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Research Article

Normal Tomographic Papillary and Macular Parameters in Young Cameroonians Aged 6 to 20 Years

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Abstract

Introduction: Optical Coherence Tomography (OCT) is a vital tool for diagnosing and monitoring retinal conditions. While OCT devices include normative databases for adults, such data is lacking for pediatric populations, especially those of Black African descent. This study aimed to describe the normal papillary and macular tomographic parameters in young Cameroonians.

Methodology: This cross-sectional study, conducted from October 2022 to August 2023 in Yaoundé, included 314 Black African subjects (628 eyes) aged 6 to 20 years with no detectable ocular abnormalities. All participants underwent papillary OCT, macular ganglion cell complex (GCC) analysis and macular OCT examinations using a Topcon Maestro 3D device. Variables analyzed included age, sex, optic disc area, excavation area, Neuroretinal Rim (NRR) area, cup-to-disc (C/D) ratios, retinal nerve fiber layer (RNFL) thickness, GCC thickness, Mean Macular Thickness (MMT) and central macular thickness. Data was analyzed using SPSS 26.0, with a significance level set at $p < 0.05$.

Results: The median age of participants was 13 years (9-16), with a male-to-female ratio of 0.6. The mean optic disc area was 2.35 ± 0.40 mm². The median excavation area was 0.14 mm² and the mean NRR area was 1.62 ± 0.36 mm². The median vertical C/D ratio was 0.60. The mean RNFL thickness was 119.4 ± 11 µm. The mean GCC thickness was 111.9 ± 6.7 µm. The mean macular thickness was 278 ± 13.8 µm and the central macular thickness was 172.2 ± 15.4 µm. The NRR area ($r = -0.20$; $p = 0.001$) significantly decreased with age. Mean RNFL thickness was significantly higher in females. There was no significant difference in MMT ($p = 0.93$) between sexes.

Conclusion: The observed differences highlight the necessity for normative databases specific to ethnicity and OCT technology for accurate assessment of ocular diseases in this population.

Keywords: Optic Disc; Macula; Optical Coherence Tomography; Black Individuals; Cameroon

Introduction

Optical Coherence Tomography (OCT) has revolutionized ophthalmology by providing high-resolution, non-invasive imaging of retinal and papillary structures. This indispensable tool is crucial for diagnosing and monitoring various ocular conditions, including diabetic retinopathy, age-related macular degeneration and glaucoma [1, 2, 3]. In routine clinical practice, OCT is the preferred imaging modality for structural glaucoma assessment, enabling early detection of optic nerve alterations and disease progression tracking [3]. Accurate interpretation of OCT results in patients with retinal pathologies hinges on reliable normative data. However, OCT parameters are known to vary significantly with age, sex and ethnicity [3,4]. Consequently, utilizing population-specific normative data is essential for rigorous clinical interpretation. While numerous studies have established

normative values for papillary and macular OCT in adults and most OCT devices include normative databases for individuals aged 18 to 21 years and older, data for pediatric populations, particularly in Africa, remain limited [5-8]. The increasing prevalence of retinal pathologies in African children, such as congenital glaucoma and juvenile macular dystrophies, underscores the importance of OCT in this demographic [9]. OCT offers significant advantages for pediatric patients, who may be less cooperative during traditional ophthalmic examinations. Furthermore, OCT facilitates early detection and monitoring of these conditions, which are often underdiagnosed and potentially more severe in children.

While some studies have explored papillary and macular OCT parameters in children, primarily focusing on Retinal Nerve Fiber Layer (RNFL) and macular thickness, normative data for the African pediatric population, especially in Cameroon, are scarce [10,11]. This study aims to establish normal papillary and macular OCT parameters in healthy young Cameroonians to address this knowledge gap. These data will be instrumental in improving the diagnosis and management of retinal pathologies in Cameroonian children.

Materials and Methods

Study Population

A cross-sectional analytical study was conducted over 11 months, from October 1, 2022, to August 31, 2023, at two hospital centers: the Yaoundé University Hospital Center (CHUY) and the Essos Medical-Surgical Center (CMCE). The study included healthy Black Cameroonian subjects aged 6 to 20 years who presented to CHUY. Inclusion criteria required eyes to have a corrected visual acuity of 10/10, an adjusted intraocular pressure (IOP) below 21 mmHg, absence of clinically detectable anterior and posterior segment abnormalities and no history of ocular surgery or disease, except for refractive error with a spherical equivalent less than 6 diopters. Participants also had to be free of systemic pathologies. Sampling was non-probabilistic, consecutive and non-exhaustive, enrolling all eligible subjects during the study period. The study strictly adhered to the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the institutional ethics committee of the Faculty of Medicine and Biomedical Sciences (FMSB) at the University of Yaoundé I (approval number: 0534/UY1/VDRC/DAASR/CSD). Written informed consent was obtained from each participant, or their parent/legal guardian, following a detailed explanation of the study procedures.

Data Collection

Data collection began with a comprehensive interview to gather participants' age and medical/ophthalmic history. A complete ophthalmic examination followed, including: measurement of distant visual acuity using Monoyer and Snellen E charts, ocular motility assessment, Intraocular Pressure (IOP) measurement and Central Corneal Thickness (CCT), with normal CCT defined as 494–564 μm. Subsequently, a slit-lamp examination of the anterior segment, an ocular refraction study and a fundus examination, including cup-to-disc ratio (C/D) evaluation, were performed. Finally, Optical Coherence Tomography (OCT) was conducted, comprising papillary OCT with macular ganglion cell complex analysis and cross-sectional macular OCT.

Measured papillary parameters included neuroretinal rim area, optic disc area, cup area, vertical and horizontal C/D ratios, mean C/D ratio, cup volume, neuroretinal rim volume and vertical and horizontal disc diameters. A normal disc size was defined as an area between 1.29 and 4.09 mm^2. Retinal nerve fiber layer (RNFL) thickness was measured at 3.4 mm around the disc, encompassing average, peripapillary, four quadrant and twelve clock-hour sector thicknesses. Macular OCT covered a 6.0×6.0 mm region. Macular thickness was represented according to the Early Treatment Diabetic Retinopathy Study (ETDRS) grid, including foveal, para- and perifoveal thicknesses, macular volume and central macular thickness. The primary variables investigated included age, sex, IOP, optic disc excavation, refraction, papillary parameters, peripapillary RNFL thickness, macular Ganglion Cell Complex (GCC) thickness, mean macular thickness and macular volume.

Statistical Analysis

Data were entered and analyzed using Microsoft Word 2013, Excel 2013 and SPSS 26.0. Qualitative variables are described by their counts and frequencies, while quantitative variables are presented as mean ± standard deviation or median, depending on their distribution. Correlations were assessed using Pearson or Spearman coefficients. Comparisons between quantitative variables utilized Student's t-test and between qualitative variables, Chi-Square or Fisher's exact tests. Statistical significance was set at $p<0.05$.

Results

Sociodemographic Characteristics

The study enrolled 314 participants meeting the established inclusion criteria. The median age was 13 years (interquartile range: 9 to 16 years). The most represented age group was 12 to 15 years, constituting 24.2% of the total sample (Fig. 1). The majority of participants were female (61.8%; n=194), while 38.2% were male (n=120), resulting in a sex ratio of 0.6.

Clinical Ophthalmological Characteristics

Central Corneal Thickness (CCT) ranged from 433.5 to 608 μm, with a mean of 517±33.4 μm. Overall, 67.5% of corneas (n=424) exhibited central thickness within normal limits. The mean adjusted intraocular pressure (IOP) was 17±1.9 mmHg. The median clinical excavation was 0.4 (interquartile range: 0.2 to 0.4), with extreme values ranging from 0.1 to 0.7. A large clinical excavation was observed in 46.5% of eyes (n=292). Regarding refractive status, hyperopia was the most prevalent ametropia, affecting 43.3% of participants (n=272). Only 4.5% of eyes (n=28) were emmetropic. The spherical equivalent ranged from −3.5 to +4.19 diopters, with a median of +0.5 diopters (interquartile range: 0 to 1.1 diopters). The distribution of eyes according to refraction is presented in Table 1.

Tomographic Characteristics

Optic Disc and Retinal Nerve Fiber Layer (RNFL) Parameters

Tomographic analysis focused on ten optic disc parameters. The mean optic disc area was 2.35±0.40 mm^2, with extreme values ranging from 1.41 to 3.74 mm^2. No eye presented with a large optic disc (defined as disc area >4.09 mm^2). The mean vertical cup-to-disc (C/D) ratio was 0.60 (interquartile range: 0.50 to 0.66). Detailed optic disc parameters are listed in Table 2. The mean clinical C/D ratio was significantly higher on OCT, with a difference of 0.2 ($p<0.001$).

Mean RNFL thickness was 119.4±11 μm, with values ranging from 95 to 160 μm. Fig. 2 illustrates the distribution of eyes based on mean RNFL thickness per quadrant. Analysis revealed that the RNFL was thinnest in the 9 o'Clock sector, followed by the 3 o'clock sector and thickest in the 6 o'Clock and 12 o'clock sectors. Fig. 3 presents the distribution of eyes according to mean RNFL thickness per clock-hour sector. The ISNT profile of RNFL thickness, characterized by a double-hump curve, was regular and without notches in all quadrants, as shown in Fig. 4.

A statistically significant positive correlation was observed between age and horizontal C/D ratio, as well as between age and mean C/D area ratio. Conversely, a statistically significant negative correlation existed between neuroretinal rim area and age (Table 3). Furthermore, optic disc area, neuroretinal rim area and vertical optic disc diameter were significantly larger in females, as detailed in Table 4. Mean RNFL thickness was also significantly higher in the female population, particularly in the superior and inferior sectors as shown in Table 5. No significant correlation was found between mean RNFL thickness and age Macular Ganglion Cell Complex (GCC) Parameters.

GCC thickness ranged from 93 to 125.6 μm, with a mean of 111.9±6.7 μm. The mean GCC thickness in the superior 180 degrees was 112.54±6.76 μm (range: 94.17 to 128 μm). In the inferior 180 degrees, GCC thickness ranged from 91.83 to 126.17 μm, with a mean of 111.33±7.06 μm. Fig. 5 presents the distribution of mean GCC thickness per 60-degree quadrant.

Macular Parameters

Mean Macular Thickness (MMT) was 278±13.8 μm (range: 204.4−312.4 μm). Mean central macular thickness was 272.2±15.4 μm. Parafoveal thickness was 298.2±15.9 μm and perifoveal thickness was 274.1±12.8 μm. Mean macular volume was 7.8±0.3 mm^3. Fig. 6 details the distribution of macular thickness by ETDRS quadrants.

No statistically significant correlation was found between MMT and age. However, a significant positive correlation ($p=0.11$; $r=0.046$) was observed between age and nasal parafoveal thickness. While no significant difference in MMT was found between sexes, males exhibited a significant increase in mean parafoveal thickness, as well as increased thicknesses in the inferior, nasal and temporal parafoveal sectors.

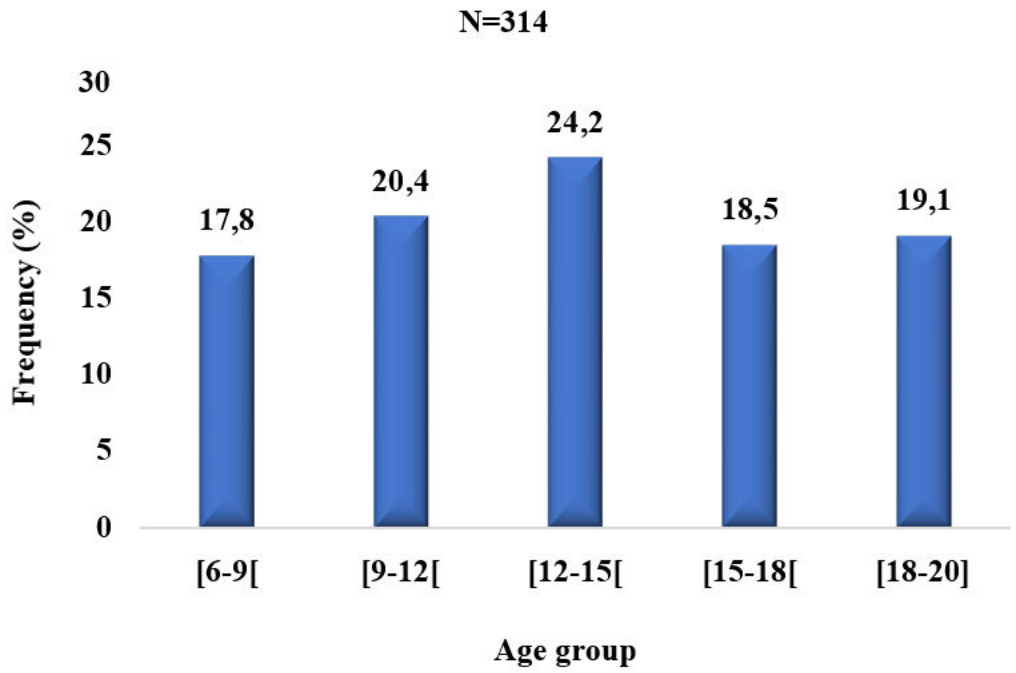

Figure 1: Distribution of patient by age group.

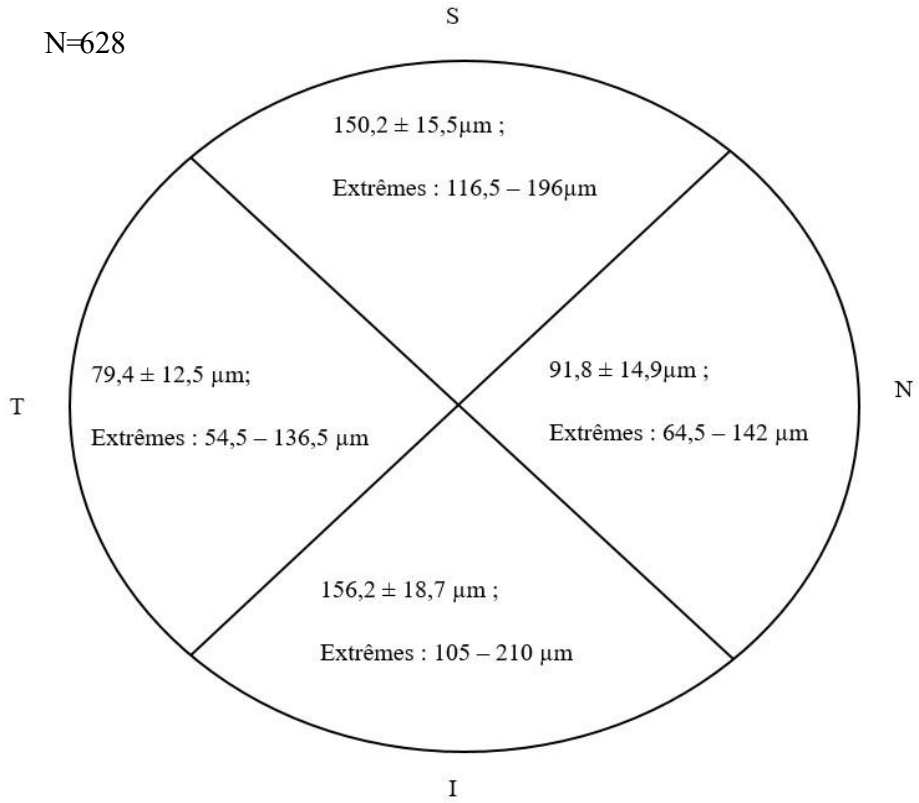

Figure 2: Distribution of eyes by mean RNFL thickness per quadrant.

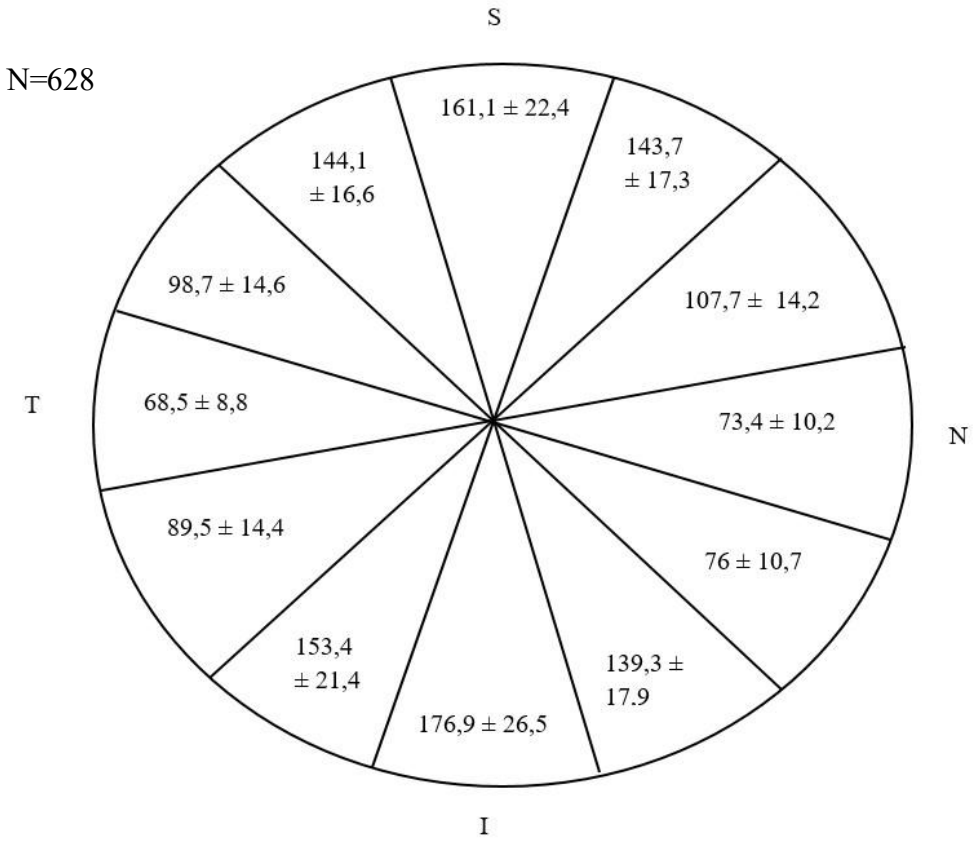

Figure 3: Distribution of eyes by mean RNFL thickness per clock hour (µm). I= Inferior; S= Superior; T= Temporal; N= Nasal.

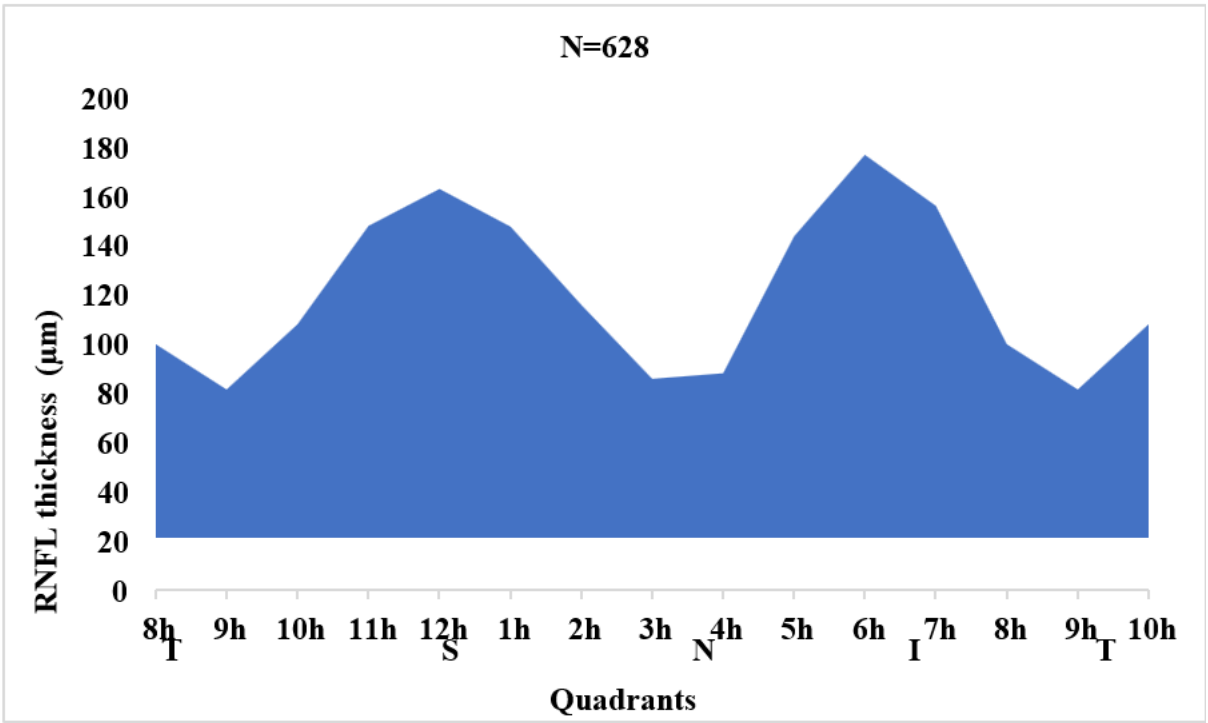

Figure 4: Distribution of eyes according to the ISNT rule. I= Inferior; S= Superior; T= Temporal; N= Nasal.

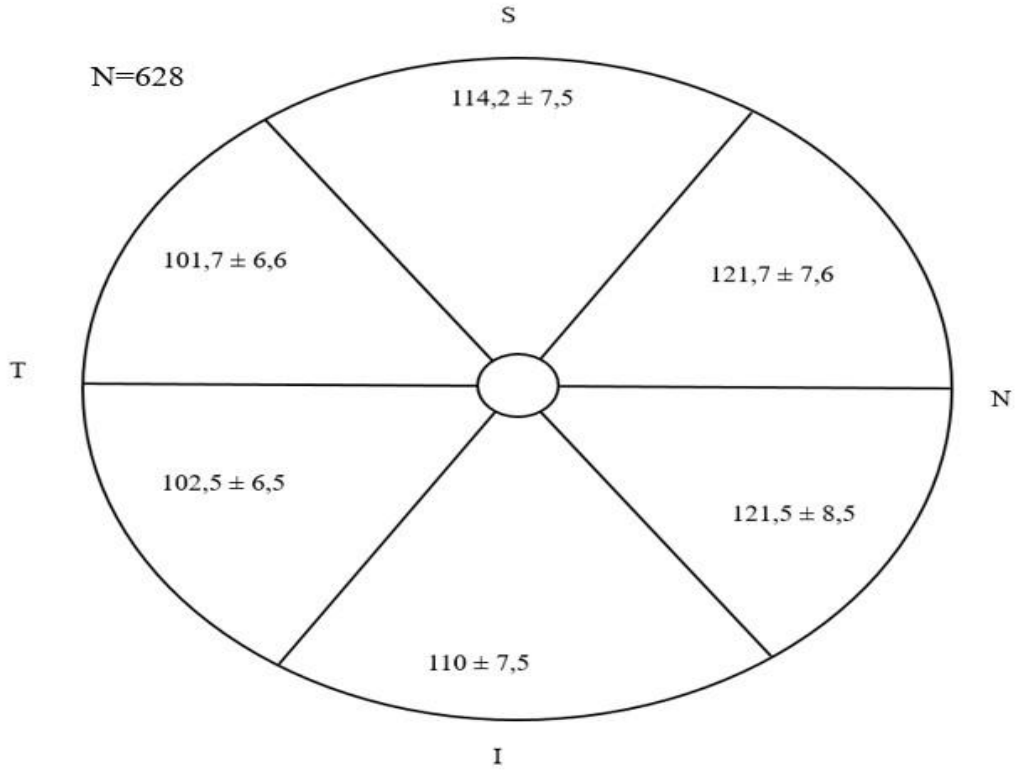

Figure 5: Distribution of eyes by mean GCIPL thickness (μm) per 60-degree quadrant.

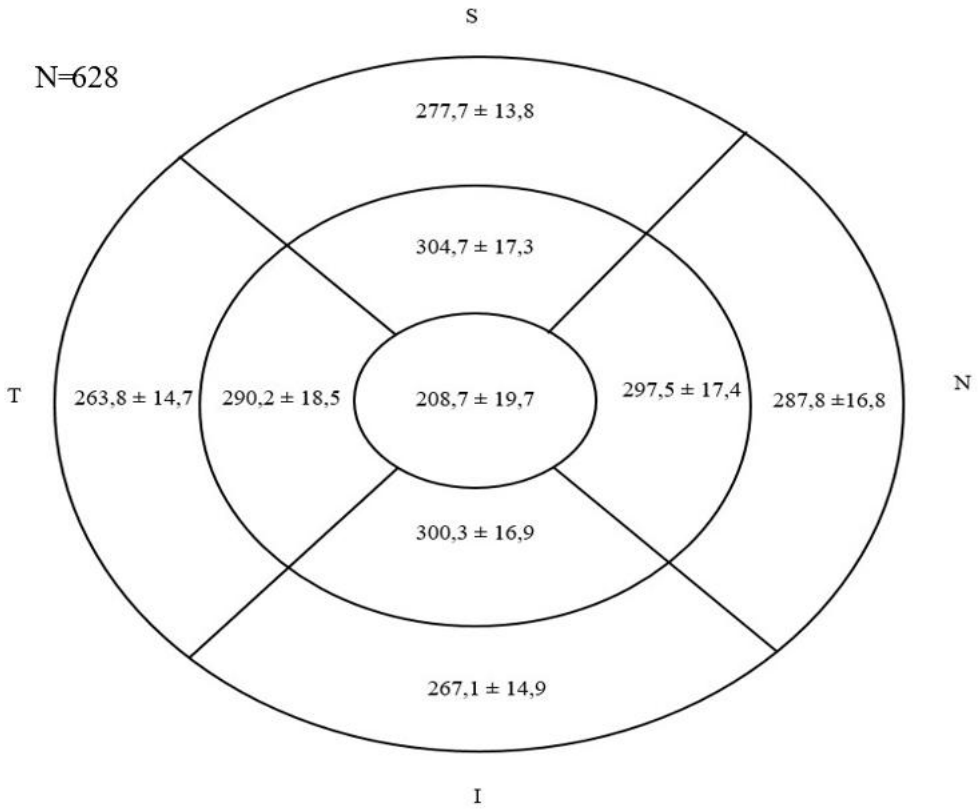

Figure 6: Distribution of eyes based on mean macular thickness per quadrant (μm) according to the ETDRS grid. I= Inferior; S= Superior; T= Temporal; N= Nasal.

Type of Ametropia	Number (N=628)	Frequency (%)
Emmetropia	28	4,5
Myopia	44	7
Hyperopia	272	43,3
mixed astigmatism	16	2,5
Hyperopic astigmatism	216	34,4
Myopic astigmatism	52	8,3

Table 1: Distribution of eyes based on refraction.

Optic Disc Parameters (N=628)	mean ± SD/ median (IQ)	Min – Max
Disc Area (mm²)	2,35 ± 0,40	1,41 – 3,74
Cup Area (mm²)	0,14 (0,08 – 0,25)	0 – 0,7
Neuroretinal Rim Area (mm²)	1,62 ± 0,36	0 – 2,87
Mean Cup-to-Disc Area Ratio	0,28 (0,18 – 0,38)	0 – 0,67
Horizontal Cup-to-Disc Ratio	0,63 (0,53 – 0,72)	0 – 0,82
Vertical Cup-to-Disc Ratio	0,60 (0,50 – 0,66)	0 - 78
Cup Volume (mm³)	0,15 (0,07 – 0,25)	0 – 0,08
Neuroretinal Rim Volume (mm³)	0,29 (0,22 – 3,38)	0,07 – 7,07
Horizontal Disc diameter (mm)	1,58 ± 1,19	0,56 – 2,15
Vertical Disc Diameter (mm)	1,87 ± 0,18	1,26 – 2,27
SD=Standard Deviatiom ; IQ= Intervalle Interquartile		

Table 2: Distribution of eyes according to the mean or median of optic disc parameters.

Optic Disc Parameters (N=628)	r	p-value
Disc area (mm²)	-0,02	0,31
Cup area (mm²)	0,11	0,05
Neuroretinal Rim Area (mm²)	-0,20	**0,001**
Mean Cup-to-Disc Area Ratio	0,13	**0,02**
Horizontal Cup-to-Disc Ratio	0,12	**0,02**

Vertical Cup-to-Disc Ratio	0,11	0,05
Cup volume (mm^3)	0,10	0,05
Neuro-rétinal rim volume (mm^3)	-0,74	0,2
Horizontal Disc Diameter (mm)	-0,06	0,25
Vertical Disc Diameter (mm)	-0,03	0,62

Table 3: Correlation between age and optic disc parameters.

Optic Disc Parameters	**Sex**		**P**
(N=628)	**Male**	**Female**	
Disc area (mm^2)	2,3 ± 0,4	2,4 ± 0,4	**0,03**
Cup area (mm^2)	0,2 ± 0,1	0,2 ± 0,1	0,27
Neuroretinal rim area(mm^2)	1,6 ± 0,2	1,7 ± 0,4	**0,018**
Mean cup to disc ratio	0,3 ± 0,1	0,2 ± 0,1	0,17
Horizontal Cup to disc ratio	0,5 ± 0,1	0,5 ± 0,1	0,09
Vertical Cup to disc ratio	0,5 ± 0,1	0,4 ± 0,1	0,06
Cup volume (mm^3)	0,2 ± 0,1	0,2 ± 0,1	0,27
Neuroretinal rim volume mm^3)	0,3 ± 0,1	0,4 ± 0,7	0,06
Horizontal Disc Diameter (mm)	1,6 ± 0,2	1,6 ± 0,2	0,95
Vertical disc diameter	1,8 ± 0,2	1,9 ± 0,2	**0,002**

Table 4: Variation of optic disc parameters according to sex.

RNFL Thickness	**Sex**		**P**
N =628	**Male**	**Female**	
Mean RNF	117,8 ± 8,8	120,4 ± 12,1	**0,04**
Superior RNFL	146,3 ± 13,6	152,5 ± 16,1	**0,001**
Inférior RNFL	153,5 ± 16	157,8 ± 20,1	**0,046**
Nasal RNFL	91,7 ± 12,9	80,3 ± 16,1	0,90
Temporal RNFL	80,3 ± 14,7	78,8 ± 10,9	0,29
RNFL: Retinal Nerve Fiber Layer			

Table 5: Variations in RNFL thickness according to sex.

Discussion

This analytical cross-sectional study successfully established normal tomographic parameters of the optic disc and macula in healthy young Cameroonians, utilizing the Topcon 3D-Maestro OCT. It is crucial to acknowledge that OCT measurements are inherently device-specific which consequently limits the direct generalization of these findings to other OCT platforms [3,4,6]. Furthermore, the hospital-based recruitment strategy may introduce a sampling bias, potentially impacting the representativeness of the broader general population. The primary strength of this research lies in its focus on a Black African population, a demographic notably underrepresented in existing scientific literature. In stark contrast to numerous studies predominantly centered on Caucasian populations, there is a distinct lack of normative data for African populations. Our comprehensive analysis, covering a broad spectrum of papillary and macular OCT parameters, offers a more complete characterization of the retinal and optic nerve head structures in young Cameroonians, differentiating it from studies that often focus on more limited aspects.

The median age of 13 years (interquartile range: 9-16 years) in our cohort is higher than that reported in studies conducted in France and Lebanon which typically included younger populations [1,10]. This age discrepancy underscores the critical influence of age in cross-study comparisons. The observed hyperopia prevalence of 43.3% and a median spherical equivalent of +0.5 diopters align consistently with previously published data [12,13]. These findings suggest that the refractive profile of our study population is comparable to that observed in other cohorts, thereby enhancing the generalizability of our results in this regard.

Optic Disc Tomographic Data

The mean optic disc area was 2.35±0.40 mm^2. This finding is consistent with Mays, et al., research in California, which reported an optic disc area of 2.46 mm^2 in a population of African American children [14]. This consistency suggests potential commonalities in optic disc size across various ethnic groups within the African diaspora. However, our results diverge from those of Elia, et al., in Spain, who found an optic disc area of 2.05±0.39 mm^2 [15]. This discrepancy could be attributed to the use of different OCT devices, but also significantly to racial influences. Previous research has proposed that individuals of African origin tend to possess larger optic discs than Caucasians and our study provides additional empirical evidence supporting this observation [4,15]. The absence of unusually large optic discs (area >4.09 mm^2) in our cohort emphasizes the necessity of a thorough clinical evaluation for any notable optic disc excavation, as this could signal an underlying pathological condition.

Regarding the vertical cup-to-disc (C/D) ratio, the median was 0.60 (interquartile range: 0.50 - 0.66). This ratio is notably higher than values typically observed in Caucasian studies, which generally hover around 0.40 [4,15]. This suggests that individuals of Black ancestry may indeed exhibit a larger optic cup compared to Caucasians. This potential difference in C/D ratio must be meticulously considered during OCT interpretation and glaucoma diagnosis in individuals of African descent. Furthermore, the higher C/D ratio observed with OCT compared to clinical evaluation reflects inherent differences in measurement sites and methodologies; OCT provides a more objective and detailed assessment. Other optic nerve head parameters also displayed variations linked to geographical origin and race, yet these variations were not deemed pathological.

A statistically significant negative correlation was identified between the neuroretinal rim area and age ($r=-0.20$; $p=0.001$), indicating a physiological reduction in rim area with advancing age. Similarly, a statistically significant positive correlation was observed between age and the horizontal C/D ratio ($r=0.13$; $p=0.018$), suggesting a slight physiological increase in the horizontal C/D ratio with age. The optic disc area, neuroretinal rim area and vertical optic disc diameter were significantly larger in females, potentially attributable to hormonal factors or variations in overall ocular size. These specific observations contrast with Elia, et al., study which reported no significant differences in optic disc parameters related to age or sex [15].

The mean Retinal Nerve Fiber Layer (RNFL) thickness was 119.4±11 μm. This average is higher than values reported by Al-Haddad, et al., and Gire, et al., who, using a Cirrus OCT device, found values of 95.6±8.7 μm and 104.33±10.22 μm, respectively [1,10]. These disparities can be attributed to racial and device-related differences. As previously noted, different OCT devices can produce variable measurements due to differences in image acquisition technology and segmentation algorithms. Furthermore, individuals of Black ethnicity tend to have larger optic discs and, consequently, a thicker RNFL, as eyes with a larger optic disc physiologically possess a greater neuroretinal rim area and thus a higher quantity of retinal nerve fibers [16,17,18]. This relationship between optic disc size and RNFL thickness underscores the importance of considering optic disc size when interpreting RNFL thickness measurements. The mean RNFL thickness distribution by quadrant conformed to the

normal "double-hump" pattern (respecting the ISNT rule) [3,4]. This characteristic distribution, with distinct peaks in the superior and inferior sectors, is crucial for distinguishing normal variations from pathological changes. No significant correlation was found between mean RNFL thickness and age, which is consistent with results from several studies conducted in young subjects [1,10,14,15]. This absence of correlation is explained by the fact that physiological axonal loss typically occurs later in life, generally peaking after the age of 50 [19]. However, mean RNFL thickness was significantly higher in the female population, which contrasts with some studies that have observed no influence of sex on RNFL thickness [10,15].

Macular Tomographic Data

The thickness of the macular Ganglion Cell Complex (GCC) was 111.9±6.7 μm. This is similar to Wolf, et al., findings in Sweden (107.1±6.5 μm) [20], but greater than those reported by Chaglasian, et al., in the United States (105.9±8.5 μm) and Vonor, et al., in Togo (105.0±7.1 μm) [6,21]. These differences may be explained by the inclusion of predominantly adult populations (mean ages: 37.7±15.2 years and 46.3±16.3 years, respectively) in these latter studies, unlike our study which focused on a younger cohort. No significant correlation was observed between age, sex and mean or sectoral GCC thickness. Our results corroborate those of Wolf, et al., in Sweden [20]. However, Vonor, et al., study, which included a wider age range (5 to 60 years), reported a weak correlation ($r2=0.01$; $p=0.2$), suggesting that our younger study population might not have been broad enough to detect this subtle association [21].

The Mean Macular Thickness (MMT) was 278±13.8 μm. These findings are consistent with those reported by Al-Haddad, et al., in Lebanon (279.6±12.5 μm) and Krumova, et al., in Bulgaria (286.70±9.82 μm) in pediatric populations [1,22]. This consistency across studies suggests a relatively stable macular thickness in children, thereby reinforcing the reliability of our results. In line with anatomical knowledge, mean foveal thickness (208.7±19.7 μm) was thinner than both mean parafoveal (298.2±15.9 μm) and perifoveal (274.1±12.8 μm) thicknesses, given that the fovea naturally lacks outer retinal layers [3]. Furthermore, we observed that the parafoveal region was thicker than the perifoveal region. These data align with those reported in most studies, reflecting the physiological variation in retinal thickness: it is thinnest at the foveola, increases at the clivus (parafoveal region) and then gradually decreases towards the retinal periphery [1,5,11,22-28].

Conclusion

This study significantly enriches the understanding of OCT parameters in young Cameroonians, underscoring the critical need for population-specific reference data. The observed differences highlight the paramount importance of considering both ethnic origin and the specific OCT technology used, as ethnicity can influence ocular structure and retinal parameters and various OCT devices can yield different measurements. Therefore, establishing normative values tailored to both the specific population and the OCT apparatus is essential for accurate clinical interpretation. Future research should encompass broader population-based studies and investigate the influence of additional factors, such as genetics and environmental elements. Furthermore, longitudinal follow-up studies are crucial to fully understand the long-term evolution of OCT parameters in Cameroonian children.

Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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