# Analysis of Optic Disc and Vertical Cup Disc Ratio among Glaucoma Suspects in a Black Population


## Abstract

**Aim**: To analyze the optic discs and vertical cup disc ratio in a black population.

**Method**: This is a retrospective study of glaucoma suspects who presented to the clinic. Medical history was recorded and comprehensive ocular examination done on each of the subjects. Ocular examination included visual acuity, visual field, tonometry and ophthalmoscopy. Instruments used during the research were Pen torch for examination of the external structures of the eyes, Keeler ophthalmoscopes for fundus examination, Snellen's charts both literate and illiterate charts for visual acuity assessment, Reichert AT 555 Auto non-contact tonometer for measurement of the intra-ocular pressure.
The optic discs were analyzed using Optical Coherence Tomography machine. Data was analyzed using the statistical package EPI info version 6.04d, a software package designed by the Centers for Disease Control and Prevention(CDC), USA in 2001.

**Results:** This study included total of 240 optic discs of 120 participants comprising 60males and 60 females whowere examined with a mean age of 42.8±13.79; the age range was 19 to 75 years. Very Small discs (<1.0mm) 3 accounted for1.3%, Small discs (1.0-1.3mm) 4 accounted for 1.7%, Medium (1.4-1.7mm) 67 accounted for 27.9%, Large (1.8-2.0mm) 58 accounted for 24.2% while Very Large (>2.0mm) 108 accounted for 45.0% in this study. VCDR was noticed to have increased with increasing disc diameter.Optic disc diameter increased with increasing RNFL thickness as well ($p < 0.05$; $r = 0.18$).All the very small as well as the small discs were cupped 3% (n = 7/240), 14.6% (n = 35/240) of the medium to very large are also cupped while the remaining 82.5% ( n = 198/240) are normal.

**Conclusion**: There was no significant correlation between disc diameter and VCDR.There was also a weak positive correlation between the optic disc diameter and the retinal nerve fiber layer thickness of the subjects, such a correlation may be the result of either an increased number of nerve fibers in eyes with larger discs or a smaller distance between the circular scan and the true optic disc margin.



**Keywords**: Optic Disc, Vertical Cup Disc Ratio, Blacks.


## Introduction

Glaucoma is described as a group of diseases that have in common a characteristic optic neuropathy, with associated visual function loss. Although elevated intraocular pressure (IOP) is one of the primary risk factors, its presence or absence does not have a role in the definition of the disease.[1][1].It is the third leading cause of blindness in the world. The prevalence of glaucoma varies slightly worldwide. The highest prevalence (4.2%) was reported in Africa and this is likely due to the high prevalence of primary open angle glaucoma among blacks [2].[2].

The prevalence of glaucoma blindness is increasing in most African countries as a result of the increasing life expectancy.[3][3].Available data suggests that age specific glaucoma prevalence in population surveys in Nigeria is about 6.5% in people over 40 years [4], [4],given that 20% of over 150 million population are 40 years and above[5],[5], it then implies that there are approximately 2 million people over 40 years with glaucoma in Nigeria. Of these, 90% (1.8 million) individuals are undiagnosed and there is considerable visual dysfunction at time of diagnosis.[4][4].Published works in Nigeria show that glaucoma is the second commonest cause of blindness being responsible for between 16.7% and 43.3% of cases of blindness.[6-9][6-9].Glaucoma studies done in Rivers State revealed a prevalence of 7.95% [10][10] and blindness from glaucoma accounted for 20.8% of blindness in the region.

A glaucoma suspect is defined as an adult who has one of the following findings in at least one eye: an optic nerve or nerve fiber layer defect suggestive of glaucoma like enlarged cup–disc ratio, asymmetric cup–disc ratio, notching or narrowing of the neuroretinal rim, a disc haemorrhage, or suspicious alteration in the nerve fiber layer, a visual field abnormality consistent with glaucoma, an elevated IOP greater than 21 mm Hg. The diagnosis of a glaucoma suspect is also dependent on a normal open angle on gonioscopy. [11]Some authors have however classified glaucoma suspects into open angle and angle-closure suspects. The angle-closure suspects were based on the following criteria: posterior trabecularmeshwork not visible 180 degrees, pigmented trabecular meshwork not visible 270 degrees without indentation or posterior trabecular meshwork not visible 180 degrees and IOP 22 mmHg or greater. Studies conducted globally have used a wide variety of definitions to identify open-angle glaucoma suspects, reporting a prevalence of 1–8%. [12]

Optical coherence tomography (OCT), was introduced in 1991 as a new technique for high-resolution cross-sectional imaging of various ocular structures. The OCT was used in this study to assess the optic disc parameters in the University of Port Harcourt Teaching Hospital (UPTH). This study provides information on the disc diameter, vertical cup disc ratio (VCDR) and how this correlates with the RNF layer thickness.

**Methods**

This is a non-intervention, observational, hospital based study, using consecutive allocation of glaucoma suspects as they presented to the glaucoma clinic. The study population consisted of 120 glaucoma suspects, who were seen at the outpatient clinic of the ophthalmology department, of University of Port Harcourt Teaching Hospital. Medical history was recorded and comprehensive ocular examination done on each of the subjects. Ocular examination included visual acuity, visual field, tonometry and ophthalmoscopy. Instruments used during the research were Pen torch for examination of the external structures of the eyes, Keeler ophthalmoscopes for fundus examination, Snellen's literate and illiterate charts for visual acuity assessment, Reichert AT 555 Auto non-contact tonometer for measurement of the intra-ocular pressure. The anterior chamber angle was then examined with Goldman three-mirror gonio-lens (Volks,indirect gonioscopy).Carl Zeiss Stratus OCT Model 3000 software version 4.0 was used to assess the retinal nerve fibre layer of the patients.

Approval to carry out this study was granted by the Ethics Committee of the University of Port Harcourt Teaching Hospital, Port Harcourt.(PLEASE MOVE THE ETHICAL APPROVAL, TO THE END OF THE ARTICLE, AFTERDISCUSSION, BUT BEFORE THEREFERENCE.

The subjects included in the study were glaucoma suspects aged 18 years and above with open angles on gonioscopy (grade 3 and 4 Shaffers'system)consenting to the study as well as those with normal central visual field and signal strength above 5 on optical coherence tomography testing.The participant's pupils were dilated using tropicamide 1% and phenylephrin 2.5%. A slit lamp binocular indirect ophthalmoscopy using +78D (Volks) lens was used to examine the optic nerve head and retinal nerve fiber layer. Participants with superficial splinter hemorrhages,focal loss of neuroretinal rim (notching), generalized loss of neuroretinal rim (VCDR $\geq$0.5), cup-disc ratio asymmetry ($\geq$ 0.2) or loss of retinal nerve fibers proceeded with the study. Also included were participants whose optic nerve head and nerve fibers appeared normal but had IOP greater than 21 mmHg. Red-free illumination of the posterior pole was also done to evaluate the retinal nerve fiber layer. Automated visual-field examination was done using 24-2 Swedish interactive thresholding algorithm standard visual-field examination ( Humphery visual-field analyzer, model 750). Participants with normal fields were then dilated for the OCT testing using tropicamide 1% and phenylephrine 2.5%. The same procedures for obtaining OCT measurements was followed for both eyes. Signal strength of 6 or higher is considered adequate for analysis of the results.

The data were analyzed using the statistical package EPI info version 6.04d,a software package designed by the Centers For Disease Control and Prevention(CDC),USA in 2001.Frequency was presented in percentages. Means and standard deviation were calculated for descriptive and comparative purposes. For

comparison between the two groups, all data were subjected to student t-test and p-value. The disc parameters were analyzed as well as their correlation with RNFL thickness using the Pearson's correlation coefficient .The level of p-value was set at $P < 0.05$

**Results**

A total of 240 eyes of 120participants were examined in this study. This was a100 % coverage.

**Table 1: Age and sex distributions of study subjects**

| AGE GROUP | SEX | | TOTAL% | Chi-Square | P value |
|---|---|---|---|---|---|
| | MALE% | FEMALE% | | | |
| <20 | 3 (2.5) | 1 (0.8) | 4(3.3) | 5.57 | 0.472* |
| 20-29 | 7 (5.8) | 14 (11.7) | 21(17.5) | | |
| 30-39 | 12 (10.0) | 12 (10.0) | 24 (20.0) | | |
| 40-49 | 14 (11.7) | 17 (14.2) | 31 (25.8) | | |
| 50-59 | 15 (12.5) | 11 (9.2) | 26 (21.7) | | |
| 60-69 | 8 (6.7) | 4 (3.3) | 12 (10.0) | | |
| 70-79 | 1 (0.8) | 1 (0.8) | 2 (1.7) | | |
| TOTAL | 60 (50.0) | 60 (50.0) | 120 (100.0) | | |

*Not Significant **. Df=6 MEAN ± SD =42.8± 13.79**

A total of 60 (50%) males and 60(50%) females were examined giving a male to female ratio of 1:1 (see Table 1). The ages range from 19 years to 75 years with a mean of 42.8 ± 13.79. The age group 40-49 years had the highest representation (25.8%; n = 31/120) while those aged 70-79 years constituted the least (1.7%;n = 2/120). There was no statistically significant difference in sex in gender representation (p>0.05).

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**Table 2: Relationship between disc size and VCDR**

| DISC DIA (mm) | No.of eyes (=240) (freq) (%) | VCDR (Mean± SD) | t-test | p-value | df |
|---|---|---|---|---|---|
| Very Small (<1.0) | 3 (1.3) | 0.77 (0.16) | 1.84 | 0.001* | 4 |
| Small (1.0-1.3) | 4 (1.7) | 0.73 (0.10) | | | |
| Medium (1.4-1.7) | 67 (27.9) | 0.62 (0.12) | | | |
| Large (1.8-2.0) | 58 (24.2) | 0.64 (0.10) | | | |
| V. Large (>2.0) | 108 (45.0) | 0.67 (0.10) | | | |

*Significant

In table 2, the mean VCDR is higher at the extremes of disc sizes. The highest VCDR (0.77±0.12) was found among the very small discs followed by the very large discs (0.67±0.10).the lowest VCDR (0.62±0.12) was found among the medium sized discs. VCDR is noticed to have increased with increasing disc diameter (medium = 0.62, large =0.64, very large = 0.67) with a p- value of 0.001, this is statistically significant.(KINDLY MOVE ALL EXPLANATIONS REGARDING TO THE TABLES, TO UNDER RESULTS. THEN EXPLAIN FROM THERE)

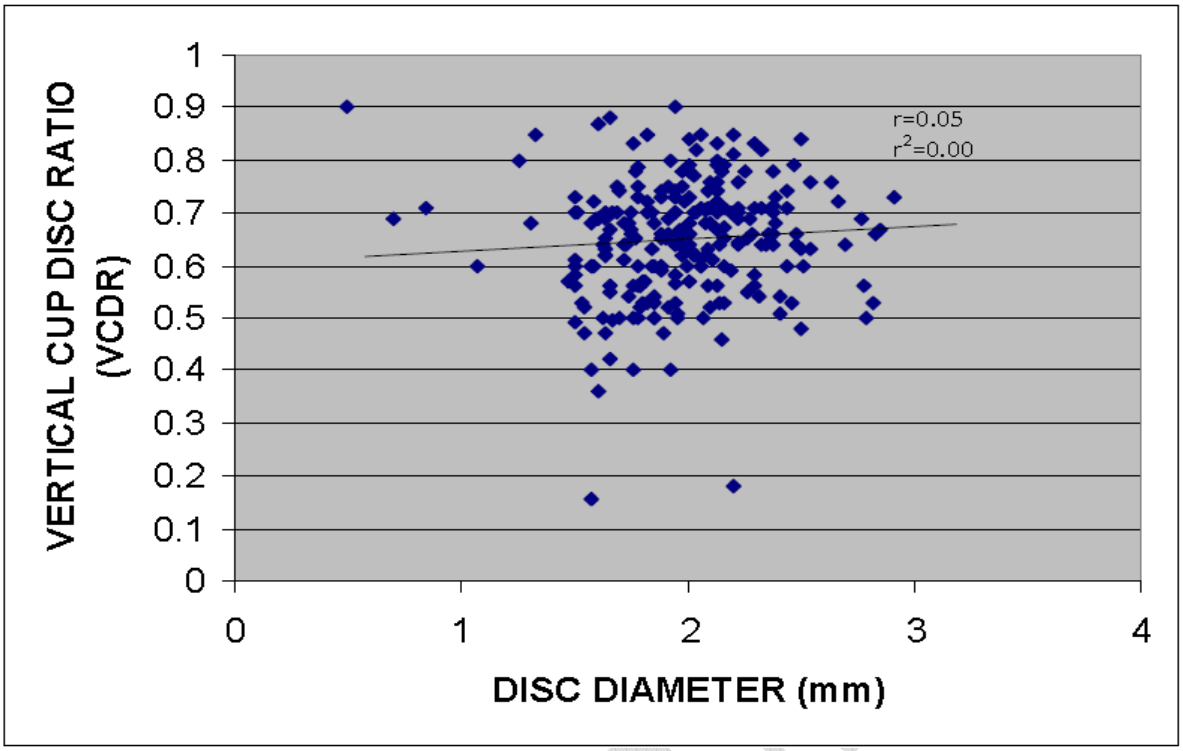


**Figure 1: Scatter plot graph of disc diameter and VCDR**

Figure 1 shows no significant correlation between disc diameter and VCDR

**Table3:Relationship between disc size and cupping**

| DISC DIAMETER (mm) | No. of eyes (=240) (freq) (%) | Abnormal VCDR/cupped discs [n=42 (17.5%)] | | Normal VCDR [n=198 (82.5%)] | |
|---|---|---|---|---|---|
| Very Small (<1.0) | 3 (1.3) | No of eyes.>0.33 | 3 (1.3) | No. of eyes.<0.33 | 0 (0.0) |
| Small (1.0-1.3) | 4 (1.7) | No of eyes.>0.59 | 4 (1.7) | No. of eyes .<0.59 | 0 (0.0) |
| Medium (1.4-1.7) | 67 (27.9) | No. of eyes>0.66 | 25 (10.4) | No. of eyes<0.66 | 42 (17.5) |
| Large (1.8-2.0) | 58 (24.2) | No. of eyes>0.74 | 6 (2.5) | No. of eyes<0.74 | 52 (21.7) |
| V. Large (>2.0) | 108 (45.0) | No. of eyes>0.83 | 4 (1.7) | No. of eyes<0.83 | 104 (43.3) |

Table3 shows that all the very small as well as small discs are cupped 3% ( n = 7/240), 14.6% (n = 35/240) of the medium to very large are also cupped. The remaining 82.5% ( n = 198/240) are normal.

(KINDLY MOVE ALL EXPLANATIONS REGARDING TO THE TABLES, TO UNDER RESULTS. THEN EXPLAIN FROM THERE)

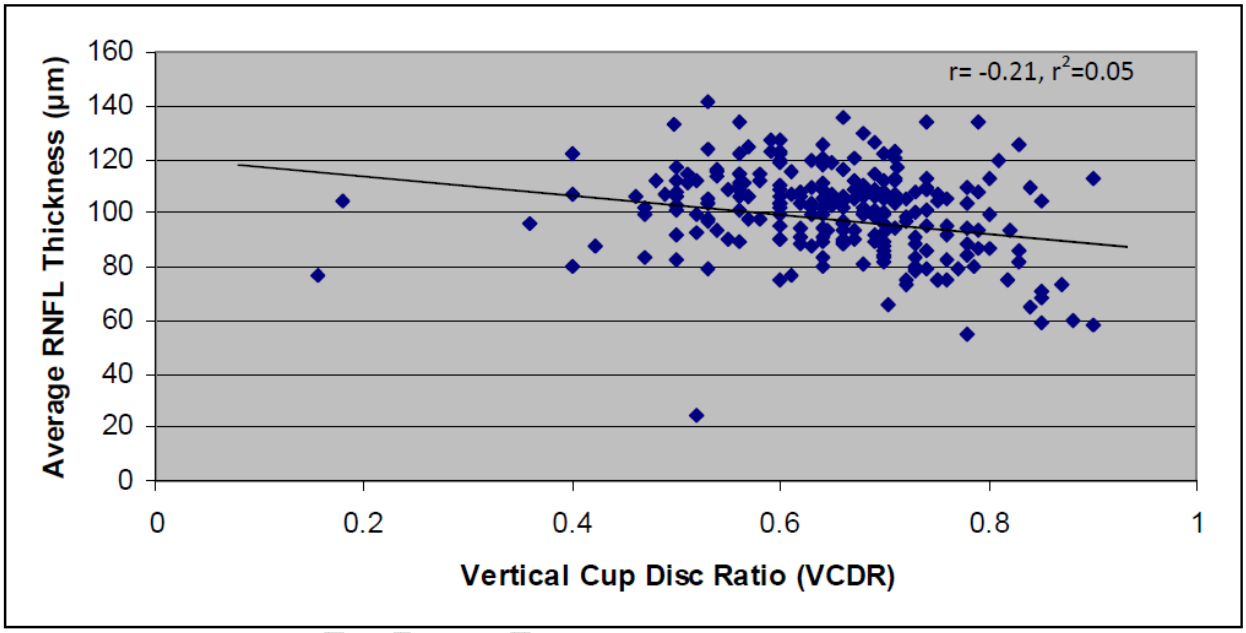


**Figure 2: SCATTER PLOT GRAPH OF VCDR AND AVERAGE RNFL THICKNESS**

Figure 2 shows that VCDR increases, as the average retinal nerve fiber layer thickness decreases. This though is a poor correlation.

## Discussion

The early diagnosis of glaucoma is a critical step in the management of the disease. If treated early, the prognosis for vision is excellent. One of the first structures to be damaged in glaucoma is the retinal nerve fiber layer (RNFL), which is the retinal layer containing the axons of the retinal ganglion cells[13,14]. It correlates towiththeir age, disc diameter, vertical cup disc ratio (VCDR). This study also showed the relationship between VCDR and disc size. A total of 120 participants, 60 (50%) males and 60 (50%) females were examined, this was not intentional as participants were consecutively recruited for the study. The age of participants examined ranged from 19 to 75 years with a mean age of 42.8 ± 13.79. The age group 40-49 years had the highest population of those examined (31) while the age group 70-79 constituted the least (2) see table 1. There was no statistically significant difference in the age and sex distribution of the study sample.

From a clinical point of view, it is important to observe that if larger discs really do contain more retinal ganglion cell axons they may benefit from a higher anatomic reserve capacity in progressive optic neuropathies. On the other hand, we may consider our findings in a different light and interpret them as an artifact of the OCT methodology, owing to the fact that the circular scan has a fixed diameter of 3.4 mm, as suggested by previous studies.[15]

This study shows the mean VCDR of eyes of participants to be higher at the extremes of disc sizes (table 2 and fig. 1). The highest mean VCDR (0.77±0.12) was found among the very small discs followed by the very large discs (0.67±0.10). The lowest mean VCDR (0.62±0.12) was found among the medium sized

discs. This is comparable with the study by Teal et al. [16]

Considering the fact that 90% of the eyes tested were “large” and “very large” it then implies that the VCDR increased with increasing disc diameter (medium = 0.62, large =0.64, very large = 0.67) with a p-value of 0.001, this is statistically significant. However the Pearson correlation coefficient showed a very poor correlation ( r = 0.05,r2= 0.00 ) between disc diameter and VCDR of the glaucoma suspects examined.

A published normative data in 2004 [17] relates VCDR to disc size using data from the Blue Mountain Eye Study in Australia. Investigators there found the average disc diameter to be 1.5 mm and they classified discs from 1.0 to 1.3 mm as small, from 1.4 to 1.7 mm as medium, and from 1.8 to 2.0 mm as large. The mean VCDR was about 0.35, 0.45, and 0.55 for the respective size categories; the 95th percentiles for upper limit of normal VCDR were 0.59, 0.66 and 0.74. In this study we had eyes with disc diameters less than 1.0mm and eyes with disc diameters greater than 2.0mm. The upper limit of normal VCDR for these sizes using the analysis of the Blue Mountain Eye Study. So the upper limit of normal VCDR for the very small discs and the very large discs were placed at 0.33 and 0.83 respectively.

It has been recognized for some time that there is a wide range of optic cup size in normal eyes, with VCDRs from 0.0 to 0.87 at the extremes[18,19,20]. Much of the variability in cup size results from the physiological relation between the size of the cup and the size of the optic disc. This relationship was rediscovered in the 1970s,[21] although it was demonstrated by Elschnig on the basis of histological work at the end of the last century. The poor correlation in this study could result from the fact that some of the

participants examined had glaucomatous cupping and thus compromising the normal positive correlation that exists between disc size and VCDR. Bujak et al[22] in Canada noticed a positive correlation between VCDR and disc size and therefore concluded that since disc size asymmetry is commonly present in eyes with asymmetric cup size, that disc sizes be measured before cup–to–disc asymmetry can be used as an independent risk factor in the diagnosis of primary open angle glaucoma.

All the very small and small discs were cupped 3% (n = 7/240), 14.6% (n = 35/240) of the medium to very large were also cupped. The remaining 82.5% (n = 198/240) were normal (table 3).

Using the above figures we found that only 42 eyes (17.5%) of all the eyes (240) had cupped discs while 198 eyes (82.5%) had normal VCDR. This thus implied that most of the glaucoma suspects do not have glaucoma based on VCDR analysis.

In this study, only 9.6%( 23) of the eyes had VCDR less than 0.5 while 90.4% (217) of the eyes had VCDR greater than 0.5,implying in this study that most of the eyes tested had VCDR greater than 0.5. This is not surprising since the criterion used for glaucoma suspect definition in this study is mainly on the disc findings. The 23 eyes with VCDR less than 0.5 were those with cup asymmetry in the two eyes, or elevated intraocular pressure.This study also showed that the VCDR of 0.5-0.6 range had the thickest average RNFL while the VCDR of 0.8-0.9 range had the thinnest. There is a decrease in RNFL with increasing VCDR especially among eyes with VCDR greater than 0.5 ( 90.4% of cases ), see fig 2.This was statistically significant in all except the temporal quadrant fibers (p= 0.118). The Pearson correlation coefficient, however showed a weak negative correlation between RNFL thickness and VCDR with only 5% of VCDR values correlating.

## Conclusion

Majority of the discs were very large, followed by medium and large discs. The very small discs were the fewest followed by the small discs. Whereas all small and very small discs were cupped, only a fraction of the medium to the very large discs were cupped. There was no significant correlation between disc diameter and VCDR. There was also a weak positive correlation between the optic disc diameter and the retinal nerve fiber layer thickness of the subjects, such a correlation may be the result of either an increased number of nerve fibers in eyes with larger discs or a smaller distance between the circular scan and the true optic disc margin.

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