ORIGINAL RESEARCH

Clinical Profile of Primary Open-angle Glaucoma Patients at an Eye Center in Nigeria

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Abstract

Aim: Globally, one of the leading causes of preventable blindness is primary open-angle glaucoma (POAG). The study assessed the clinical presentations of POAG patients attending an eye center in Abuja, Nigeria.

Materials and methods: Records of 188 eyes, collected from 94 patients diagnosed with POAG for a period of 1 year at the eye center, were reviewed. Clinical records, including age, gender, visual acuity (VA), central cornea thickness (CCT), intraocular pressure (IOP), cup-to-disk ratios, and retinal nerve fiber layer (RNFL) thickness of the participants, were extracted and analyzed.

Results: The majority of the participants were males (56.4%) and adults (57.4%), most of whom had normal VA (>70% in each eye). Our analysis revealed normal average estimates of RNFL thickness, IOP, and CCT among the participants. Females had thicker RNFL compared to males ($p = 0.02$). Although CCT decreased with age ($r = -0.28$, $p = 0.005$), there was no such link between IOP and CCT ($r = 0.09$, $p = 0.38$).

Conclusion: Central cornea thickness (CCT), RNFL thickness, and IOP in isolation should not be used as early indicators for POAG; rather, a combination of these and other indices is recommended. Early detection through active screening and treatment in the community for at-risk groups is highly advised.

Keywords: Abuja, Central cornea thickness, Intraocular pressure, Nigeria, Primary open-angle glaucoma, Retinal nerve fiber layer thickness.

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Introduction

The second largest cause of blindness in the world and the main factor contributing to irreversible blindness is glaucoma.[1] Globally, 60 million people are thought to have glaucoma, and among these, 8.4 million suffer from glaucoma-related blindness.[2] Globally, 111.8 million individuals are expected to have glaucoma by 2040, with populations in Africa and Asia seeing a disproportionally higher growth.[3]

Studies[1,3] in sub-Saharan African countries showed that primary open-angle glaucoma (POAG) is the most common type of glaucoma in Africa and African-derived populations (Caribbean and African Americans), accounting for 3.12 million blind people and 75% of all glaucoma cases.[1,4] According to estimates from 2013, there were 44 million cases of POAG worldwide. This number was expected to increase to 53 million by 2020 and to 79.76 million by 2040 as a result of population aging.[4,5]

Approximately, 10 million Africans have POAG out of the 58 million people recorded worldwide.[3] Also, Africans or individuals of African descent were reported to have a POAG three times more probable than others.[6] In addition, POAG was recorded to have an early development and faster progression in Africans than in other ethnic groups.[1] Men were found to be more likely to have primary open-angle glaucoma (POAG) than women. Several studies[7–10] showed that the use of glaucoma drugs, including prostaglandins analogs, which are known as the initial course of glaucoma treatment, may contribute to the fast progression of glaucoma as it reduces the central corneal thickness as a long- or short-term effect. However, records on the extent and the mechanism of reduction are inconsistent. There is a need for more studies in this area.

Primary open-angle glaucoma (POAG) hardly presents with symptoms, and only when the condition has progressed to an advanced stage are many patients diagnosed.[5] Severe visual impairment and blindness at presentation are indicative of late diagnosis and late presentation. The lack of symptoms and screening at the onset of POAG contribute to late presentation. Early diagnosis of POAG is essential to prevent blindness. There is a dearth of studies-related literature that assessed the clinical presentation of POAG in Nigeria. To improve the prevention and treatment of POAG in Nigeria,

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there is a need to assess clinical presentations of POAG in Nigeria to compare with the findings from other regions and countries. The aim of this study is, therefore, to assess the clinical presentation of patients with POAG seen at a private eye center in Abuja, Nigeria.

Materials and Methods

Study Design and Setting

The study was a descriptive cross-sectional study that included all individuals who visited Rachel Eye Center, Abuja, from January to December 2019 and were diagnosed with POAG. The eye center is well equipped and is one of the best eye centers in Abuja, Nigeria. It has subspecialty clinics, including glaucoma, retina, pediatrics, anterior segment, and optometric centers for providing different eye care services in Abuja and its environs.

Inclusion and Exclusion Criteria

All individuals who visited the facility within the study period and were diagnosed with POAG were eligible and included in the study. Those whose medical files had insufficient information, including the type of glaucoma and clinical characteristics, were excluded. Individuals whose refractive errors were ≥3 D, who had eye surgeries in the past, and those with any ocular condition that could affect the visual field or increase intraocular pressure (IOP) were excluded. Also excluded were individuals with ocular hypertension (increased IOP of >21 mm Hg but without any remarkable changes in their fundus and visual field). In addition, eligible participants whose case files showed that their fundus was obscured or inaccessible due to the presence of some ocular conditions and those with systemic or eye conditions that affect the integrity of the fundus were excluded. Based on these criteria, a total of 94 patients' records were included in the study.

Data Collection Procedure

Records of all patients diagnosed with POAG from January 2019 to December 2019 were reviewed. Information about age, gender, IOP, presenting visual acuity (VA), vertical cup-to-disk ratios (VCDR), central cornea thickness (CCT), horizontal CDR (HCDR), pattern standard deviation (PSD), retinal nerve fiber layer (RNFL), and mean deviation (MD) were documented. The eye center uses Snellen notation; therefore, the presenting VA was measured in Snellen notation. Humphrey visual field analyzer (Humphrey 740; Carl Zeiss Meditech, Dublin, California, United States of America) was used to measure the presenting visual field. IOP was measured for all patients between 8.00 am and 4.00 pm when the IOP is expected to be stable and reliable[11] with the Goldmann applanation tonometer. Fourier-domain optical coherence tomography (Spectralis, Heidelberg, Germany) was used to check the anterior chamber depth, CCT, fundus, and RNFL.

Primary Open-angle Glaucoma (POAG) Diagnosis Criteria

The guidlines of the International Society for Geographical and Ophthalmology is used by the majority of eye clinics in Nigeria, including Rachel Eye Center, for glaucoma diagnosis and categorization. POAG was identified by an open and normal-appearing angle with an IOP > 21 mmHg, a VCDR of 0.7 or more (based on the normative data from the Nigeria national survey) and <0.9, a VCDR asymmetry of 0.2 or more, or a neuroretinal rim width reduced to ≤0.1 (any violation of the ISNT rule), and a distinct visual field defect consistent with glaucoma.

Ethics

Ethical clearance for the study was sought and obtained from the Institutional Review Board of Madonna University, Nigeria (MAU/SREC/A/0481/03/2019). The management of Rachel Eye Centre, Abuja gave permission to access the patients' case files. The Declaration of Helsinki was adhered to.

Statistical Analysis

Data collected were analyzed with IBM Statistical Package for the Social Sciences (version 25.0). Kolmogorov–Smirnov test was used to check for normal distribution of data. Percentage frequencies and mean were used to present categorical and continuous variables, respectively. Equality of variance was assessed with A-Levene's test since the proportion of sex was not equal in the sample population. Associations between CCT, age, and IOP were determined using correlational analysis, and data was considered statistically significant at 0.05. Also, a Bonferonni *post hoc* analysis was used to adjust the *p*-value.

Results

A total of 94 files of eligible participants were enumerated, and data was extracted for analysis. Among the participants, the majority (56.4%) were males. Most (57.4%) of the participants were adults, and this is reflected in our prevalence estimates as glaucoma is known to be common among people of the adult age-group and above. There was a statistically significant association between the proportion of male youth and female youth. A Bonferonni *post hoc* analysis revealed that no specific subgroup of sex and age-group was responsible for the observed association (adjusted $p = 0.006$). The presenting VAs for each participant were generally good, 73.4% had normal vision in the right eye and 78.7% in the left eye (Table 1). This high proportion of normal presenting VA among the sample studied indicates that the patients presented to the facility early enough for their management and treatment to have a good prognosis.

Average Clinical Indices According to Sex

An analysis of the average clinical indices with dispersion statistics among the study population was performed according to the sex

Table 1: Distribution of age-group and presenting visual impairment according to sex

		Sex			
Variables		*Female*	*Male*	*Total (%)*	*p-value*
Age-group	Children	3_a	1_a	4 (4.3)	**0.022**
	Youth	16_a	9_b	25 (26.6)	
	Adult	20_a	34_a	54 (57.4)	
	Elderly	2_a	9_a	11 (11.7)	
Right eye	Normal vision	33_a	36_a	69 (73.4)	0.387
	Mild VI	3_a	7_a	10 (10.6)	
	Moderate VI	5_a	10_a	15 (16.0)	
Left eye	Normal vision	32_a	42_a	74 (78.7)	0.630
	Mild VI	3_a	6_a	9 (9.6)	
	Moderate VI	6_a	5_a	12 (11.7)	
Total		41	53	94 (100.0)	

Bold digits in tables show variables where there were associations or correlations; Each subscript letter denotes a subset of sex categories whose column proportions do not differ significantly from each other at the 0.05 level

Table 2: Average clinical indices according to sex

	Sex			*Levene's test for equality of variances*	
Clinical index	*Male (n = 53)*	*Female (n = 41)*	*Total*	*F*	*Significance*
CCT OD (µm)	530.87 ± 40.81	532.09 ± 27.57	531.40 ± 35.48	4.32	**0.040**
CCT OS (µm)	532.53 ± 42.57	532.59 ± 26.36	532.77 ± 35.97	5.99	**0.016**
HCDR OD	0.78 ± 0.13	0.69 ± 0.17	0.74 ± 0.15	1.16	0.285
HCDR OS	0.77 ± 0.13	0.70 ± 0.16	0.74 ± 0.15	0.01	0.911
VCDR OD	0.67 ± 0.13	0.57 ± 0.16	0.62 ± 0.15	1.52	0.220
VCDR OS	0.67 ± 0.13	0.58 ± 0.14	0.63 ± 0.14	0.04	0.840
Average RNFL (µm) OD	96.04 ± 15.95	103.12 ± 14.65	99.13 ± 15.72	0.89	0.348
Average RNFL (µm) OS	97.15 ± 12.93	103.17 ± 11.79	99.78 ± 12.74	0.65	0.422
MD (dB) OS	−7.26 ± 2.49	−6.72 ± 2.51	−7.02 ± 2.51	0.15	0.705
MD (dB) OS	−7.10 ± 2.43	−7.16 ± 2.63	−7.12 ± 2.51	0.13	0.716
PSD-OD (dB)	2.63 ± 2.96	2.30 ± 2.44	2.49 ± 2.73	0.89	0.348
PSD-OS (dB)	2.40 ± 2.12	2.50 ± 2.40	2.44 ± 2.23	0.33	0.566
OD IOP	21.98 ± 6.81	20.51 ± 5.27	21.34 ± 6.20	3.45	0.067
OS IOP	22.00 ± 6.50	20.68 ± 4.73	21.43 ± 5.80	3.80	0.054

Bold digits in tables show variables where there were associations or correlations; OD, right eye; OS, left eye

Table 3: Mean differences of clinical indices according to sex

Clinical index	*Mean difference*	*Standard error*	*Significance (two-tail)*
CCT OD (µm)	−1.220	7.417	0.869
CCT OS (µm)	−0.060	7.575	0.994
HCDR OD	0.090	0.031	**0.004**
HCDR OS	0.070	0.030	**0.021**
VCDR OD	0.100	0.030	**0.001**
VCDR OS	0.090	0.028	**0.002**
Average RNFL (µm) OD	−7.080	3.203	**0.029**
Average RNFL (µm) OS	−6.020	2.325	**0.022**
MD (dB) OS	−0.540	0.520	0.302
MD (dB) OS	0.060	0.524	0.909
PSD-OD (dB)	0.330	0.571	0.565
PSD-OS (dB)	−0.100	0.467	0.831
OD IOP	1.470	1.287	0.256
OS IOP	1.320	1.206	0.277

Bold digits in tables show variables where there were associations or correlations; OD, right eye; OS, left eye

group of participants. A Levene's test for equality of variance was done to determine if there was any significant difference between the variances of clinical indices due to the unequal distribution of sex. There was a statistically significant difference between variances of CCT and sex, while the analysis revealed no statistically significant difference of variances between males and females for the remaining indices assessed (Table 2). There were no statistically significant differences between means of CCT, MD, and PSD among sex; however, there were statistically significant differences in the means of the remaining clinical in-dices such as RNFL and CDR and sex (Table 3).

Correlations between CCT, IOP, and Age

Based on the association between CCT and sex, a correlational analysis was performed to determine the correlation between CCT and other variables. There was a negative correlation between CCT and age. Hence, as age increases, the CCT decreases. IOP did not have a significant correlation with CCT. Due to the correlation between CCT and age, a partial correlation test was performed on CCT and IOP while controlling a confounding factor, age; there was no statistically significant correlation between the variables (Table 4).

Table 4: Correlations between CCT, IOP, and age

Variables	*R*	R^2	*p-value*
OD CCT vs OD IOP	0.084	0.007	0.419
OD CCT vs OD IOP*	0.092	–	0.380
OS CCT vs OS IOP	0.057	0.003	0.585
OS CCT vs OS IOP*	0.071	–	0.500
OD CCT vs age	−0.286	0.082	**0.005**
OS CCT vs age	−0.222	0.049	**0.029**

Bold digits in tables show variables where there were associations or correlations; *Controlled for confounding factors and age; OD, right eye; OS, left eye

Discussion

In Nigeria, a representative sample population was used to investigate the clinical characteristics of POAG. Even though the VA on presentation was satisfactory, it was found that all the participants had thin RNFLs, which suggests that there may be modifications in terms of damage in the periphery of the retina. This finding indicates that the participants were introduced to the facility earlier than usual, and eye care professionals are readily available in Nigeria.[12,13] This differed considerably from findings from other studies in sub-Saharan Africa, where it is still difficult to access eye care services.[14] Studies[13,15] that were conducted among glaucoma patients in Africa yielded results that were comparable to the average RNFL that was found in this study. Compared to persons who do not have glaucoma, patients diagnosed with POAG tend to have a thinner RNFL in Africa.[13–20]

According to the findings of this study, females have a thicker RNFL than males. Between females and males, the average RNFL decreased by 7 µm. The difference is statistically significant in our study, perhaps because of our smaller sample size and higher proportion of older males in our sample. However, results from recent reports lend credence to this observation's accuracy of

females having a Thicker RNFL compared to males.[13,21] Nevertheless, Alasil et al.[22] had observed no difference in the RNFL thickness among males and females of people from different racial backgrounds. This may be because of the variations in the study population, size, and age range of their study participants. The majority of our study participants were adults, and their age range is a reflection of the reported frequency of glaucoma among people of black heritage and those aged 40 and above in Nigeria.[23] Further, there were more males than females in this cohort, although studies in Nigeria have reported no significant gender difference.[23,24] It is possible that the pattern of males' access to medical treatment is different from that of females, which explains why men dominate in glaucoma studies in Nigeria as suggested by Malu et al.[23]

With CCT affecting the measurement of IOP—the sole clinical index that can be altered in the treatment of glaucoma,[25] the findings of CCT in this study are consistent with those found in other studies as well as reported normative ranges for CCT (530–540 µm) among healthy people.[26] The findings of this current study reveal that CCT could not be a good sole predictor of the advancement of glaucoma in this cohort. This is because only thinner CCTs have the ability for such effects, and the findings of this study imply that CCT cannot be considered as a strong predictor.[2527–29] However, CCT has been found to be a more accurate marker of people at risk of developing POAG than IOP when paired with specific ocular risk factors, according to a study that was conducted in Nigeria.[30] A study by Mehboob et al.[31] in Pakistan also found CCT to be positively correlated to some visual field parameters.

There was an inverse relationship between CCT and age; as people get older, the thickness of CCT decreases. This observation is in line with the findings of earlier research that have reported on the effects of aging on CCT.[25,32,33] According to these studies, there is a drop in the density of keratocytes, a reduction in inter-collagen fiber lengths, and denaturing of collagen fibers as a person advances in age with resultant alteration in CCT.[34,35] Studies conducted in Nigeria and Africa at large have borne this out in studies quite similar to ours in which the authors reported that aging was associated with corneal thinning.[15,25,36,37] Although our study did not reveal significant clinical profiles that are typical of patients developing POAG that can be used as early indicators for the disease, apart from the usual monitoring of IOP, it is clear that individuals who require evaluation and management of glaucoma can be identified more readily through the provision of screening services and health education in communities, work, and religious institutions[38] so that patients at risk of glaucoma can be identified early and treated to avoid late presentation to the eye clinic with glaucoma and its associated complications.

Strength and Limitations

We realize that there are some inherent limitations in our study. Because our data were gathered retrospectively from a single center, we were unable to extrapolate our conclusions to the full community. In addition, the small sample size and the fact that normal tension glaucoma patients and socioeconomic factors were not assessed in our study further limited the Generalizability of our study findings. Also, our study did not include methods of management and their effects on the ocular parameters. However, despite the limitations, our study was the first to include the younger age-group and OCT parameters in reporting clinical presentations of POAG patients in Nigeria, and our findings were comparable to findings from other parts of the world.

Conclusion

We conclude that patients attending the Abuja Eye Center and diagnosed with POAG have overall normal presenting vision because of early presentation to the eye care facility. Our study showed that RNFLT, CCT, and IOP are better used for early detection of POAG and should not be used independently or singly to diagnose glaucoma because of the confounding effect of age, gender, and ethnicity. Glaucoma, therefore, remains a silent "thief" of sight, and we suggest that in order to reduce avoidable blindness from glaucoma, early detection through active screening of populations at risk of the disease, such as the aged (over 40 years) and people of black African descent, accompanied with appropriate treatment remains the most effective strategy. Further studies that will include normal tension glaucoma, ocular hypertension, and nonglaucomatous patients are recommended.

Data Availability Statement

The dataset is available upon request from the corresponding authors.

Author Contributions

Conceptualization, IVI. and NEE; methodology, KKE; validation, NEE, KPM, and MAK; formal analysis, MAK and ST; investigation, MAK and ST; resources, GO; data curation, IVI, NEE, and MAK; writing—original draft preparation, NEE; writing, review and editing, MAK and ST; visualization, NEE, and MAK; supervision, KPM, NEE, and ST; project administration, IVI, KKE, and GO. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board Madonna University, Elele campus, Rivers State, Nigeria (MAU/SREC/A/0481/03/2019).

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References

1. Kyari F, Entekume G, Rabiu M, et al. A population-based survey of the prevalence and types of glaucoma in Nigeria: results from the Nigeria National Blindness and Visual Impairment Survey. BMC Ophthalmol 2015;15(1). DOI: 10.1186/S12886-015-0160-6
2. Zhao Y, Fu J-L, Li YL, et al. Epidemiology and clinical characteristics of patients with glaucoma: an analysis of hospital data between 2003 and 2012. Indian J Ophthalmol 2015;63(11):825–831. DOI: 10.4103/0301-4738.171963
3. Bonnemaijer PWM, Lo Faro V, Sanyiwa AJ, et al. Differences in clinical presentation of primary open-angle glaucoma between African and European populations. Acta Ophthalmol 2021;99(7):e1118–e1126. DOI: 10.1111/aos.14772
4. Kapetanakis V V, Chan MPY, Foster PJ, et al. Global variations and time trends in the prevalence of primary open angle glaucoma (POAG): a systematic review and meta-analysis. Br J Ophthalmol 2016;100(1):86–93. DOI: 10.1136/bjophthalmol-2015-307223

5. Zhang N, Wang J, Li Y, et al. Prevalence of primary open angle glaucoma in the last 20 years: a meta-analysis and systematic review. Sci Rep 2021;11(1):13762. DOI: 10.1038/s41598-021-92971-w
6. Tham Y-C, Li X, Wong TY, et al. Global prevalence of glaucoma and projections of glaucoma burden through 2040. Ophthalmology 2014;121(11):2081–2090. DOI: 10.1016/j.ophtha.2014.05.013
7. Kadri R, Shetty A, Parameshwar D, et al. Effect of prostaglandin analogues on central corneal thickness in patients with glaucoma: A systematic review and meta-analysis with trial sequential analysis. Indian J Ophthalmol 2022;70(5):1502–1512. DOI: 10.4103/ijo.IJO_1971_21
8. Wisely CE, Sheng H, Heah T, et al. Effects of netarsudil and latanoprost alone and in fixed combination on corneal endothelium and corneal thickness: post-hoc analysis of MERCURY-2. Adv Ther 2020;37(3):1114–1123. DOI: 10.1007/s12325-020-01227-y
9. Meda R, Wang Q, Paoloni D, et al. The impact of chronic use of prostaglandin analogues on the biomechanical properties of the cornea in patients with primary open-angle glaucoma. Br J Ophthalmol 2017;101(2):120–125. DOI: 10.1136/bjophthalmol-2016-308432
10. Viswanathan D, Goldberg I, Graham SL. Longitudinal effect of topical antiglaucoma medications on central corneal thickness. Clin Experiment Ophthalmol. 41(4):348–354. DOI: 10.1111/j.1442-9071.2012.02870.x
11. Ezinne NE, Ojukwu CS, Ekemiri KK, et al. Prevalence and clinical profile of glaucoma patients in rural Nigeria - a hospital based study. PLoS One 2021;16(12). DOI: 10.1371/journal.pone.0260965
12. Palmer JJ, Chinanayi F, Gilbert A, et al. Mapping human resources for eye health in 21 countries of sub-Saharan Africa: current progress towards VISION 2020. Hum Resour Health 2014;12(1):44. DOI: 10.1186/1478-4491-12-44
13. Kyei S, Aberor J, Assiamah F, et al. Optical coherence tomography indices in the diagnosis and discrimination of stages of primary open-angle glaucoma in an African population. Int Ophthalmol 2021;41(3):981–990. DOI: 10.1007/s10792-020-01652-6
14. Bechange S, Jolley E, Virendrakumar B, et al. Strengths and weaknesses of eye care services in sub-Saharan Africa: a meta-synthesis of eye health system assessments. BMC Health Serv Res 2020;20(1):381. DOI: 10.1186/s12913-020-05279-2
15. Mashige KP, Oduntan OA. Retinal nerve fibre layer thickness values and their associations with ocular and systemic parameters in black South Africans. Afr Health Sci 2017;16(4):1188–1194. DOI: 10.4314/ahs.v16i4.39
16. Sani R, Abdu L, Pam V. Retinal nerve fiber layer thickness measurements of normal Northern Nigerian adults using optical coherence tomography. Ann Afr Med 2016;15(2):52–57. DOI: 10.4103/1596-3519.172557
17. Zhao L, Wang Y, Chen CX, et al. Retinal nerve fibre layer thickness measured by Spectralis spectral-domain optical coherence tomography: the Beijing eye study. Acta Ophthalmol 2014;92(1):e35–e41. DOI: 10.1111/aos.12240
18. Wu J, Du Y, Lin C, et al. Retinal nerve fibre layer thickness measured with SD-OCT in a population-based study: the handan eye study. Br J Ophthalmol 2023;107(8):1156–1164. DOI: 10.1136/bjophthalmol-2021-320618
19. Bowd C, Zangwill LM, Weinreb RN, et al. Racial differences in rate of change of spectral-domain optical coherence tomography–measured minimum rim width and retinal nerve fiber layer thickness. Am J Ophthalmol 2018;196:154–164. DOI: 10.1016/j.ajo.2018.08.050
20. Patel S, Reddy N, Lin X, et al. Optical coherence tomography retinal nerve fiber layer analysis in eyes with long axial lengths. Clin Ophthalmol 2018;12:827–832. DOI: 10.2147/OPTH.S162023
21. Ocansey S, Abu EK, Owusu-Ansah A, et al. Normative values of retinal nerve fibre layer thickness and optic nerve head parameters and their association with visual function in an African population. J Ophthalmol 2020;2020:1–14. DOI: 10.1155/2020/7150673
22. Alasil T, Wang K, Keane PA, et al. Analysis of normal retinal nerve fiber layer thickness by age, sex, and race using spectral domain optical coherence tomography. J Glaucoma 2013;22(7):532–541. DOI: 10.1097/IJG.0b013e318255bb4a
23. Malu K, Ramyil A, Malu D. Pattern of presentation and visual outcome of glaucoma in a tertiary hospital, Makurdi, Nigeria. J Med Trop 2021;23(1):23–28. DOI: 10.4103/jomt.jomt_58_20
24. Olawoye O, Tarella S. Spectrum of glaucoma presentation in a Nigerian tertiary hospital. Niger J Ophthalmol 2014;22(1):11–15. DOI: 10.4103/0189-9171.142747
25. Kyei S, Assiamah F, Kwarteng MA, et al. The association of central corneal thickness and intraocular pressure measures by non-contact tonometry and Goldmann applanation tonometry among glaucoma patients. Ethiop J Health Sci 2020;30(6):999–1004. DOI: 10.4314/ejhs.v30i6.18
26. Sood A, Nazir A, Runyal F, et al. Clinical estimation of intraocular pressure with a non-contact tonometer and Goldman applanation tonometer as a tool for mass screening and its correlation with central corneal thickness: a comparative hospital-based study. Glob J Med Public Heal 2015;4(4):1–12. https://www.gjmedph.com/Uploads/O9-Vo4No4.pdf
27. Ko YC, Liu C, Hsu WM. Varying effects of corneal thickness on intraocular pressure measurements with different tonometers. Eye(Lond) 2005;19(3):327–332. DOI: 10.1038/sj.eye.6701458
28. Dohadwala AA, Munger R, Damji KF. Positive correlation between tono-pen intraocular pressure and central corneal thickness. Ophthalmology 1998;105(10):1849–1854. DOI: 10.1016/S0161-6420(98)91029-6
29. Bhan A, Browning AC, Shah S, et al. Effect of corneal thickness on intraocular pressure measurements with the pneumotonometer, Goldmann applanation tonometer, and Tono-Pen. Invest Ophthalmol Vis Sci 2002;43(5):1389–1392.
30. Iyamu E, Ituah I. The relationship between central corneal thickness and intraocular pressure: a comparative study of normals and glaucoma subjects. Afr J Med Med Sci 2008;37(4):345–353. https://pubmed.ncbi.nlm.nih.gov/19301712/
31. Mehboob MA, Sarfraz MH, Haq RI. Correlation between central corneal thickness and visual field defects, cup to disc ratio and retinal nerve fiber layer thickness in primary open angle glaucoma patients. Pak J Med Sci 2017;33(1):132–136. DOI: 10.12669/pjms.331.11623
32. Iyamu E, Iyamu JE, Amadasun G. Central corneal thickness and axial length in an adult Nigerian population. J Optom 2013;6(3):154–160. DOI: 10.1016/j.optom.2012.09.004
33. Wangsupadilok B, Orapiriyakul L. Correlation between central corneal thickness and visual field defect, cup to disc ratio and retinal nerve fiber layer thickness in primary open-angle glaucoma patients. J Med Assoc Thai 2014;97(7):751–757. DOI: 25265775
34. Nemesure B. Corneal thickness and intraocular pressure in the barbados eye studies. Arch Ophthalmol 2003;121(2):240–244. DOI: 10.1001/archopht.121.2.240
35. Muhammad A, Joma A, Abdulgani A. The relation between central corneal thickness and axial length in a sample of Erbil population. Zanco J Med Sci 2015;19(3):1096–1103. DOI: 10.15218/zjms.2015.0038
36. Bagus T, Alberto K, Muteba M, et al. Analysis of corneal biometry in a black South African population. African Vis Eye Heal 2019;78(1). DOI: 10.4102/aveh.v78i1.495
37. Mercieca K, Odogu V, Fiebai B, et al. Comparing central corneal thickness in a Sub-Saharan Cohort to African Americans and Afro-Caribbeans. Cornea 2007;26(5):557–560. DOI: 10.1097/ICO.0b013e3180415d90
38. Kyei S, Obeng PA, et al. Epidemiology and clinical presentation of glaucoma in a referral facility in Ghana: any lessons for public health intervention? PlosOne. 2021;16(1):e0245486. https://doi.org/10.1371/journal.pone.0245486