Original Article

Ocular biometric measurements and optical coherence tomography parameters in children with refractive errors and emmetropia

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Purpose: The aim of this study was to estimate and compare the differences in ocular biometric measurements (OBMs), central macular thickness (CMT), and retinal nerve fiber layer thickness (RNFLT) between children with refractive errors and those with emmetropia. **Methods:** A cross-sectional observational study of 205 children (334 eyes) aged between six and 18 years consisting of four groups (emmetropia, hypermetropia, myopia, and astigmatism) was carried out. Best-corrected visual acuity (BCVA), a detailed ocular examination, OBMs, spectral-domain optical coherence tomography (SD OCT) for RNFLT and CMT in both eyes were evaluated for each child. **Results:** Mean age of 205 children was 12.4 ± 3.2 years. 55.6% (n = 114) were girls and 44.4% (n = 91) were boys. There was a significant difference between the four groups for the parameters spherical equivalent (SE), keratometer readings K1and K2, axial length (AL), anterior chamber depth (ACD), vitreous chamber depth (VCD) and lens thickness (LT) ($P < 0.0001$). The mean central corneal thickness (CCT) was not significantly different between the four groups ($P = 0.076$). The mean RNFLT was thinner in the myopic group compared with the emmetropic group ($P = 0.0048$) There was no significant difference in the mean CMT across the four groups ($P = 0.458$). **Conclusion:** The data obtained are helpful in providing the normative as well as a comparative database on OBMs, RNFLT and CMT of the pediatric population. This also facilitates evaluation of RNFLT and CMT measurements in children with amblyopia, optic neuropathies, glaucoma, macular and retinal diseases.

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Refractive error (RE) is one of the most common causes of visual impairment around the world and the second leading cause of treatable blindness.[1] The global prevalence of myopia between 5 and 15 years ranges from 3% to 35%, whereas that of hyperopia from 0.4% to 17% and astigmatism from 2.2% to 34%.[2]

Ocular structures go through continuous development and alteration before and after birth.[3] The ocular biometric measurements (OBMs), which include the anteroposterior axial length (AL), radius of curvature of cornea (K1 and K2), central corneal thickness (CCT), lens thickness (LT), anterior chamber depth (ACD) and vitreous chamber depth (VCD) keep continuously changing with age. Refractive errors (REs) occur due to the mismatch of these OBMs. Hence, the final refractive status is determined by the net balance of these OBM changes.[4]

The normal range of retinal nerve fiber layer thickness (RNFLT) in adults has been measured by several investigators using optical coherence tomography (OCT) but less is known about normative RNFLT and central macular thickness (CMT) values in children.[5-7]

Although RNFL measurements taken from TD-OCT and SD-OCT are comparable, significant differences exist and values cannot be used interchangeably.[8,9] Only few studies in the literature aimed at reporting normative reference ranges using SD-OCT.[10-15] The clinical applications of SD-OCT are increasingly expanding;[16] normal reference values for RNFLT and CMT are needed in the pediatric population where the software has no nomogram for comparison. Hence, the purpose of this study was to measure and compare the aforementioned parameters in different types of REs and emmetropia (E) in the pediatric population and thus would help create a reference range for further studies.

Methods

This cross-sectional, hospital-based, observational clinical study was carried out at a tertiary care eye hospital in South India between July 2017 and April 2018. The study was approved by the institutional review board and adhered to all the principles mentioned in the Declaration of Helsinki 2000. Patients attending the out-patient department were enrolled in the study. Written informed consent was obtained from all participants' parents or guardians. Based on outcome variables with minimum difference on CMT of 10, with SD = 55, 90% statistical power, 5% significance, sample size estimated to be 325 eyes. After considering the 5% noncooperative to the study the required sample size was 360 eyes, 90 eyes in four groups

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each (emmetropia, hypermetropia, myopia, and astigmatism). Each group was further subdivided into three subgroups based on age range (30 eyes in each sub-age group). Inclusion criteria: children aged between six and 18 years of either sex with emmetropia or myopia or hypermetropia or astigmatism in either eye or both eyes.

Exclusion criteria

Uncooperative children, children with squint, amblyopia, pathological myopia and hypermetropia of 6 diopters or worse, astigmatism of – 4 dioptre or worse, ocular abnormalities like ptosis, corneal scars, corneal infections, allergic conjunctivitis, congenital and juvenile glaucoma; congenital nystagmus, congenital cataract, optic nerve or retinal disease.

Refractive errors definition

Refractive status was determined by the post cycloplegic spherical equivalent refraction (SER), calculated as sphere + ½ cylinder. Myopia was defined as SER of –0.5 D or worse in one or both eyes.[17] Pathological myopia was defined as SER of ≥-6 D in one or both eyes.[18] Hypermetropia was defined as SER of ≥+0.5 in one or both eyes.[19] Astigmatism was defined as SER of ≥1.00 D in one or both eyes.[20] Emmetropia was defined as SER between –0.5 and +0.5 in one or both eyes.[19] Uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) for distance using log MAR 3 meter chart (English letters or Symbols chart) and near vision using reduced log MAR near vision chart (E- chart or Numbers) was recorded in each eye separately. Detailed anterior segment evaluation was done using slit lamp. OBMs were done before dilatation for both the eyes by same examiner. Corneal radii of curvature K1 and K2 were measured by auto refracto keratometer (Topcon KR-800 model, frequency 50-60Hz, Topcon Corp, Tokyo, Japan) in each eye. After administration of 1 drop of 0.5% proparacaine, AL, LT and ACD was obtained using ultrasound biometry machine (Biomedix scan model Echorule 2, probe frequency of 10 MHz). The average of ten measurements was taken and accepted if the standard deviation of these ten readings was ≤0.05. If the standard deviation was ≥0.05, then the procedure was repeated. CCT was measured using pachymetry machine (Tomey pachymeter S P-3000 model). The average of ten measurements was taken and accepted if the standard deviation of these ten readings is <2. If the standard deviation is >2 then the procedure was repeated. Total of ACD (mm), LT (mm), and CCT (mm) values were deducted from AL (mm) to calculate the VCD (mm). Cycloplegic refraction was performed after instillation of 2 drops of 1% cyclopentolate hydrochloride along with 1 drop of tropicamide 5 minutes apart. After ensuring that cycloplegic effect was attained (usually after 45 minutes) refraction was done by using streak retinoscope. This was also confirmed by automated refractometer. Fundus examination was carried out with indirect ophthalmoscopy using +20 D condensing lens and with slit-lamp biomicroscopy using +90 D lens. The OCT parameters, RNFLT and CMT were measured by same examiner in a dim room after dilatation of pupils of both eyes, using Topcon 3D OCT-2000 system Software Edition Version 4.0 x Topcon, Tokyo, Japan (spectral-domain OCT). 3D scan protocol was used which involves scanning area of 6 × 6 mm cube which is centered on the disc with a scan resolution of 512 × 128 pixels. RNFLT measurements were obtained by automated software along a circle of 3.4 mm diameter centered on the disc. An inbuilt internal fixation target was used in all scans for proper alignment of the eye. Images with Image Quality Value (IQV) of >50 which indicate a good scan quality sufficient enough to provide reliable analysis was chosen for analysis. RNFLT of each of the 4 quadrants and the global RNFLT were recorded in micrometers (μm). 3D macular scan protocol was used which involves scanning area of 6 × 6 mm cube with a scan resolution of 512 x 128 pixels. Macular thickness is reported in a modified Early Treatment of Diabetic Retinopathy Study (ETDRS) macular map with the central subfield 1 mm in diameter. The CFT (central foveal thickness) was defined as the average of all points within the central 1 mm diameter circle surrounding fixation.[21] All findings observed were recorded and later data was analyzed.

Statistical analysis: The data were analyzed descriptively first with mean and then standard deviation estimates were derived. The analysis of variance test (ANOVA) was used to compare the mean refractive error parameters between all four groups. Where there was an overall mean difference between all four groups, *post hoc* test of Bonferroni correction was utilized to find out between which groups the difference existed. Similarly, the analysis was carried out for different age groups. Independent sample *t* test was used to compare the mean difference between male and female samples. The normal distribution curves reported wherever necessary. A two-sided *P* value <0.05 was considered to be statistically significant. All statistical analysis was carried out by using the SPSS 17.0 version (SPSS, Chicago, IL, USA) software for windows.

Results

A total of 205 children (334 eyes were analyzed though intended was 360 eyes) aged between six and 18 years were included in the analysis, 55.6% ($n = 114$) were girls and 44.4% ($n = 91$) were boys. On comparison of refractive errors with emmetropes in post- hoc analysis, there exists a significant differences for SE, AL, ACD between emmetropia and hypermetropia groups ($P < 0.01$ for all). The mean SE, AL, ACD, VCD, LT, and RNFLT were significantly different between emmetropia and myopia groups ($P < 0.05$ for all) However, the mean SE, K1, and K2 were the only parameters significantly different between emmetropia and astigmatism groups ($P < 0.0001$ for all) [Table 1]. The subgroup analysis based on age group was done. In the age group of 6-10 years there exists a significant difference between all four groups only for SE and K1 ($P < 0.05$). The *post hoc* analysis revealed significant differences only for mean SE between emmetropia and hypermetropia, myopia, and astigmatic groups [Table 2]. In the age group of 11–14 years, there exists a significant difference for the parameters of SE, K2, AXL, VCD, and CCT ($P < 0.05$). The *post hoc* analysis revealed the significant differences for SE between emmetropia and hypermetropia groups ($P < 0.05$). The mean SE, AL, and VCD were significantly different between emmetropia and myopic groups ($P < 0.05$). The AL and VCD were longest in the myopic group as compared to emmetropic group. The mean SE, K2, and CCT were significantly different between emmetropic and astigmatic group ($P < 0.05$). The CCT was thinner in astigmatic group as compared to emmetropic group [Table 3]. In the age group of 15–18 years there exists a significant difference between all the four groups in 15-18 years for the parameters of SE, K2, AL, ACD, and VCD ($P < 0.05$). The *post hoc* analysis revealed the significant differences for SE between emmetropia and hypermetropia groups ($P = 0.001$).

The mean SE, AL, and VCD were significantly different between emmetropic and myopic groups ($P < 0.0001$). The AL and VCD were longest in the myopic group as compared to emmetropic group. The mean SE was the only parameter significantly different between emmetropic and astigmatic groups ($P = 0.001$) [Table 4]. The mean comparison of different ocular measures between male and female children in each group shows the RNFLT, AL and CMT were significantly different between male and female children in emmetropia

Table 1: Differences in OBMs, CMT and RNFLT in children with emmetropia and different types of refractive errors

Parameters	Emmetropia (*n*=83)	Hypermetropia (*n*=90)	Myopia (*n*=80)	Astigmatism (*n*=81)	*P*
No of Subjects	55	57	43	50	
Age, year					
Mean±SD	12.9±3.0	12.4±3.2	12.6±3.2	11.5±3.3	0.137
SE in Diopters	0.05±0.25	1.12±0.94	-2.05±1.22	-1.63±0.51	<0.0001
K1	43.22±1.31	42.83±1.35	43.43±1.44	42.28±1.39	<0.0001
K2	43.83±1.34	43.65±1.39	44.14±1.48	45.01±1.36	<0.0001
AL	23.14±0.61	22.67±0.75	23.95±0.85	23.12±0.82	<0.0001
CCT	538.39±31.05	530.98±31.79	526.73±27.07	528.53±31.96	0.076
ACD	3.63±0.26	3.46±0.30	3.76±0.27	3.52±0.29	<0.0001
VCD	15.38±0.57	15.16±0.67	16.24±0.83	15.50±0.76	<0.0001
LT	3.61±0.24	3.54±0.28	3.44±0.27	3.57±0.23	<0.0001
CMT	220.40±20.31	215.98±18.31	218.01±16.48	217.54±17.36	0.458
RNFLT	105.30±7.73	104.34±8.15	102.03±7.19	104.58±8.23	0.049

OBMs=Ocular biometric measurements, CMT=Central macular thickness, RNFLT=Retinal nerve fibre layer thickness, SD=Standard deviation, SE=Spherical equivalent, K1=Horizontal meridian, K2=Vertical meridian, AL=Axial length, CCT=Central corneal thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth, LT=Lens thickness

Table 2: Differences in OBMs, CMT and RNFLT in different types of refractive errors in children between 6 and 10 years

Age (6-10 years)	Emmetropia OD/OS (*n*=15)	Hypermetropia OD/OS (*n*=17)	Myopia OD/OS (*n*=13)	Astigmatism OD/OS (*n*=19)	*P*
SE in Diopters	0.07±0.23	1.13±0.99	-1.46±1.27	-1.63±0.48	<0.0001
K1	43.36±1.62	42.84±1.46	44.15±1.61	42.09±1.48	0.004
K2	44.08±1.66	43.65±1.64	44.96±1.91	44.88±1.38	0.071
AL	22.83±0.71	22.64±0.82	23.22±1.15	23.04±0.91	0.315
CCT	523.20±22.19	530.59±20.03	535.38±23.95	529.79±30.25	0.629
ACD	3.60±023	3.45±0.37	3.67±0.36	3.48±0.34	0.229
VCD	15.07±0.66	15.06±0.84	15.51±1.18	15.43±0.81	0.350
LT	3.63±0.27	3.66±0.43	3.51±0.42	3.60±0.21	0.656
CMT	221.53±20.72	209.82±14.23	217.46±13.66	212.74±20.05	0.264
RNFLT	106.20±5.77	106.53±6.17	102.54±4.91	103.63±7.07	0.217

OBMs=Ocular biometric measurements, CMT=Central macular thickness, RNFLT=Retinal nerve fibre layer thickness, SD=Standard deviation, SE=Spherical equivalent, K1=Horizontal meridian, K2=Vertical meridian, AL=Axial length, CCT=Central corneal thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth, LT=Lens thickness

Table 3: Differences in OBMs, CMT and RNFLT in different types of refractive errors in children between 11 to 14 years

Age (11 to 14 years)	Emmetropia OD/OS (n=20)	Hypermetropia OD/OS (n=20)	Myopia OD/OS (n=15)	Astigmatism OD/OS (n=18)	*P*
SE in Diopter	0.13±0.24	0.87±0.57	-1.88±1.05	-1.69±0.50	<0.0001
K1	42.93±1.19	42.93±1.04	43.23±1.09	42.43±1.47	0.289
K2	43.46±1.29	43.83±1.11	44.10±0.99	45.21±1.34	<0.0001
AL	23.31±0.60	22.74±0.79	23.99±0.72	23.23±0.73	<0.0001
CCT	548.60±32.58	524.70±36.79	529.47±27.35	519.44±32.85	0.041
ACD	3.67±0.32	3.57±0.26	3.73±0.22	3.58±0.27	0.277
VCD	15.50±0.52	15.12±0.65	16.32±0.59	15.59±0.63	<0.0001
LT	3.60±0.24	3.53±0.26	3.46±0.24	3.54±0.24	0.440
CMT	221.10±21.69	212.90±19.04	215.60±15.98	220.11±12.92	0.452
RNFLT	105.60±8.84	102.80±10.23	101.20±7.95	104.33±6.77	0.474

OBMs=Ocular biometric measurements, CMT=Central macular thickness, RNFLT=Retinal nerve fibre layer thickness, SD=Standard deviation, SE=Spherical equivalent, K1=Horizontal meridian, K2=Vertical meridian, AL=Axial length, CCT=Central corneal thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth, LT=Lens thickness

group ($P < 0.05$ for all). In hyperopes, only AL and CMT were significantly different between male and female children ($P < 0.05$ for all). In myopia group only the mean AL was significantly different between male and female children ($P = 0.008$) but not other parameters. However, in astigmatism group, none of these were significantly different between male and female children ($p > 0.05$ for all). **Post-hoc test of Bonferroni:** Since there was an overall mean difference between all four groups, *post hoc* test of Bonferroni correction was utilized to find out between which groups the difference existed: The *post hoc* analysis revealed the significant differences for SE, AL, ACD between emmetropia and hypermetropia groups ($P < 0.01$ for all) and the mean SE, AL, ACD, VCD, LT, and RNFL thickness were significantly different between emmetropia and myopia groups ($P < 0.05$ for all). However, the mean SE, K1 and K2 were the only parameters significantly different between emmetropia and astigmatism

Table 4: Differences in OBMs, CMT and RFNLT in different types of refractive errors in children between 15 to 18 years

Age (15 to 18 years)	Emmetropia OD/OS (*n*=20)	Hypermetropia OD/OS (*n*=20)	Myopia OD/ OS (*n*=15)	Astigmatism OD/OS (*n*=13)	*P*
SE in Diopter	0.09±0.26	1.37±1.43	-2.37±1.38	-1.34±0.36	<0.0001
K1	43.50±1.18	42.59±1.66	43.38±1.53	42.86±1.25	0.177
K2	42.12±1.16	43.44±1.56	43.78±1.43	45.21±1.63	0.009
AL	23.18±0.42	22.80±0.69	24.12±0.70	23.32±0.87	<0.0001
CCT	530.10±30.61	531.60±35.22	510.60±23.78	528.62±29.49	0.187
ACD	3.62±0.20	3.45±0.28	3.77±0.26	3.61±0.17	0.003
VCD	15.41±0.49	15.42±0.52	16.44±0.77	15.67±0.88	<0.0001
LT	3.62±0.27	3.46±0.23	3.49±0.27	3.50±0.23	0.213
CMT	219.0±17.77	223.05±15.72	218.67±17.37	215.31±18.92	0.650
RNFLT	105.80±7.95	105.75±8.09	102.00±7.42	104.38±11.18	0.550

OBMs=Ocular biometric measurements, CMT=Central macular thickness, RNFLT=Retinal nerve fibre layer thickness, SD=Standard deviation, SE=Spherical equivalent, K1=Horizontal meridian, K2=Vertical meridian, AL=Axial length, CCT=Central corneal thickness, ACD=Anterior chamber depth, VCD=Vitreous chamber depth, LT=Lens thickness

Table 5: Comparison of our study with various studies done for RNFLT and CMT with OCT in normal children

Author	Ethnicity	No of subjects	Age range (years) (Mean±SD)	Global RNFLT µm (mean±SD)	OCT Version
Our study	South India	205	6-18 12.4±3.2	104.08±7.90	Topcon SD-OCT
Sushil *et al*.	Rural Indian	59	5-15 10.55±2.9	91.66±13.682	Cirrus HD OCT
Neelam Pawar *et al*.	Indian	120	5-17 10.8±3.24	106.11±9.5	Stratus OCT
Ayala *et al*	Sweden	80	3.8-16.7 9.1±3.3	105±10.3	Topcon SD-OCT
Salchow *et al*.	92% Hispanic, 8%, African American, 1%, Caucasian	92	4-17 9.7±2.7	107±11.1	Stratus OCT
Ahn *et al*.	Korean	72	9-18	105.53±0.33	Stratus OCT
Turk *et al*	Turkish	107	6-16 10.46±0 94	106.45±9.41	Spectralis OCT
Parikh *et al*.	Asian Indian	59	5-20	100.15±10.8	Stratus OCT
Author	**Ethnicity**	**No of subjects**	**Age range (years)**	**CMT µm (mean±SD)**	**OCT Version**
Our study	South india	205	6-18	217.94±18.18	Topcon SD OCT
Sushil *et al*	North rural india	70	5-17	243.26±22.136	Cirrus HD OCT
Katiyar *et al*.	North india	157	6-17	234.31±18.15	Cirrus SD OCT
Gupta *et al*.	India	18	6-13	221±10.9	Not mentioned
Eriksson *et al*	Sweden	56	5-16	204±19	Stratus OCT
Turk *et al*	Turkish	107	6-16	258.6±17.2	Spectralis SD OCT
Barrio-Barrio *et al*	Spain	283	4-17	253.8±19.8	Cirrus SD OCT
Al- Haddad *et al*	Middle eastern	108	6-17	249.1±20.2	Cirrus SD OCT

groups ($P < 0.0001$ for all). In subgroup age analysis there exists a significant difference between all four groups in 6–10 years only for the parameters of SE and K1 ($P < 0.05$) and the post-hoc analysis revealed the significant differences only for mean SE between emmetropia and hypermetropia, myopia, and astigmatic groups. There exists a significant difference between all the four groups in 11-14 years for the parameters of SE, K2, AXL, VCD, and CCT ($P < 0.05$) and the *post hoc* analysis revealed the significant differences for SE between emmetropia and hypermetropia groups ($P < 0.05$). The mean SE, AL, and VCD were significantly different between emmetropia and myopic groups ($P < 0.05$) and the mean SE, K2, and CCT were significantly different between emmetropic and astigmatic group ($P < 0.05$). There exists a significant difference between all the four groups in 15–18 years for the parameters of SE, K2, AL, ACD, and VCD ($P < 0.05$) and the *post hoc* analysis revealed the significant differences for SE between emmetropia and hypermetropia groups ($P = 0.001$). The mean SE, AL, and VCD were significantly different between emmetropic and myopic groups ($P < 0.0001$) and the mean SE was the only parameter significantly different between emmetropic and astigmatic groups ($P = 0.001$).

Discussion

OCT has become a widely used tool in clinical ophthalmology. Normative data are provided automatically by OCT for individuals 18 years and older and there is very limited data

available for the pediatric age group. In our study, the corneal curvature in the vertical meridian (K2) was steeper (with-the rule astigmatism) in all the groups, which was similar to Arini *et al*. study.[22] On comparing different types of refractive errors with emmetropia, we observed that AL was shorter (0.47 mm) and ACD was shallower (0.15 mm) in hyperopes. Like other studies, we too observed that children with myopia had significantly longer AL[17,23,24], deeper ACD, and longer VCD[17,23] as compared to emmetropic children. In astigmatic children the above parameters were similar as compared to emmetropes. The mean total RNFLT was 104.08 ± 7.90 μm which was comparable to data obtained from previous studies.[10-12,18,25-29]

In all the four groups RNFLT followed ISNT rule (thickest being the inferior followed by superior, nasal, and temporal), a pattern which is a similar finding in adults as seen in previous studies.[15,30-32] We found that myopes had thinner RNFLT than emmetropes which has been well documented in other studies.[18,32-34]

The age range was similar in all the above studies however we had higher number of children in our study. The parameters, RNFLT and CMT vary due to racial, ethnicity, and age differences [Table 5]. Similarly, we found that the RNFLT in our Indian (southern part) population of emmetropes, myopes, and hyperopes was different and had higher values as compared to that measured by Lee *et al*. in their study.[35] However, in another study by Lee *et al*. to investigate the RNFLT in emmetropes, myopes, and hyperopes using SD OCT had results similar to our study.[35] The mean CMT was 217.94 ± 18.18 μm which was comparable to data obtained from previous studies.[36-38] Confounding variables like ethnicity, race, gender ratio, and the mean age of the studied population could explain the discrepancies noted in recorded normative SD-OCT values from different countries. In our study, the mean age was 12.4 ± 3.2 years that was statistically higher than the comparable Barrio-Barrio *et al*.[15] (mean age 10.71 ± 3.12 years) and Al-Haddad *et al*.[30] (10.71 ± 3.12 years) study ($P = 0.001$). All our children were of south Indian origin, Al-Haddad *et al*.[30] study had white and Middle Eastern subjects while the Barrio-Barrio *et al*.[15] (Spain) were having Caucasian subjects from a Spanish population [Table 5]. The mean CMT was thickest in emmetropes and thinnest in hyperopes though statistically not significant. CMT in emmetropes, myopes, and hyperopes had higher values in our study as compared to those measured by Yau *et al*.[38] and Lee *et al*.[35] These discrepancies could be due to racial and age differences.

Study analysis based on age group: We carried out a subgroup analysis based on age. In the age group of 6-10 years, the values of all the ocular parameters were comparable across the four groups. In the age group of 11–14 years, CCT was thinnest in astigmatic children therefore frequent follow up is necessary in these children to rule out keratoconus. In the age group of 15–18 years the AL (0.94 mm) and VCD (1.03 mm) were longer. Across all the subage groups, there was a general trend of increase in AL in all types of refractive errors. Amongst the types of refractive errors, the increase of AL is maximum in myopes so frequent follow up is necessary to detect change in refractive error and also retinal problems. There was general trend of increase in ACD as age increases. However, it was shallowest in hyperopes as compared to other groups; therefore these children should be evaluated and followed up carefully for development of primary angle closure. There was general trend of increase in VCD across all subage groups and all four groups which was more evident in myopes. The CCT decreased with increase in age in the myopia group whereas there was no specific pattern in other groups. The LT was thinner in hyperopes and myopes as compared to emmetropes. The LT was similar in all subage groups in emmetropia, myopia and astigmatism groups but in hypermetropia group it decreased with increasing in age. In our study, the RNFLT is almost similar in all the sub age groups, In contrast to study conducted by Al-Haddad *et al*.[30] where RNFLT values were lesser in all there subgroups. The CMT was similar in all the subage groups in myopia, emmetropia and astigmatism groups except in hyperopia group where we found that CMT increased with an increase in age. Al-Haddad *et al*.[30] conducted a similar subage group analysis of CMT. The CMT values were found to be higher in all subage groups in the study conducted by Al-Haddad *et al*.[30] as compared to our study population.

Limitations

This study was hospital-based and not population-based. Our study was cross-sectional rather than being longitudinal; it would have been interesting to have followed the same children to analyze the changes of OBMs, RNFLT, and CMT with increasing age. We have used contact ultrasound biometry which indents the cornea and therefore this might have given risen to shorter anterior chamber depth and axial length. We have not analyzed choroidal thickness. The normative data obtained from our study may not be generalizable to other areas in Karnataka or may not be possible to apply for general population in view of smaller numbers. Moreover, we considered only one uniform ethnic group (Malnad region only), so the effect of race and ethnicity could not be tested.

Conclusion

After thorough literature search and to the best of our knowledge our study is the first normative data base study with a higher sample size describing the distribution of OBMs, RNFLT and CMT in Indian children aged between six and 18 years and comparing the same between different types of refractive error and emmetropia with sub-age group analysis. This data facilitates evaluation of OCT measurements in children with optic neuropathies, glaucoma, and macular diseases.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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