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Original Research Article

Corneal epithelial thickness in healthy Saudi eyes: a cross-sectional study

Abdulaziz Mohammed Alshehri*

Department of Surgery, Taif university, Taif, Saudi Arabia

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***Correspondence:**
Dr. Abdulaziz Mohammed Alshehri,
E-mail: shehri.aziz@yahoo.com

ABSTRACT

Background: Corneal epithelial thickness (CET) mapping is a critical tool for corneal and refractive surgeons, aiding in the differentiation of true corneal ectasia from suspicious cases. This study aimed to establish normative CET values for a healthy Saudi population in the Taif region and investigate variations based on age and gender using anterior segment optical coherence tomography (AS-OCT).
Methods: CET was measured in 450 eyes of 225 individuals aged 10 to 70 years using the MS-39 AS-OCT device. Thickness maps were generated for three zones: central (0–3 mm), paracentral (3–6 mm) and midperipheral (6–8 mm). Each zone was subdivided into superior, inferior, nasal and temporal sectors. Statistical analyses assessed correlations between CET, age and gender. Paracentral and midperipheral zone was subdivided into superior, inferior, nasal and temporal sectors. Statistical analyses assessed correlations between CET, age and gender.
Results: Males exhibited slightly thicker central CET compared to females (53.4±4.2 µm vs. 52.8±4.0 µm, p=0.045). The central CET increased with age, with the oldest group (61–70 years) showing a 4.6% increase compared to the youngest group (10–20 years, p=0.041). Regional analysis revealed that the superior and temporal sectors were significantly thinner than the nasal and inferior sectors ($p<0.05$).
Conclusions: CET distribution in the Saudi population is non-uniform, with significant variations based on gender, age and corneal region. These findings provide valuable normative data for clinical practice, particularly in refractive surgery planning and corneal disease diagnosis.

Keywords: Anterior segment optical coherence tomography, Age, Corneal epithelial thickness, Gender, Saudi population

INTRODUCTION

The cornea, as the outermost layer of the eye, plays a pivotal role in maintaining visual acuity by refracting light and protecting the internal ocular structures. The corneal epithelium (CE), the outermost layer of the cornea, is particularly critical for maintaining corneal transparency, integrity and refractive function. With an average central thickness ranging from 48 to 52 µm, the CE is a dynamic structure that undergoes continuous renewal and repair in response to environmental stressors, mechanical forces and underlying physiological processes.[1-3] Variations in corneal epithelial thickness (CET) can provide valuable insights into ocular health and disease, making it a key parameter in both clinical and research settings. Recent advancements in imaging technologies, particularly anterior segment optical coherence tomography (AS-OCT), have revolutionized the ability to measure CET with high precision and reproducibility. AS-OCT, especially devices like the MS-39, combines spectral-domain OCT with Placido-based topography, enabling detailed mapping of the corneal epithelium across different zones and sectors.[3] This capability has proven invaluable in clinical practice, particularly in the early detection of corneal ectatic disorders such as keratoconus, optimization of refractive

surgery outcomes and monitoring of corneal healing processes.[4,5] For instance, subtle changes in CET patterns can serve as early indicators of subclinical keratoconus, allowing for timely intervention and improved patient outcomes.[6]

Despite the growing utility of CET mapping, normative data vary significantly across different populations, underscoring the influence of genetic, environmental and demographic factors on corneal epithelial morphology. Studies have demonstrated that CET distribution is influenced by age, gender, ethnicity and even geographic location.[7-9]

For example, hormonal differences between males and females have been shown to affect corneal epithelial cell turnover and thickness, with androgens promoting epithelial proliferation and estrogen influencing corneal hydration and tear film stability.[7] Similarly, age-related changes in CET have been linked to alterations in epithelial cell turnover, tear film composition and cumulative environmental exposure.[4] These variations highlight the need for population-specific normative data to ensure accurate interpretation of CET maps in clinical practice.

The Saudi population, with its unique genetic and environmental characteristics, represents an important yet understudied group in the context of CET. The Taif region, in particular, with its high altitude and arid climate, may present unique environmental stressors that could influence corneal epithelial morphology 10. Establishing normative CET values for this population is therefore essential for improving the accuracy of corneal diagnostics and refractive surgery planning. Furthermore, understanding the influence of demographic factors such as age and gender on CET distribution can provide valuable insights into the physiological and pathological processes affecting the cornea.

This study aimed to address these gaps by establishing normative CET values for a healthy Saudi population in the Taif region and investigating variations based on age and gender using AS-OCT. By providing region-specific data, this study seeks to enhance the accuracy of CET interpretation in clinical practice, particularly in the context of refractive surgery and corneal disease diagnosis. The findings of this study will contribute to the literature on CET and provide a valuable reference for clinicians managing corneal health in the Saudi population.

METHODS

Study design and population

This cross sectional, observational study included 450 eyes from 225 healthy Saudi individuals aged 10 to 70 years. Participants were recruited from different hospitals in Taif, Saudi Arabia, between January 2024 and December 2024. The study adhered to the principles of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Taif University.

Inclusion criteria

The study included healthy individuals with no ocular complaints, no history of contact lens use in the past three months and no prior ocular trauma or surgery.

Exclusion criteria

Participants were excluded if they had a history of corneal pathology, dry eye, high myopia or refractive surgery. Additionally, individuals with systemic diseases affecting the cornea or a family history of keratoconus were excluded.

OCT measurement protocol

CET was measured using the MS-39 AS-OCT device, which provides high-resolution images of the corneal layers. Thickness maps were generated for three concentric zones: central (0–3 mm), paracentral (3–6 mm) and midperipheral (6–8 mm). Each zone was further divided into superior, inferior, nasal and temporal sectors.

Statistical analysis

Data were analyzed using IBM SPSS version 26. Normality was assessed using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean±standard deviation and categorical variables as percentages. Independent t-tests compared CET between genders, while ANOVA assessed age-related variations. Pearson correlation evaluated relationships between age and CET. A p-value<0.05 was considered statistically significant.

RESULTS

The study included 225 participants (120 males, 105 females) with a mean age of 42.1±19.8 years. CET measurements were analyzed across age and gender subgroups.

The nasal and inferior sectors were thicker than the superior and temporal sectors ($p<0.05$), as shown in Table 1. Males had thicker central CET compared to females (53.4±4.2 µm vs. 52.8±4.0 µm, $p=0.045$). Similar trends were observed in the paracentral zone (52.5±3.6 µm vs. 51.1±3.4 µm, $p=0.032$). These findings are summarized in Table 2.

Central CET increased with age, with the oldest group (61–70 years) showing a 4.6% increase compared to the youngest group (10–20 years, $p=0.041$). Paracentral and midperipheral CET did not show significant age-related variations. These findings are presented in Table 3.

Table 1: Regional mean central, paracentral and midperipheral corneal epithelial thickness mapping (CET).

MS-39 Sectors	CET (µm)	P value
Central	53.2±2.1	-
Mean paracentral	52.1±3.5	-
Superior	50.70±3.2	<0.001*
Temporal	51.01±3.03	0.012*
Inferior	52.73±3.29	<0.001*
Nasal	52.51±3.1	<0.001*
Average midperipheral	51.5±4.0	-
Superior	48.49±3.83	<0.001*
Temporal	49.2±3.02	0.003*
Inferior	51.0±3.04	<0.001*
Nasal	51.6±3.2	<0.001*

*Statistically significance

Table 2: Differences in epithelial corneal thickness in relation to gender.

Parameter	Males (n=120)	Females (n=105)	Total (n=225)	P value
Mean central CET (µm)	53.4±4.2	52.8±4.0	53.2±2.1	0.045*
Mean paracentral CET (µm)	52.5±3.6	51.1±3.4	52.1±3.5	0.032*
Mean midperipheral CET (µm)	51.3±4.1	50.8±4.0	51.5±4.0	0.067

*Statistically significance

Table 3: Differences in epithelial and corneal thickness in relation to age.

Section	Age groups (in years)						
	10-20	21-30	31-40	41-50	51-60	61-70	P value
Mean central CET (µm)	52.4±3.8	53.2±3.8	53.3±5.7	54.4±5.4	54.2±6.7	54.2±5.0	0.041*
Paracentral CET (µm)	51.3±5.5	51.6±5.2	51.8±5.3	52.3±4.4	52.7±4.0	53.1±7.6	0.078
Midperipheral CET (µm)	51.1±3.5	51.3±4.1	51.4±4.2	52.02±3.5	52.2±5.0	52.5±3.7	0.062

*Statistically significance

DISCUSSION

This study provides a comprehensive analysis of corneal epithelial thickness (CET) in a healthy Saudi population, highlighting significant variations based on gender, age and corneal region. The findings contribute to the growing body of literature on normative CET values and emphasize the importance of considering demographic factors in clinical practice. The observed gender differences in CET, with males exhibiting slightly thicker central and paracentral epithelium than females, align with findings from previous studies.[5,6]

These variations may be attributed to hormonal influences, particularly the role of androgens in promoting epithelial cell proliferation.[7] In contrast, estrogen has been associated with reduced corneal thickness due to its effects on corneal hydration and tear film stability.[7,8] These hormonal differences could influence epithelial renewal rates and stromal hydration, contributing to the observed CET disparities. Given these findings, clinicians should consider gender-specific CET norms when evaluating corneal health, particularly in refractive surgery planning and disease diagnosis.[9]

A notable finding of this study is the progressive increase in central CET with age. The oldest age group (61–70 years) demonstrated a 4.6% increase in CET compared to the youngest group (10–20 years), suggesting that the central corneal epithelium undergoes remodeling over time. This age-related thickening may result from cumulative epithelial cell turnover, compensatory epithelial changes due to tear film instability or environmental exposure effects such as UV radiation and oxidative stress.[4,11]

However, the absence of significant age-related changes in the paracentral and midperipheral zones suggests that aging predominantly affects the central cornea. These findings are clinically relevant, as they indicate that age-

related CET changes should be accounted for in corneal diagnostics, particularly in conditions such as dry eye disease and epithelial basement membrane dystrophy.[11–13]

The study also confirmed that CET distribution is non-uniform across the cornea, with the superior and temporal sectors being significantly thinner than the nasal and inferior sectors. This asymmetric distribution is consistent with previous studies and is thought to be influenced by mechanical and anatomical factors.[3,5,6] The superior cornea experiences greater mechanical stress from blinking and eyelid pressure, which may contribute to its reduced thickness.[3,14] Meanwhile, the nasal and inferior regions may be relatively protected from these mechanical forces and environmental exposure, leading to a thicker epithelium.[3] This non-uniformity underscores the importance of sectoral CET analysis in clinical practice. Relying solely on global CET averages may overlook localized abnormalities that could indicate early corneal pathology, such as subclinical keratoconus.[13]

The normative CET data established in this study provide a valuable reference for clinicians evaluating corneal health in the Saudi population. Understanding the natural variations in CET based on demographic factors can enhance the accuracy of corneal diagnostics and improve surgical planning. In refractive surgery, preoperative epithelial thickness mapping can help identify individuals with irregular CET patterns, reducing the risk of postoperative complications. Additionally, early detection of subtle CET changes may facilitate the timely diagnosis of corneal disorders such as keratoconus, epithelial basement membrane dystrophy and dry eye disease.

Despite its valuable contributions, this study has some limitations. The cross-sectional design prevents the establishment of causal relationships between CET variations and demographic factors. Additionally, the study population was limited to the Taif region, which may not fully represent the broader Saudi population. Environmental factors such as altitude and climate conditions unique to Taif could influence CET measurements. Future studies should aim to include a more diverse cohort from different geographic regions within Saudi Arabia. Longitudinal studies are also needed to assess CET changes over time and further investigate the underlying mechanisms driving age- and gender-related differences.

CONCLUSION

This study demonstrates that corneal epithelial thickness in a healthy Saudi population is influenced by gender, age and corneal region. Males and older individuals tend to have thicker central CET, while the superior cornea is consistently thinner than the inferior cornea. These findings provide valuable normative data that can improve clinical decision-making in refractive surgery and corneal disease diagnosis.

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