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Original Research Article

A cross-sectional study to compare the regional corneal thickness profiles in various age groups of Saudi population using 7 mm wide optical coherence tomography scans

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ABSTRACT

Background: Measuring age-matched normative corneal thickness (CT) values in the center and peripheral regions can be useful in clinical practice. To determine the influence of age and gender on the central, paracentral and mid-peripheral corneal pachymetry profile in normal eyes using spectral domain optical coherence tomography (SD-OCT); and to estimate the average regional CT profiles across all the age groups.

Materials and Methods: Five ninety-six healthy eyes of 298 subjects aged between 10 and 98 years were evaluated using REVO FC anterior segment SD-OCT with predefined concentric corneal ring-shaped zones. CT was calculated in 17 sectors within a central 7-mm circle. Central zone CT (CCT: 2mm), paracentral (PCT: 2 to 5-mm), and midperipheral (MPCT: 5 to 7-mm) in the superior, superior temporal, temporal, inferior temporal, inferior, inferior nasal, nasal and superior nasal cornea; minimum, maximum, median thickness within the 7-mm diameter area were recorded. The mean CT in corresponding zone was compared between genders and correlations with age were evaluated.

Results: The distribution of CCT was 537.9±38μm with no significant difference between right and left eyes, or between males and females CCT. No significant difference noted between male and female participants with respect to age, and no interocular asymmetry in CT was identified either in paracentral or midperipheral zones (17 sectors). The PCT was 1.6% to 5.2% thicker whereas the MPCT sector was 2.3% to 11.4% thicker than the CCT, with the paracentral and midperipheral sectors' superior and superior nasal zones were the thickest zones in the normal population. The mean paracentral inferior temporal (537.9±38.0) and temporal (538.7±37.2) zones' CT were similar to mean CCT-2mm (537.7±36.3). CT varied with age in the seven groups of both genders, specifically in the paracentral and mid-peripheral zones. CT decreases, but its dependence on age is weaker. The CT increased gradually from the center to midperipheral ring with the superior and superior nasal regions had the thickest CTs, while the thinnest points are located primarily in the temporal and inferior temporal cornea.

Conclusion: With the help of SD-OCT, this is the first study establishes the normative central, paracentral, mid-peripheral, and minimum CT data, which differ significantly from Saudi Arabians in location and magnitude. Based on the results, decisions regarding refractive surgery and corneal diagnosis can be made.

1. Introduction

Central and peripheral corneal thicknesses (CT) are vital indicators of endothelial pump function and corneal health.[1] Accurate assessment of central corneal thickness

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(CCT) is critical in diagnosing keratoconus, estimating correct intraocular pressure (IOP) as part of glaucoma therapy, and predicting graft survival following penetrating keratoplasty.[2,3] Mapping the peripheral CT, on the other hand, is critical in monitoring several corneal disorders such as Fuchs endothelial dystrophy and pellucid marginal degeneration.[4,5] Pachymetry maps including the paracentral and peripheral cornea are useful tools for diagnosing and monitoring corneal disorders in which there is greater corneal asymmetry than in normal eyes. Precise preoperative measurement of CCT, paracentral CT (PCT) and mid-peripheral CT (MPCT) can be used to determine the feasibility of surgery, minimizing the occurrence of postoperative ectasia, while planning the outcome and success rate of refractive surgical treatment.[6]

Because CT is influenced by demographic, genetic, and environmental factors, understanding the distribution of CT measurements in different populations is imperative. Several studies have reported variability in mean CCT measurements in both normal and glaucomatous eyes between different ethnic groups such as Caucasian, Hispanic, African American, and Asian, with the thinnest cornea being more common in African Americans.[7,8] Other studies have also shown significant differences in CCT between ethnic subgroups, such as in a study that included various Asian populations: Chinese, Japanese, Koreans, Filipinas, Pacific Islanders, and South Asians, showing that the thinnest corneas are found in South Asia populations.[9] In a worldwide meta-analysis, normal eyes from different racial groups had an average CCT of 544 μm, regardless of the device used.[10]

Currently, various non-contact imaging modalities such as optical biometers enable the measurement of corneal pachymetry, where optical coherence tomography (OCT) uses low-coherence interferometry and reflected near-infrared light to create high-resolution cross-sectional tomograms. The first commercially available OCT device for assessing the anterior segment was a time domain OCT. Since then, these OCT devices have undergone various improvements such as faster scan speeds and improved resolution, and they are increasingly used to measure CT. In addition, spectral domain anterior segment OCT (SD-AS-OCT) is capable of performing pachymetry mapping that includes simultaneous thickness measurements over a large area of the cornea, proving to be accurate, repeatable and reproducible at higher scan speed and resolution. The acquisition of radial scans in SD-AS-OCT allows the acquisition of central, paracentral and mid-peripheral CT information.[11,12] Studies have reported the distribution of CCT measurements with respect to age (17 to 57 years)[13] and CT tomography in Saudi men aged 18 to 21 years;[14] however, little information is available about the regional distribution of CT measurements based on gender and different age groups. Due to the lack of studies on the regional corneal pachymetry normative database, this study aimed to investigate the association between the CT profile and age and gender. This study has significant implications for establishing normative CT tomography scores, which are critical for countries like Saudi Arabia where keratoconus is more common, and also provides a normative database for the Saudi population. Thus, this study aimed to report the normative data of SD-OCT measurements of the central, paracentral, and midperipheral CT of healthy Saudi eyes with a sex and age distribution.

2. Materials and Methods

2.1. Study design and population

This was an observational, cross-sectional study conducted in a tertiary care ophthalmology facility in the Central Province of Saudi Arabia. The research protocols were approved by the institutional review boards of Qassim University and conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from each subject after being provided with an explanation of the nature of the study. The subjects recruited for this study were healthy Saudi males and females aged ≥10 years. The study included 596 eyes from 298 normal, healthy subjects. Cases are divided into 14 groups, 7 groups of each sex according to age as follows: Group 1: 10 to 20 years old; Group 2: 21 to 30 years; Group 3: 31 to 40 years; Group 4: 41 to 50 years; Group 5: 51 to 60 years; Group 6: 61 to 70 years; Group 7: > 70 years.

2.2. Ocular examination

All subjects underwent a complete ocular examination, which included ocular and medical history, measurement of visual acuity using the LogMAR chart, autorefraction using the Tomey autorefractor and kerato-refractometer (Tomey Corp., Model RC-5000), and subjective Refraction to determine refractive error and measurement of IOP included with iCare tonometry, anterior and posterior segment examination. Normal subjects were those who had no complaints of eye irritation, no history of contact lens wear, no anterior segment abnormalities on biomicroscopic examination, and an apparent refractive error of < -4.00 diopters (D) and astigmatism of < -2 .00 D who had the best corrected visual acuity of 20/20 or better. Subjects with eye trauma, eye surgery, corneal opacity, corneal dystrophy, keratoconus, myopia of > -4.00 D, history of contact lens wear, dry eye, diabetes, and autoimmune diseases were excluded from the study.

2.3. OCT measurement

The REVO FC SD-OCT device (Optopol Technology S.A, Zawiercie, Poland, software version 11.0.7) was used to acquire the corneal thickness map (CTM)/pachymetry map.

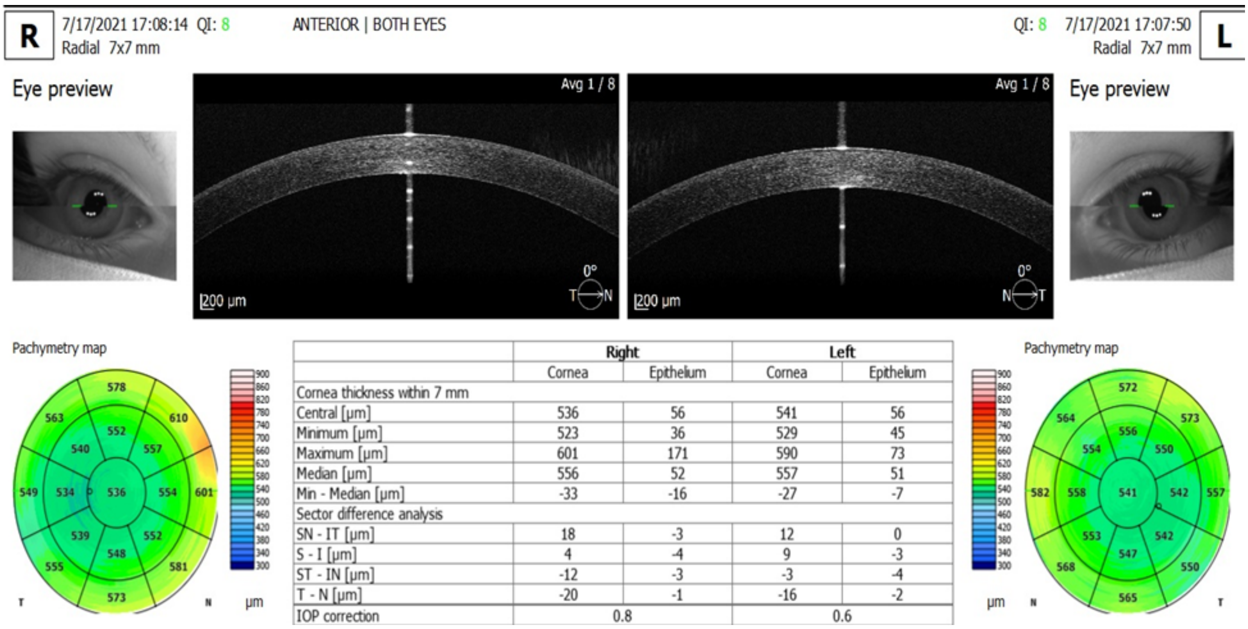

Figure 1: Corneal thickness produced by REVO FC SD-OCT

It acquires corneal images using an 830 nm wavelength superluminescent diode at a scan speed of 12,000 A-scans per second and has an axial tissue resolution of 5 μm and a transverse resolution of 18 μm. All subjects' corneas were scanned using the anterior segment radial scan protocol. The scan acquisition used to determine CT comprises eight 7 mm long radial line scans arranged at equal angles to the common axis, consists of 2560 A-scans each and produces a 7 mm x 7 mm single scan time pachymetry map of 1.58 seconds.[12] Each subject's head was stabilized with a chin rest and asked to fixate the internal fixation target on OCT. The pachymetry scans were centered on the pupil and the images were displayed on the screen in real time to facilitate alignment. If the subject moved their eyes or blinked during the measurements, the scan was repeated to obtain the required quality without artifacts. Data were processed with SD-OCT review software (version 11.0), which provides the average automated CT of three concentric ring-shaped zones centered on the center of the cornea [central (CCT): 0-2 mm, middle ring: paracentral: 2–5 mm and the outermost ring: median circumference 5–7 mm (Figure 1). The CT was evaluated in the sectors superior (S), superior nasal (SN), nasal (N), inferior nasal (IN), inferior (I), inferior temporal (IT), temporal (T) and superior temporal (ST) for paracentral and mid-peripheral sectors. Surrounding the CCT (Zone:1) are the following paracentral sectors: paracentral S, paracentral ST, paracentral T, paracentral IT, paracentral I, paracentral IN, paracentral N and paracentral SN (Zone: 2: PCT: 8 sectors). Outside of these paracentral zones, there are the following mid-peripheral sectors: mid-peripheral S, mid-peripheral ST, mid-peripheral T, mid-peripheral IT, mid-peripheral I, mid-peripheral IN, mid-peripheral N, and mid-peripheral SN (Zone 3: MPCT: 8 sectors). The average thickness in the different corneal sections consisting of 17 sectors was calculated and displayed accordingly in the corneal pachymetry map using a false color representation (Figure 1). The commercial software for CT mapping in the RENO OCT device determines the parameters such as CT within 7 mm (central, minimum, maximum median and min medium thickness in m) and sectoral difference analysis (SN-IT, S-I, ST- IN, T-N in). m). The CT in seven groups of each sex was compared for age changes. The male and female groups were compared with each other with regard to the gender-specific effect.

2.4. Statistical analysis

Data analysis was performed with the help of using IBM Statistic SPSS (SPSS Inc., Chicago, IL, USA) version 20.0. Normality was judged via statistical test called Kolmogorov-Smirnov test. Continuous variables are represented by means and standard deviations, whereas as differences between gender were calculated using independent t test. The paired t test was performed for inter-eye comparison of the mean CET of each sector within an age group. The intraclass correlation coefficient (ICC) was used to measure the interocular symmetry in males and females' group. The one-way ANOVA test was done to assess the variance of the mean CT of each sector across the various age groups. To assess differences between central, paracentral and midperipheral CT, one-way ANOVA test was used. Pearson correlation was used to correlate between age and sectoral CT. P-value of <0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics

Table 1 provides a classification of subjects related characteristics divided into 7 age groups. Of the 298 included participants, the majority were females (n=159; 53.4%), whereas male subjects constituted a slightly smaller proportion (n=139; females; 46.6%). A total of 596 eyes of 298 healthy Saudi individuals with the mean age of 41.9±20.4 years (males: 42.9±21.9 years and females: 41.1±19.1 years) were included in the study. The subjects were divided into seven age groups and the classification of subjects according to their age and gender was shown in Table 1. A high degree of interocular symmetry was observed based on the CT measurements obtained using the REVO FD OCT device for right and left eyes with the ICC 0.94. Average CT measured by REVO FC SD-OCT for 298 Saudi adults for the left eye and the right eye was shown in the Figure 2.

3.2. Corneal thickness by sector

The CT values for each corneal location was presented in Table 2. The CT was thinnest in the sectors of the IT regions, with mean values of 537.9±38μm, and 550±43.8μm in the paracentral and the midperipheral locations, respectively. The SN sector was found to be thickest at the paracentral and midperipheral locations averaging 566.1 ±43.1μm, and 593.9±55.2μm, respectively. The paracentral sectors of the cornea were between 0.02% and 5.2% thicker than the central cornea, with the SN sector showing the greatest thickness. The midperiphery zone of cornea was found to be between 2.3% and 11.4% thicker than the CCT-2mm zone, with the superior sector having the highest thickness.

3.3. Correlation of sectorial corneal thickness with age and gender

No statistically significant differences could be detected between male and female participants with respect to age (p=0.456). No interocular asymmetry of CT in any sectors was noted (p=0.708). Table 3 depicts the association between the CT map and gender, demonstrating that no significant variation was seen in any sectors between male and female patients.

The CCT (2mm) was 538.7±33.5μm, 554.1±28.4μm, 528.4±30.6μm, 531.7±24.9μm, 537.4±33.8μm, and 539.8±8.8μm for the seven female groups, respectively, demonstrating no significant change with age (r=-0.107; p> 0.05) (Table 4) and 531±36.1μm, 557.2±25.4μm, 526.9±36.4μm, 531.7±24.9μm, 547.3±29.1μm, 517.8±36.1μm, and 536.7±69.6μm for the seven males groups, respectively, demonstrating significant change with age (r= -0.126; p< 0.05) (Table 5). The CT in both paracentral and midperipheral zones differed significantly between the seven groups of both genders, with the majority of the zones indicating significant variation with age. The paracentral N (r=-0.143, p=0.01), paracentral IN (r=-0.140, p=0.02), paracentral IT (-0.144, p=0.01), paracentral T (r=-0.140, p=0.02), paracentral SN (r=-0.164, p=0.04), midperipheral IN (r=-0.143, p=0.01), midperipheral IT (r=-0.229, p=0.001), midperipheral T (r=-0.134, p=0.03), midperipheral SN (r=-0.205, p=0.004), minimum thickness (r=-0.214, p=0.002) and median thickness (r=-0.143, p=0.01) among female groups. For male groups, paracentral N (r=-0.126, p=0.03), paracentral IN (r=-0.138, p=0.02), paracentral I (r=-0.162; p=0.005), paracentral IT (r=-0.121; p=0.04), paracentral T (r=-0.144; p=0.01), paracentral ST (r=-0.131; p=0.02), midperipheral IN (r=-0.128; p=0.03), midperipheral SN (r=-0.214, p=0.002), minimum thickness (r=-0.151, p=0.009) and median thickness (r=-0.123, p=0.03). Although there is a statistically significant negative correlation, the relationship between age and regional CT is rather weak (Tables 4 and 5). Representative mean (± standard deviation) total CT maps of 17 sectors of males (left) and females (right) depicting the significance levels (p) obtained by testing mean CT of each sector across the seven age groups for both genders are shown in Figure 3.

4. Discussion

The present study analyzed the distribution of CT in healthy Saudi subjects aged 10 to 98 years to create the normative reference database by examining the association of CT with age and gender. Paracentral, midperipheral and peripheral CT are not routinely measured despite of their importance in ensuring a better match between host and donor corneas in penetrating and deep anterior lamellar keratoplasties. In the present study, the CCT measurements were significantly thinner than the mean PCT and MPCT values of each zone, consistent with previous studies evaluating the CT map using the Orbscan system and OCT-based technologies.[15–17] The progressive increase in CT measurements from the center to the periphery has been illustrated in studies of children, young adults, and middle-aged adults due to the increase in the number of collagen fibrils in the peripheral stroma compared to the central stroma and the change in Bowman's layer thickness toward the corneal periphery.[18–21] Therefore, in our study, the PCT and MPCT measurements were asymmetric and this finding was consistent with the studies examining peripheral CT showing different CT measurements.[10,22,23]

In our study, Saudi participants showed a lower mean CCT of 537.7±36.3 μm compared to studies from Saudi Arabia, which showed a slightly higher mean CCT of 543.8±34.5 μm[13] 545.7± 27.6 μm in adults aged 17-

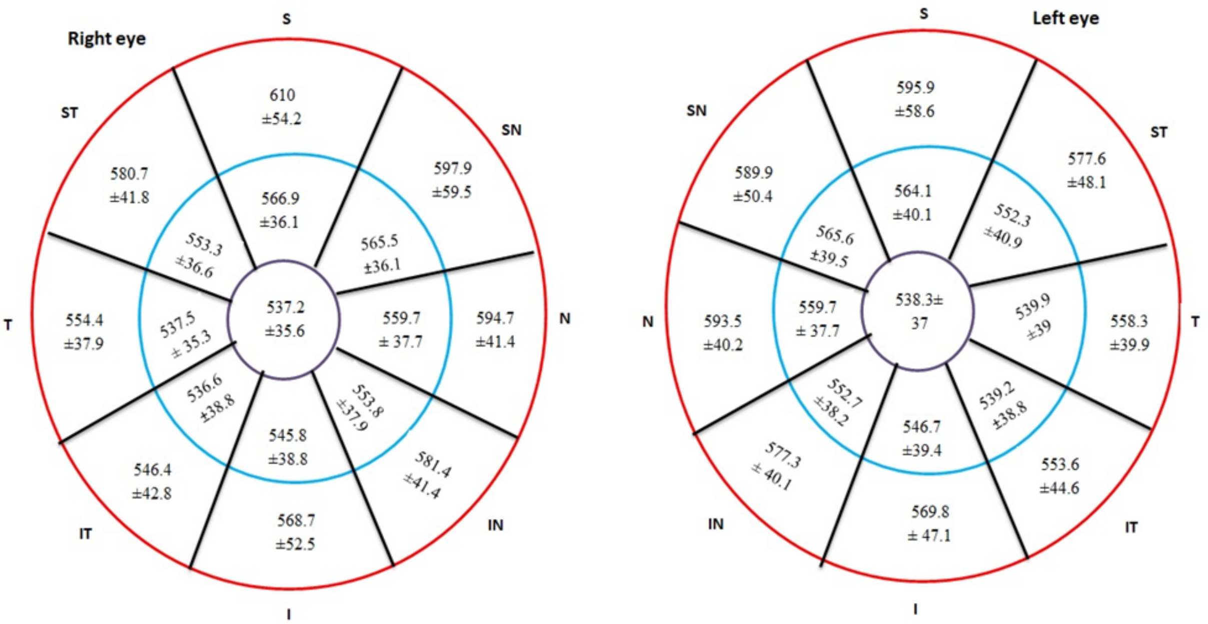

Figure 2: Corneal thickness maps (7mm width) from 17 sectors shows normal variations of corneal thickness among right and left eyes

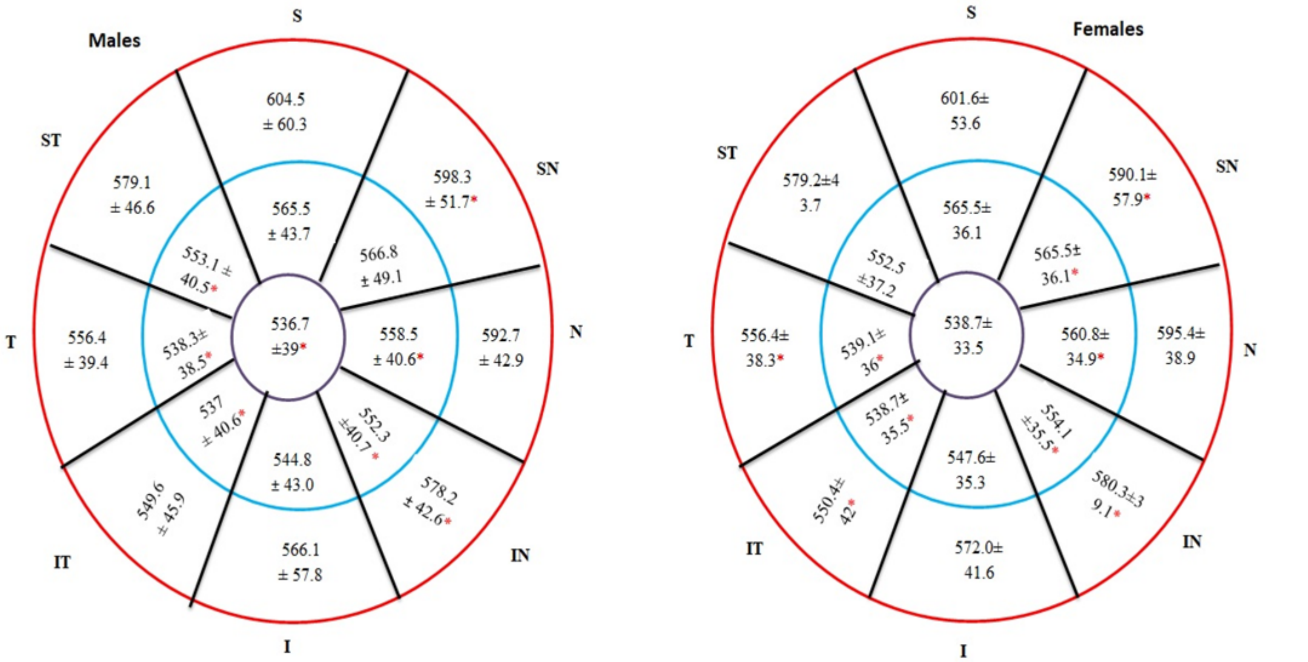

Figure 3: Corneal thickness maps (7mm width) from 17 sectors shows normal variations of corneal thickness among males and females

Table 1: Distribution of males and females according to their age group

Age group	No. of Males (%) [Age: Mean ± SD]	No. of females (%) [Age: Mean ± SD]	Total no. of subjects (%) [Age: Mean ± SD]
10-20 years	23 (7.7%) [17.2±3.6]	22 (7.4%) [19.1±1]	45 (15.1%) [18.1±2.8]
21-30 years	30 (10.1%) [25.9±2.4]	42 (14.1%) [25.4±2.7]	72 (24.2%) [25.6±2.6]
31-40 years	18 (6.0%) [34.3±2.8]	23 (7.7%) [35.2±3.0]	41 (13.7%) [34.8±2.9]
41-50 years	17 (5.7%) [46.1±2.8]	23 (7.7%) [45.7±2.6]	40 (13.4%) [45.9±2.7]
51-60 years	21 (7.0%) [53.5±1.5]	19 (6.4%) [54.4±2.1]	40 (13.4%) [53.9±18.8]
61-70 years	15 (5.0%) [63.8±2.4]	15 (5.0%) [65.4±3.0]	30 (10%) [64.6±2.8]
> 70 years	15(5%) [86.7±12.7]	15 (5%) [78.3±9.3]	30 (10%) [82.5±11.7]
Total no subjects	139 (46.6%) [42.9±21.9]	159 (53.4%) [41.1±19.1]	298 [41.9±20.4]

Table 2: Thickness by section

Section	Paracentral (μm)	Midperipheral (μm)	p-value
Central 537.7±36.3			
Nasal	559.7±37.7	594.1±40.8	0.0001
Inferior nasal	553.2±38.0	579.3±40.8	0.0001
Inferior	546.3±39.1	569.3±49.8	0.0001
Inferior temporal	537.9±38.0	550.0±43.8	0.0001
Temporal	538.7±37.2	556.4±38.9	0.0001
Superior temporal	552.8±38.8	579.1±45.0	0.0001
Superior	565.5±39.8	602.9±56.9	0.0001
Superior nasal	566.1±43.1	593.9±55.2	0.0001

Table 3: Difference in corneal thickness by sex

Section	Males (n=139)	Females (n=159)	p-value
Central (μm)	536.7±39.3	538.7±33.5	0.503
Paracentral nasal (μm)	558.5±40.6	560.8±34.9	0.457
Paracentral inferior nasal (μm)	552.3±40.7	554.1±35.5	0.564
Paracentral inferior (μm)	544.8±43.0	547.6±35.3	0.383
Paracentral inferior temporal (μm)	537±40.6	538.7±35.5	0.586
Paracentral temporal (μm)	538.3±38.5	539.1±36	0.794
Paracentral superior temporal	553.1±40.5	552.5±37.2	0.851
Paracentral superior (μm)	565.5±43.7	565.5±36.1	1.000
Paracentral superior nasal (μm)	566.8±49.1	565.5±36.1	0.711
Midperipheral nasal (μm)	592.7±42.9	595.4±38.9	0.421
Midperipheral inferior nasal (μm)	578.2±42.6	580.3±39.1	0.531
Midperipheral inferior (μm)	566.1±57.8	572.0±41.6	0.149
Midperipheral inferior temporal(μm)	549.6±45.9	550.4±42	0.824
Midperipheral temporal (μm)	556.4±39.4	556.4±38.3	1.000
Midperipheral superior temporal (μm)	579.1±46.6	579.2±43.7	0.979
Midperipheral superior (μm)	604.5±60.3	601.6±53.6	0.534
Midperipheral superior nasal (μm)	598.3±51.7	590.1±57.9	0.070

57 years,[24] whereas a higher mean CCT of 558.5±33.8 μm was observed in 18- and 21-year-old Saudi males.[14] Li Y et al. (2010) reported a similar mean central zone thickness (1.3 mm) of 536.9 ± 27 μm using Fourier domain OCT in subjects aged 20 to 59 years in California, USA.[25] It has been reported from various studies conducted worldwide that the mean CT in normal subjects is 514 to 575 μm. However, these studies used different techniques such as high-frequency ultrasound, ultrasound pachymetry, slit scan topography, and OCT, and allowed for significant differences in CT measurement due to different degrees of accuracy.[25–27] Using the SD-OCT method, the mean CCT in our subjects appears to be lower compared to European populations(561.1±32.3μm).[28] In contrast, Ramesh PV et al. (2017) reported that the CCT by OCT in the subjects was 516.3±29.8 μm with a mean age of 53±8.3 years,[29] which is a lower CCT compared to our study population. Several studies have shown that corneal thickness varies by ethnicity. Saudi participants' mean CCT was also found to be lower than the CCT from Turkish population (552 μm),[30]

Table 4: Corneal thickness in different sectors in seven female groups according to age

Section	**Age-groups**							**Correlation with age**	
	10-20y	21-30y	31-40y	41-50y	51-60y	61-70y	> 70 y	r	p-value
Central (2mm)	538.7±33.5	554.1±28.4	528.4±30.6	531.7±24.9	537.4±33.8	537.2±48.7	539.8±8.8	-0.107	0.06
Paracentral (2-5mm)									
Paracentral nasal	560.8±34.9	576.3±24.2	552.6±35.1	548.3±24.9	560.4±35.3	557±57.2	556.5±12	-0.143	0.01
Paracentral inferior nasal	554.1±35.5	568.8±25.7	548.6±34.7	541.5±235	548.8±36.5	554.1±58	544.8±17.2	-0.140	0.02
Paracentral inferior	547.6±35.3	561.3±29.0	540±31	534.3±27.3	539.3±36.5	552.9±59.5	542.8±15.1	-0.104	0.07
Paracentral inferior temporal	538.7±36.0	554.8±33.3	532.2±28.6	528±28.5	531.3±35.1	538.3±55.8	532.2±14.8	-0.144	0.01
Paracentral temporal	539.1±36.0	556.6±36.5	532.1±28.2	533.1±29.5	537.6±31.7	533.1±52.3	531.2±11.8	-0.140	0.02
Paracentral superior temporal	552.5±37.2	569.6±32.9	544.4±30.5	551.6±34.6	559.9±30.8	543.9±54.7	546.5±31.1	-0.088	0.14
Paracentral superior	565.5±36.1	581.6±27.8	556.3±32.4	566.5±39.5	569.1±27.2	558.7±60.1	570.7±18.2	-0.058	0.31
Paracentral superior nasal	565.4±37.1	581.1±24.7	557±33.8	560.3±33.5	575.1±34.8	560.5±60.1	551.5±29.7	-0.164	0.04
Midperipheral (5-7mm)									
Midperipheral nasal	595.4±38.9	609.5±29.0	586.2±35.4	580.3±23.4	589.7±33.8	599.5±67.5	594.7±23.4	-0.076	0.19
Midperipheral inferior nasal	580.3±39.1	592.7±26.1	576.6±38.2	566.6±25.6	572.6±30.4	587.6±63	564.7±40.9	-0.143	0.01
Midperipheral inferior	572.0±41.6	584.1±33.4	565.4±41.7	549.7±39.0	559.7±32.1	575.2±70.9	571.8±36.9	-0.027	0.64
Midperipheral inferior temporal	550.4±42.0	568.2±37.0	548.3±232.4	532.5±42.8	543±34.1	543.8±68.1	528.8±45.9	-0.229	0.001
Midperipheral temporal	556.4±38.3	574.3±37.7	554.2±34.1	548.6±37.7	560.5±36.4	536.2±56	545.8±15.7	-0.134	0.03
Midperipheral superior temporal	579.2±43.7	594.8±38.1	570.9±39.9	581.1±44.3	592.3±27.1	565.3±53.6	570.3±62.3	-0.053	0.36
Midperipheral superior	601.6±53.6	613.8±35.0	591.5±47.1	606.5±62.4	603.7±66	586.9±82.5	620.7±70.8	0.068	0.24
Midperipheral superior nasal	590.1±58.0	608.5±33.1	589.4±41.5	591.3±47.9	572.7±59.2	592.1±85.4	564.8±78.5	-0.205	0.004
Minimum Thickness	499.3±55.3	521.6±42.5	493.0±66.6	496.8±37.9	494.1±33.2	462.6±90.2	487.5±32.8	-0.214	0.002
Maximum Thickness	614.8±45.4	623.26±37.1	598.9±36.1	609.2±57.7	630.4±34.5	610.3±71.8	650.5±38.9	0.0521	0.37
Median	559.5±34.6	576.0±26.8	554.2±31	550.7±29.5	558.5±30.1	554.7±57.6	554±12.6	-0.143	0.01

Note: Values in bold represent statistical significance

Table 5: Corneal thickness in different sectors in seven male groups according to age

Section	**Age-groups**							**Correlation with age**	
	10-20y	21-30y	31-40y	41-50y	51-60y	61-70y	> 70 y	r	p-value
Central (2mm)	531±36.1	557.2±25.4	526.9±36.4	531.7±24.9	547.3±29.1	517.8±36.1	536.7±69.6	-0.126	0.03
Paracentral (2-5mm)									
Paracentral nasal	555.5±37.4	580.8±27.0	548.8±30.5	548.3±24.9	567.4±23.2	536.5±42.8	564.3±73.9	-0.138	0.02
Paracentral inferior nasal	549.3±38.3	573.4±26.0	543.1±28.4	541.5±23.5	564.4±20.8	534.4±51.6	552.8±72.5	-0.162	0.005
Paracentral inferior	541±37.8	564.0±25.7	532.3±41	534.3±27.3	560.7±20.0	533.1±55.2	543.2±75.1	-0.112	0.05
Paracentral inferior temporal	532.2±36.4	555.5±25.5	526.3±35.4	528.0±28.5	551.9±22.1	523±48.6	536.7±71.6	-0.121	0.04
Paracentral temporal	533.5±35.6	556.6±25.3	528±32.3	533.1±29.5	549.8±25.2	521.7±36.9	540.3±70.2	-0.144	0.01
Paracentral superior temporal	545.5±36.0	573.5±27.0	542.2±30.5	551.6±34.6	562.1±30.4	534.2±33.4	557.3±74.8	-0.131	0.02
Paracentral superior	556.5±39.2	586.4±27.3	552.6±32.1	566.5±39.5	574.0±33.2	544±35.6	574±79.3	-0.087	0.13
Paracentral superior nasal	560.1±37.4	587.3±27.6	565.2±76.2	560.3±33.5	574.0±30.4	541±36.7	574.7±80.	-0.111	0.06
Midperipheral (5-7mm)									
Midperipheral nasal	593.7±40.7	612.7±32.6	579.8±28.1	580.3±23.4	597.9±20.1	576±60	605.7±69.6	-0.096	0.09
Midperipheral inferior nasal	578.8±42.7	599.7±29.3	570.6±25.4	566.6±25.6	585.1±12.5	555.4±57.8	586.8±72.1	-0.128	0.03
Midperipheral inferior	560.9±68.3	586.0±28.1	559.4±27.3	549.7±39.0	583.4±23.2	556.4±63.8	575±97.8	-0.073	0.21
Midperipheral inferior temporal	547.7±39.9	566.4±26.8	537.7±38	532.7±42.8	563.9±19.0	540.7±62.8	557.8±77.8	-0.084	0.15
Midperipheral temporal	551.1±36.2	570.6±30.8	546.1±29.5	548.6±37.7	565.9±26.1	546.6±37.1	565.7±70.8	-0.114	0.05
Midperipheral superior temporal	570.8±42.8	600.8±31.3	571±31.4	581.1±44.3	585.2±27.6	556.8±49.3	586.7±81.7	-0.114	0.05
Midperipheral superior	587.7±58.2	623.6±36.6	586.6±45.6	606.5±62.4	624.7±50.2	580.1±51.1	625±91.6	-0.033	0.58
Midperipheral superior nasal	591.2±42.2	621.3±33.2	583.9±34.5	591.3±47.9	613.7±32.1	565.1±52.2	615.2±92.1	-0.214	0.002
Minimum Thickness	506.2±44.3	531.9±37.0	497±53.3	496.8±37.9	515.3±31.3	479.2±39.5	519± 75	-0.151	0.009
Maximum Thickness	605.7±44.4	626.5±32.2	598±32.4	607.2±57.7	627.0±29.4	592.3±41.4	608.3± 93.1	-0.019	0.74
Median	555.5±36.6	578.9±26.0	549.3±27.9	550.8±29.5	570.7±22.4	539.8±44.1	565.8±78.1	-0.123	0.03

Note: Values in bold represent statistical significance and Iranian population (555.6 μm)[31] which were relatively higher compared to other ethnic groups. The CT of 801 eyes from various ethnic groups was measured by Aghaian E et al (2004)[8] and showed a mean thickness of 542.9 μm, slightly thicker than that of our study participants. In addition, we found that the CCT for our participants was lower than that of Chinese (555.6 μm), Caucasians (550.4 μm), Filipina (550.6 μm), Hispanics (548.1 μm) Iraqi citizens (543.9 μm), while more than that of Japanese (531.7 μm) and African Americans (521.0 μm).[8]

There was no significant association found between any zones of CT and gender and there is no significant variability of CT in any of the 17 sectors between right and left eye was noticed. The average paracentral T and paracentral IT sectoral thickness measurements were similar to the mean CCT-2mm zone measurement (CCT-2mm: 537.7±36.3μm Vs. paracentral T: 2-5mm: 538.7±37.2μm vs. paracentral IT 2-5mm: 537.9±38.0μm), whereas paracentral and midperipheral nasal and superior sectors were thicker than the paracentral and midperipheral inferior and temporal sectors. These findings of our study were highly consistent with the study conducted by Li Y et al (2010) showed that the average thickness from the pericentral temporal and inferior temporal zone corneal thickness were comparable with the mean central (1.7mm) thickness (central 1.7mm: 536.9 ± 27.0 μm Vs. pericentral T 2.4-5.7mm: 539.8 ± 27.9 μm Vs. paracentral IT 2.4-5.7mm: 538.3±28.6μm) while the pericentral nasal and superior sectors were significantly thicker than the inferior and inferior temporal sectors.[25] Similarly, SD-AS-OCT based studies have shown that superior and nasal quadrants were thicker than the inferior and temporal quadrants for both the paracentral and peripheral cornea.[22,31–34]

Our study found that the PCT and MPCT sectorial zones but not the central 2mm zone CT was negatively associated with age. Wang et al. (2013) also found no association between CCT and age whereas CT in the 4 to 10 mm diameter regions was negatively associated with the age in Chinese population ranging from 12 to 89 years old.[35] Furthermore, studies form western countries also showed an inverse relationship between age and paracentral and peripheral CT but no association between age and CCT was reported.[36–38] Compared to ultrasound pachymetry, SD-OCT provides greater reproducibility, enhanced precision, and less reliance on examiner expertise. It is crucial in detecting corneal diseases and assessing corneal parameters prior to surgery.[39,40] The CT data generated from healthy Saudi participants using SD-OCT assists eye-care specialists in comparing CT parameters to identify and diagnose corneal diseases, as well as preoperative management prior to any corneal surgical procedures.

5. Conclusion

In this study, CCT, PCT and MPCT values from 17 sectors within 7 mm of the central cornea in normal Saudi subjects of different age groups were characterized. However, the CT gradually increased from the central to mid-peripheral region, with the thickest CT in the superior and superior nasal regions, and the thinnest points mainly located in the temporal and inferior temporal sectors of the cornea. Our findings on sectoral CT serve as a useful normative reference database for decision-making regarding transepithelial ablation depths and assessment of corneal ectatic disorders for the Saudi population. A limitation of our study is that it was performed in a hospital setting and the study population was selected from individuals in need of ophthalmic care. Therefore, CT parameters are unlikely but may not be fully representative of the entire population. Moreover, this study recommends the evaluation of sectoral CT for the clinical diagnosis of corneal disease, as it shows typical patterns of variation in the general population.

6. Source of Funding

None.

7. Conflict of Interest

The author reports no conflicts of interest in this work.

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