsmokers (0.26 ± 0.01) with p value of 0.01. These findings will aid the clinicians in diagnosing and treating different ophthalmic diseases involving the optic cup.
Conclusion: Cup to Disc Ratio was significantly increased in myopic eyes and significantly decreased in hypermetropic eyes compared to emmetropic eyes. Smokers and nonsmokers also showed significant variations in CDR. This study concludes that the cup to disc ratio is significantly affected by the refractive errors and smoking status.

Keywords: Optic Disc, Refractive Errors, Smokers, Cup to Disc Ratio.

Introduction

The optic Cup-to-Disc Ratio (CDR) is a fundamental, ophthalmologic, parametric test used in the clinical setting for evaluation of various eye conditions and progression of ocular diseases. It shows the proportion of the optic cup's diameter to that of the optic disc and is crucial in assessing the health and integrity of the optic nerve head. The optic cup and disc are located at the posterior pole of the eye globe, appearing as a pale, circular structure, visible through fundoscopy.[1]

The optic disc is a slightly vertical oval area which marks the region from where retinal nerve fibers exit the eyeball to form the optic nerve. The optic cup is a central depression within the optic disc. The vertical dimensions of both are critical for assessing the anatomical and physiological conditions of the optic nerve head. The CDR is expressed as a ratio, quantifying the relative sizes of the cup and disc. The size of the optic disc effects the measurements of CDR. Eyes having larger optic discs tend to have larger cups, ensuing relatively smaller CDR, while smaller discs have higher CDR values because of proportionately larger cup size.[2]

Examination and measurement of CDR helps clinicians to get valuable insights into underlying ocular conditions.[3] Any deviation in CDR from the normal may suggest optic nerve damage due to various ophthalmic or systemic pathologies, especially glaucoma and also indicate the progression of the disease.[4,5] Understanding the link between CDR and different eye conditions is important for accurate diagnosis, timely intervention and planning of effective management strategies. The CDR is commonly influenced by factors that include anatomical features and physiological deviations besides pathological conditions. Studies have shown that the CDR increased with increase in age,[6,7] as changes in connective tissues and vascular supply contribute to alterations in optic disc morphology with advancement in age.[8] The CDR measurements have also shown to be impacted by gender, with males exhibiting increased CDR compared to females.[6] Ethnicity is also known to influence retinal thickness and optic disc morphology, showing variations in disc size, shape, and CDR among different racial groups.[9] Axial length has proven to alter CDR because the changes in the eye globe tend to change the size and shape of the optic disc.[10] In myopia, eyes with longer axial lengths, are likely to have larger optic discs and cups, leading to a potentially higher CDR. In hypermetropia, CDR tends to decrease.[11-13] Elevated intraocular pressure is also known to have mechanical stress on the retinal layers, resulting in retinal thinning leading to cupping and raised CDR. Glaucoma is commonly related with raised (IOP) resulting in progressive enlargement of the cup and hence, the increased CDR.[14] Smoking has been attributed with several ocular pathologies, including retinopathies, ischemic optic neuropathy and macular degeneration.[15] It has also been implemented in early cataract formation secondary to accumulation of toxins in the lens. Retinal scans obtained by Optical Coherence Tomography (OCT) has also shown to cause thinning in the retinal nerve fiber layer in smokers.[16] This study was formulat-

ed to investigate the relationship between CDR, refractive errors and smoking in our population. Understanding this relationship will aid ophthalmologists in diagnosis, evaluation and management of existing and prevention of potential ocular diseases.

Methodology

This cross-sectional research included 300 eyes from 300 individuals from an eye clinic of Karachi, Pakistan. Convenient sampling method was used. Sample size was calculated to be 300, using WHO sample size calculator. Ethical approval was taken from Ziauddin University, Karachi, Pakistan. (Ref. # 0271214SMA-NA) and samples were obtained from the ophthalmology OPD at Akil bin Abdul Qadir Institute because the facility of Optical Coherence Tomography was not available at Ziauddin Hospital. Participants of both sexes, more than 40 years of age and having apparently normal eyes were selected for the study. To rule out glaucoma, eyes with controlled intraocular pressure (IOP) were included only. Those eyes with any other retinal pathologies, diabetic and hypertensive retinopathies, history of laser therapy or intraocular surgery, diseases such as parkinsonism or multiple sclerosis, high refractive errors were also not included. After getting the informed consent, participants underwent a detailed ophthalmic examination which included slit-lamp bio-microscopy, refractive error testing and visual acuity. As the internal environment is the same for both the eyes, a single eye was randomly selected from each participant. The selected participants' eyes were first grouped according to the error of refraction into emmetropic (n=135), hypermetropic (n=77) and myopic (n=88) eyes. Then these participants were sent for further examination and CDR and IOP measurement. The emmetropic eyes were further evaluated to see the effects of smoking on CDR measurements. Two groups were made: Smokers (n=23) & Nonsmokers (n=112) and their CDR measurements were compared. Statistical analysis was done by SPSS, version 20. Mean and standard deviation were used for the quantitative variables. For the qualitative variables, percentages and frequencies were used. Independent T test and ANOVA was used to analyze the differences in the mentioned groups. $P = <0.05$ was taken as significant.

Results

A set of 300 eyes from 300 individuals were involved in this study. The mean age of the participants was 57.67 ± 11.42 years. The distribution of study participants according to gender and error of refraction is shown in Table 1.

Table 1: Basic distribution of Study Participants According to Gender & Error of Refraction.

Error of Refraction	Gender (N)		Total (N)
	Males	Females	
Emmetropia (N)	67	68	135
Hypermetropia (N)	35	42	77
Myopia (N)	48	40	88
Total (N)	150	150	300

N = number of eyes

Table 2 shows the CDR measurements in each group of refractive errors that include Emmetropic eyes, Hypermetropic eyes & Myopic eyes. Hypermetropic eyes show significant decrease in CDR whereas Myopic eyes show significant increase in CDR as compared to Emmetropic eyes Table 2, Figure 2.

Table 2: CDR Measurements in Eyes with Refractive Errors

Error of Refraction	N=300	CDR Mean ± S.D	P Value
Emmetropia	135	0.27 ± 0.03	
Hypermetropia	77	0.24 ± 0.05	0.01*
Myopia	88	0.31 ± 0.07	

N = number of eyes, S.D.= standard deviation *highly significant

It was observed that smoking affected the retina, involving its layers specially the retinal nerve fiber layer leading to visual disturbances. Keeping this in mind, we assessed the emmetropic eyes using the history of smoking as a variable. Out of 135 emmetropic eyes, we found that 23 eyes were of smokers and 112 eyes belonged to nonsmokers. The CDR was measured and it was found to be significantly different in between the two groups Table 3, Figure 3.

Table 3: CDR Measurements in Smokers and Non-Smokers

Smoking Status	N=135	CDR Mean ± S.D.	P Value
Smokers	23	0.31 ± 0.07	0.01*
Nonsmokers	112	0.26 ± 0.01	

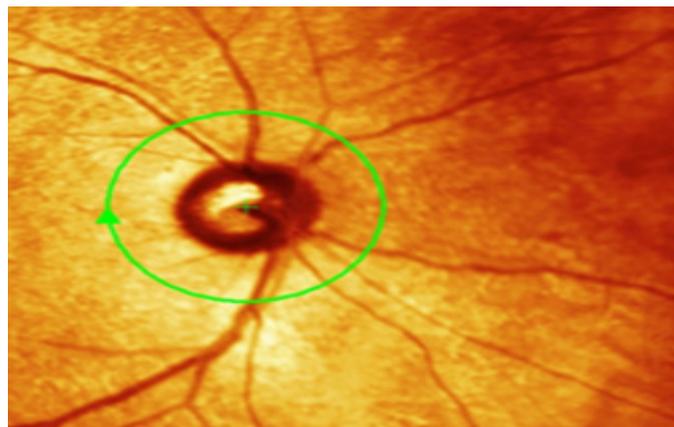N=number of eyes, S.D.= standard deviation, *highly significant

Figure 1: Optic Nerve Head in a 55 year old emmetropic male eye when observed through Optical Coherence Tomography.

Figure 1 shows the appearance of Optic Nerve Head for measurements of CDR when observed through Optical Coherence Tomography.
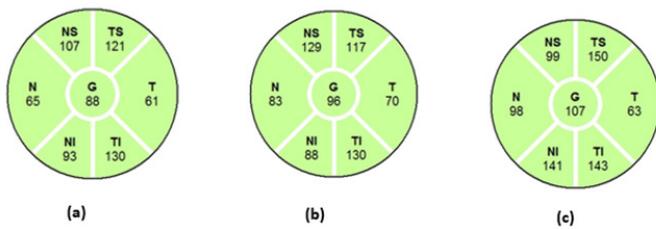
Figure 2: Retinal Nerve Fiber Layer (RNFL) thickness in each quadrant of Optic Nerve Head (ONH) in 58 years old males having (a) emmetropic eye (b) myopic eye & (c) hypermetropic eye by using OCT where G= mean global thickness at ONH, NS= Nasal Superior, TS=Temporal Superior, T=Temporal, NI= Nasal Inferior, TI=Temporal Inferior, N= Nasal
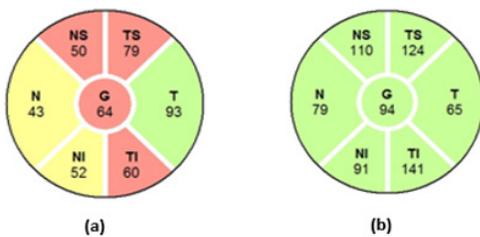

Figure 3: Retinal Nerve Fiber Layer (RNFL) thickness in each quadrant of Optic Nerve Head (ONH) in 55 years old males with (a) smoking & (b) non-smoking status by using OCT where G= mean global thickness at ONH, NS= Nasal Superior, TS=Temporal Superior, T=Temporal, NI= Nasal Inferior, TI=Temporal Inferior, N= Nasal

Discussion

A total of 300 eyes from 300 patients were examined in this study. The eyes were initially divided according to refractive errors. After examination, the division was: 135 eyes in the emmetropic group, 77 eyes in the hypermetropic group and 88 eyes in the myopic group. Based on the fact that retinal thickness ultimately effects the CDR,[2] CDR was measured of each group. The process of aging precedes ophthalmological complications, so only those subjects who were 40 years and above were selected, and the mean age of the participants that were included in our study was 57.67 ± 11. 42 years. CDR measurements in myopic group were significantly increased while in hypermetropic group CDR was significantly decreased in comparison to emmetropic group. [Table 2, Figure 2] These observed alterations could be related to difference in axial lengths which influences optic disc size. Significant increase in CDR of myopic eyes supports the fact that retinal thickness is reduced by short sightedness. When retina gets thinner the CDR increases.[12] It is postulated that the degree of elongation of the globe is related to the extent of retinal thinning, leading to reflex stretching and increased CDR.[17,18] This theory is also supported by Ganekal et al.(2021) in their study done in 2020.[19] Other studies done by Tai et al. (2018) Hamed et al. (2019) Ibrahim et al.(2020) and Oishi et al.(2020) also found the same effect of myopia and axial length on Retinal nerve fiber

layer (RNFL) thickness and subsequently on CDR.[20-23] Previous research was conducted which showed smoking to cause a significant decrease in retinal nerve fiber and ganglionic cell layers.[23] To avoid any confounding effects of refractive errors, we analyzed the difference in the CDR of smokers and non-smokers in emmetropic group only. The smokers showed significant increased CDR compared to non-smokers which could be due to decrease in retinal thickness (Figure 3). A study conducted by Dervişoğulları et al.(2015) confirmed the results of our study and proposed that smoking history of a patient should be considered when inferring the results of ophthalmic examinations.[24] Liu et al.(2015) has suggested that smoking caused decreased optic disc perfusion, leading to disruption in retinal thickness and CDR.[15] The harmful effects of cigarette smoking on deep retinal vascular density were also seen by Dogan et al.(2020)[25] In another study, Abdelshafy observed functional and structural changes in the RNF and ganglionic cell layers in heavy smokers.[26] Kaymaz et al.(2020) demonstrated that even after smoking a single cigarette, the vessel density parameters were markedly decreased.[27] The onset of age-related macular degeneration is also augmented with smoking exposure as shown in mice by Feng et al.(2020)[28] Using the results of our study as a forerunner, further studies using a larger sample size should be designed to achieve a normative data base for our population, which would help in screening of high-risk people with diseases involving ONH.

Limitations

Our study was conducted in Karachi, which is a multicultural metropolis; hence, ethnicity may pose to be a significant limitation as a confounding factor.

Conclusion

This study concludes that CDR was significantly affected by refractive errors and smoking. CDR significantly increased in myopic eyes while decreased in hypermetropic eyes compared to eyes with no refractive errors. The CDR measured in smokers was significantly raised compared to non-smokers' eyes. These parameters are important to consider while assessing ophthalmic diseases involving the retina.

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