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Original Research Article

Corneal endothelial changes in myopic adults: A cross-sectional study

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Abstract

Background: Myopia significantly impacts various ocular structures, with the corneal endothelium being one of the least studied aspects in past research. The Aim of this study is to analyse corneal endothelial cell parameters: Endothelial Cell Density (ECD), Hexagonality (HEX), Coefficient of Variation (CV), and Average Cell Size (AVG) and to study correlation between ECD and axial length (AL) in young myopes presenting to tertiary hospital in urban western Maharashtra.

Methods: A cross-sectional observational study was conducted on 132 myopic eyes of patients aged 18-30 years. Myopes were then categorised into: mild, moderate, and severe grade with 44 eyes in each group. Age and gender matched emmetropic patient's 132 eyes were included as control group. ECD, HEX, CV, and AVG of corneal endothelium were assessed via specular microscopy (non-contact) and AL was determined using optical biometry in all participants.

Results: In myopic eyes, there was reduction in ECD (2817.53 cells/mm²), a lower HEX (54.05%), alongside a rise in CV (33.39%) and AVG (331.48 cells/mm³) when compared to emmetropic eyes, with a statistically significant difference ($p < 0.001$). As the degree of myopia increases from mild to severe grade, both ECD and HEX showed a significant statistical decrease ($p < 0.001$), while CV and AVG increased with ($p < 0.001$). A statistically significant negative correlation was observed between ECD and AL in myopic eyes ($r = -0.482$, $p < 0.05$).

Conclusion: Alterations in the characteristics of corneal endothelial cells have been observed in individuals with myopia. Hence, we recommend routine evaluation of corneal endothelium in myopic patients.

Keywords: Corneal endothelium, Myopia, Endothelial cell density, Hexagonality, Coefficient of variation, Average cell size, Axial length.

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1. Introduction

The corneal endothelium plays an important role in maintaining corneal transparency.[1,2] Endothelial cells have a hexagonal shape and do not regenerate.[3] Myopia is a common refractive error among teenagers and young adults in Asia, particularly in East Asia, where the prevalence is exceptionally high—reported to be 70–90%.[4] Myopia leads to serious complications such as myopic maculopathy, posterior staphyloma, retinal detachment, choroidal neovascularization, lattice degeneration, retinal tears, and optic nerve changes like tilted optic disc.[5]

While posterior segment complications of myopia have been extensively studied, less attention has been given to its effects on the anterior segment, specifically the corneal endothelium. Myopia also influences the corneal endothelium, but there are only a few studies that have investigated this. Several studies,[1,3,6,7] have indicated association between high myopia and reduced endothelial cell density, along with abnormal endothelial morphology. However, other studies have found no significant changes in these parameters.[8,9]

Myopic undergo different refractive procedures like PRK, LASIK, and phakic intraocular lens implantation. Some studies have reported that LASIK and phakic IOL

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implantation are associated with corneal endothelial cell loss.[10,11]

Limited studies have evaluated corneal endothelial parameters across varying degrees of myopia. Additionally, contradictory findings exist regarding the correlation between myopia severity and endothelial changes, with some studies suggesting significant alterations while others report minimal or no association.

Due to the conflicting results among various studies on the corneal endothelium in myopic patients, this research focuses on evaluating corneal endothelial characteristics such as Endothelial Cell Density (ECD), Hexagonality (HEX), Coefficient of Variation (CV), and Average Cell Size (AVG) in young myopic individuals and also to study correlation between ECD and axial length (AL) in myopia.

2. Aim

To analyse corneal endothelial cell parameters (ECD, HEX, CV, and AVG) in young myopic adults.

3. Objective

1. To evaluate endothelial cell density (ECD), hexagonality (HEX), coefficient of variation (CV), and average cell size (AVG) in myopic and emmetropic adults.
2. To compare endothelial parameters across mild, moderate, and severe myopia.
3. To assess the correlation between axial length and endothelial cell density in myopes.

4. Materials and Methods

4.1. Study design and participants

This cross-sectional analytical study was conducted in the Department of Ophthalmology, Bharati Vidyapeeth Medical College and Hospital, Pune, Maharashtra, over the period from November 2022 to January 2024. After securing approval from the institutional ethics committee, a convenience sample of 132 eyes from myopic patients and 132 eyes from emmetropic (control) patients, with one eye per patient aged 18–30 years, was included in the study. Based on spherocylindrical equivalent (SE), the myopic patients were categorized into three groups: mild (-0.5 to -3.00 D), moderate (-3.00 to -6.00 D), and severe (>-6.00 D) myopia, with 44 eyes in each group.

4.2. Inclusion criteria

1. Myopes and emmetropes (controls) in the age and gender matched group of 18-30 years.

4.3. Exclusion criteria

1. Ocular pathologies affecting endothelial cell counts such as corneal pathologies, glaucoma, uveitis, ocular tumour and trauma.
2. History of intraocular or refractive surgery, lasers.
3. History of contact lens use.
4. Diabetes mellitus.

4.4. Data collection

Participants underwent a comprehensive ophthalmic evaluation, including auto refractometry, visual acuity measurement, slit-lamp examination, fundus examination. Corneal endothelial cell parameters were assessed using specular microscope (non-contact) (TOPCON SP-1P) using in built software with centre mode. Average of three successive reading were taken for ECD, HEX, CV, AVG. AL was measured using optical biometry (TOPCON ALADDIN HW3.0).

4.5. Statistical analysis

The statistical analysis for this study was conducted using SPSS software version 28.0. Descriptive statistics were employed to represent the results of all quantitative variables. To compare endothelial parameters between emmetropic and myopic subjects, an unpaired t test was utilized. To compare axial length and endothelial parameters between the control and myopic groups correlation coefficient was used, significance level of 5% was used throughout the analysis, with a p-value below 0.05.

5. Results

The study involved the right eye of 132 myopic patients (44 mild, 44 moderate, and 44 severe) and 132 emmetropic patients. Each group consisted of 59 males and 73 females. The mean age of participants in myopic group was 25.58 ± 2.32 years and emmetropic group was 25.33 ± 2.46 years. Mean ages in mild, moderate and severe groups were 25.07 ± 2.54 years, 26.05 ± 1.94 years, and 25.64 ± 2.41years, respectively. The average grade of myopia for mild was -1.59 ± 0.60D, moderate was -3.84 ± 0.74D and severe myopia was -7.50 ± 2.09D. The descriptive statistics are summarized in **Table 1**.

The results of the comparison of corneal endothelial parameters between all myopes and emmetropes are provided in **Table 2**.

Comparison of corneal endothelial parameters among mild, moderate, severe myopes with emmetropes, the results are summarized in **Table 3**.

Correlation between ECD and axial length using pearson correlation in emmetropes and myopes as shown in **Figure 1** and **Figure 2**.

Specular microscopy figure of emmetrope in **Figure 3** and severe myope in **Figure 4**.

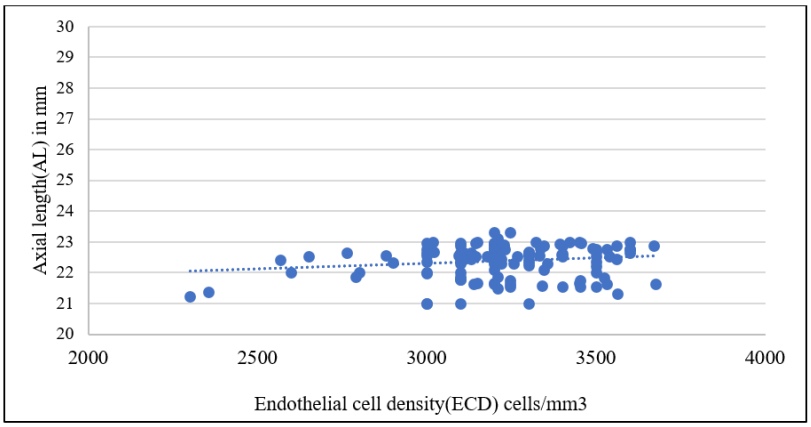

Figure 1: Correlation of endothelial cell density and axial length in emmetropes

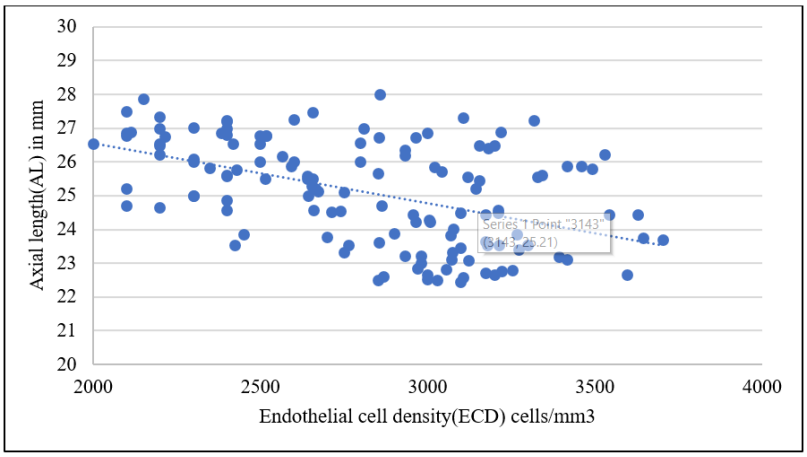

Figure 2: Correlation of endothelial cell density and axial length in myopes

Figure 3: Specular microscopy in emmetropes

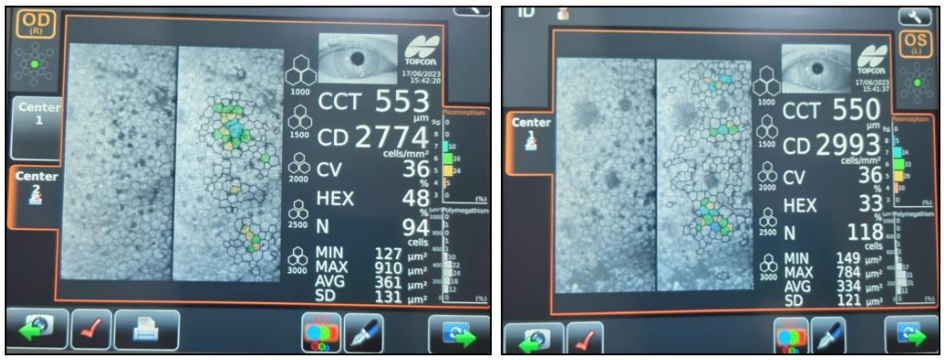

Figure 4: Specular microscopy in myopes (severe)

Table 1: Descriptive statistics

Endothelial Parameters	Grades	Min	Max	Mean ± SD
ECD (cells/mm2)	Total Myopes	2000	3704	2817.53±413.75
	Mild	2424	3704	3073.27±301.7
	Moderate	2100	3531	2782.34±380.98
	Severe	2000	3459	2596.98±417.57
	Emmetropes	2300	3657	3220.61±236.62
HEX (%)	Total Myopes	40	76	54.05±7.18
	Mild	45	76	58.07±6.85
	Moderate	40	68	53.57±6.43
	Severe	40	67	50.50±6.08
	Emmetropes	44	72	60.86±6.42
CV (%)	Total Myopes	23	40	33.39±3.52
	Mild	23	40	32.02±4.07
	Moderate	27	39	33.98±3.15
	Severe	25	39	34.16±2.87
	Emmetropes	22	37	30.84±2.95
AVG (μm^2)	Total Myopes	203	398	331.48±33.88
	Mild	270	398	327.39±30.04
	Moderate	250	389	332.50±35.47
	Severe	203	397	334.57±36.81
	Emmetropes	210	359	298.81±35.34

ECD: Endothelial cell density, HEX: Hexagonality, CV: Coefficient of variation and AVG: Average cell size

Table 2: Comparison of corneal endothelial parameters between total myopes and emmetropes

Endothelial Parameters	Mean difference	T statistic	P value
ECD (cells/mm2)	-403.08	9.7159	<0.001
HEX (%)	-6.82	8.1295	<0.001
CV (%)	2.55	6.3634	<0.001
AVG (μm^2)	32.67	7.6665	<0.001

P value calculated using unpaired T test*;* ECD: Endothelial cell density, HEX-Hexagonality, CV: Coefficient of variation; AVG- Average cell size

Table 3: Comparison of corneal endothelial parameters among mild, moderate, severe myopes with emmetropes

Endothelial Parameters	Groups	Mean Difference	Std. Error	p-value
ECD	Mild vs. Emmetrope	-147.333	53.642	0.039
	Moderate vs. Emmetrope	-438.265	53.642	<0.001
	Severe vs. Emmetrope	-623.629	53.642	<0.001
HEX	Mild vs. Emmetrope	-2.795	1.127	0.082
	Moderate vs. Emmetrope	-7.295	1.127	<0.001
	Severe vs. Emmetrope	-10.364	1.127	<0.001
CV	Mild vs. Emmetrope	1.182	0.555	0.205
	Moderate vs. Emmetrope	3.136	0.555	<0.001
	Severe vs. Emmetrope	3.318	0.555	<0.001
AVG	Mild vs. Emmetrope	28.576	6.039	<0.001
	Moderate vs. Emmetrope	33.689	6.039	<0.001
	Severe vs. Emmetrope	35.758	6.039	<0.001

P value calculated using ANOVA test; ECD: Endothelial cell density, HEX: Hexagonality, CV: Coefficient of variation and AVG: Average cell size

6. Discussion

The corneal endothelium maintains transparency and regulates stromal hydration through active metabolic pumps that continuously remove fluid from the stroma.[2] Human corneal endothelial cells exhibit minimal to no mitotic activity after birth, limiting their ability to regenerate.[12,13] The primary goal of this study is to evaluate the corneal endothelium in myopic adults and determine if there are any changes in endothelial cell parameters in myopic eyes. Using convenience sampling, we selected an equal number of patients in each grade of myopia, which prevents us from commenting on prevalence.

In the present study, we selected a fixed age group of 18-30 years to avoid the confounding effects of age, as the maximum progression of myopia typically occurs during this period. Additionally, individuals in this age group are more likely to undergo refractive surgeries, which could affect the corneal endothelium.

Our study found a mean ECD of 2817.53 cells/mm² in myopes, compared to 3220.61 cells/mm² in emmetropes aged 18-30 years. A similar study on the Indian population in the same age group reported ECD values of 2812.80 cells/mm² in emmetropes and 2653 cells/mm² in myopes.[6] This study found significant decrease in ECD in myopes (2817.53 cells/mm²) compared to emmetropes (3220.61 cells/mm²), both statistically significant ($p < 0.001$). ECD also declined with increasing myopia severity ($p < 0.001$), though all values remained within the normal range. Upon examining different levels of myopia, we observed that mild, moderate, and severe myopes showed significantly lower ECD compared to emmetropes ($p < 0.001$). Similar reductions in ECD among myopes have been reported in other studies.[1,3,6,7] Several studies found no significant ECD reduction.[2,8,9,14] The Japanese study by Aketa et al also reported no significant association. This could be attributed to the study's specific population of Japanese adults aged 40 years or older, limiting the generalizability to other ethnic groups. Additionally, despite adjustments for confounders, unmeasured factors might still have affected the results. A study conducted on young Sudanese individuals with myopia found no statistically significant differences in ECD across varying degrees of myopia.[9] The authors noted that the sample size and distribution were disproportionate, with a higher number of patients having low myopia compared to those with moderate and high myopia, which may have introduced bias into the results. Maqsood et al. found no significant relationship in endothelial cell density (ECD) between mild to moderate myopic eyes.[8] This lack of significance was attributed to several factors: the study was conducted exclusively on females, the sample size was small, and some participants occasionally wore contact lenses, which may have influenced the results. Sheng et al.[2] found no significant effect of myopia on ECD, possibly due to the uneven age distribution and limited racial diversity in the sample. Additionally, reliance on self-reported contact lens wear may have introduced bias, as the study only considered wear duration, without accounting for lens types, schedules, or care compliance, all of which could affect corneal endothelial morphology.

In myopic eyes, we found a strong negative correlation between axial length and ECD ($r = -0.482$, $p < 0.05$), showing that as axial length increases, ECD decreases. This highlights the effect of axial length on endothelial cell density. Since endothelial cells can't divide after birth, they flatten to cover the larger corneal surface, resulting in reduced ECD.[3,6]

HEX is a key indicator of the percentage of hexagonal cells in the endothelium, reflecting the regularity and health of the endothelial layer. A normal HEX should exceed 60%; lower values lead to pleomorphism, impairing endothelial function.[15] In this study, the mean HEX value in myopes was 54.05%, which was below normal limits and was statistically significantly lower compared to emmetropes ($p < 0.001$). We also observed a statistically significant decrease in HEX values from mild to severe grades of myopia ($p < 0.001$), indicating heightened cellular stress. However, when comparing mild myopes to the emmetropic group, the result was not statistically significant ($p = 0.082$). A possible explanation for this could be that as corneal endothelial cells have limited mitotic activity after birth, they flatten to cover the expanded surface due to the elongation of the eyeball in myopia, leading to increased cell shape variability (polymorphism). Similar results of low HEX among myopes have been reported by various studies,[1,5,14] while some have reported no significant change.[2,3,8] A study by Chang et al. found no statistically significant correlation between the severity of myopia and HEX, which they attributed to an uneven participant distribution and improper group segmentation.[3]

Our study found that myopes exhibited lower ECD and HEX which has important clinical implications like increase risk of corneal decompensation, higher risk of endothelial decompensation post-surgery especially after phacoemulsification or ICL implantation. Many myopes rely on contact lenses which may further stress an already compromised endothelium, increasing risk of hypoxia induced endothelial cell loss over time. Additionally, axial elongation in high myopes weaken the endothelium further, increasing susceptibility to ectasia like changes.

The Coefficient of variation (CV) indicates variability in endothelial cell size and should be normally below 40.[16] In this study, myopes had a mean CV of 33.39%, significantly higher than emmetropes ($p < 0.001$). CV increased with the severity of myopia ($p < 0.001$), though the difference between mild myopes and emmetropes was not significant ($p = 0.205$). All CV values in myopes remained within the normal range, consistent with other studies, although some reported no significant CV increase in myopes.[2,3]

The Average cell size (AVG) of corneal endothelial cells is crucial for evaluating endothelial health, with normal sizes ranging from 300–400 µm².[17] An increase in AVG may indicate cell loss, where remaining cells enlarge to cover the corneal surface, a condition known as Polymegathism. In this study, myopes had a mean AVG of 331.48 µm², significantly higher than emmetropes ($p < 0.001$). Statistically significant differences were found when comparing AVG across different myopia grades and with emmetropes ($p < 0.001$). No prior studies have specifically examined AVG in myopes.

7. Limitations

This is conducted on specific hospital-based population and within a particular age group of 18-30 years.

8. Conclusion

This study demonstrates significant differences in corneal endothelial parameters between myopic and emmetropic individuals. Myopic eyes exhibit lower endothelial cell density (ECD) and hexagonality (HEX), along with increased coefficient of variation (CV) and average cell size (AVG). Although ECD, CV, and AVG remained within normal ranges among myopes, HEX was lower than normal. These changes become more pronounced as myopia severity increases. Additionally, a negative correlation between axial length and ECD highlights the impact of axial elongation on endothelial morphology.

Given these findings, routine assessment of corneal endothelial parameters should be considered for myopic individuals, particularly those with moderate to severe myopia, as they may be at higher risk of endothelial alterations, and for individuals considering refractive surgeries such as phakic intraocular lens implantation.

9. Source of Funding

None.

10. Conflicts of Interest

None.

11. Ethical Approval

Ethical No.: BVDUMC/IEC/102.

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