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Research Article

Macular Thickness among Different Refractive States (Emmetropia, Myopia, and Hypermetropia): An Optical Coherence Tomography-Based Comparative Study

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ABSTRACT

Background: Refractive errors are among the most common causes of visual impairment worldwide and may influence retinal morphology, particularly macular thickness. Optical Coherence Tomography (OCT) provides a reliable and non-invasive method for quantitative assessment of retinal architecture.

Objective: To compare macular thickness among emmetropic, myopic, and hypermetropic individuals using OCT and evaluate the association between refractive error severity and retinal thickness.

Methods: A hospital-based analytical study was conducted in the Department of Ophthalmology, Jawaharlal Nehru Medical College, Ajmer, Rajasthan, from June 2024 to May 2025. A total of 180 participants were enrolled and equally divided into emmetropic (n=60), myopic (n=60), and hypermetropic (n=60) groups. All subjects underwent visual acuity assessment, refraction, fundus examination, and OCT evaluation. Mean macular thickness and central retinal thickness were compared among groups.

Results: Mean macular thickness was significantly lower in myopic eyes (279 ± 8.17 µm) compared with emmetropic (291 ± 1.49 µm) and hypermetropic eyes (294 ± 1.49 µm) ($p<0.001$). Similarly, central retinal thickness was lowest in myopic eyes (235 ± 13.6 µm) compared with emmetropic and hypermetropic eyes (246 ± 3.0 µm and 246 ± 3.24 µm, respectively) ($p<0.001$). Increasing myopia was associated with progressive retinal thinning.

Conclusion: Refractive status significantly influences OCT-derived macular thickness measurements. Myopic eyes demonstrate reduced macular and central retinal thickness, while hypermetropic eyes tend to show relatively thicker retinal architecture. Consideration of refractive status is essential for accurate interpretation of OCT findings.

Keywords: Optical Coherence Tomography, Macular Thickness, Myopia, Hypermetropia, Emmetropia, Refractive Error.

INTRODUCTION

Refractive errors are among the most common ocular disorders worldwide and represent a major cause of visual impairment. They occur when incoming light rays fail to focus accurately on the retinal plane, resulting in blurred vision and reduced visual performance. According to the World Health Organization, uncorrected refractive error remains the leading cause of visual impairment globally despite the availability of effective corrective measures (1–4).

Refractive errors are broadly classified into myopia, hypermetropia, astigmatism, and presbyopia. Myopia results from excessive axial elongation of the eyeball, causing light rays to

focus anterior to the retina. Hypermetropia occurs when the axial length is relatively shorter than normal, resulting in posterior displacement of the focal point. These refractive abnormalities not only affect visual acuity but may also influence retinal morphology and posterior segment anatomy (5,6).

The macula is the central region of the retina responsible for high-resolution central vision and color perception. Structural alterations within the macula may significantly affect visual function. Anatomical variations associated with different refractive states have been shown to influence retinal thickness measurements, particularly in the macular region. Myopic eyes generally demonstrate retinal stretching secondary to axial elongation, whereas hypermetropic eyes tend to possess a relatively compact retinal architecture (6).

Traditionally, retinal thickness assessment relied on slit-lamp biomicroscopy, stereoscopic photography, and fluorescein angiography. However, these techniques provide limited quantitative information and may fail to detect subtle structural changes. Previous studies have demonstrated that retinal thickness correlates more closely with visual function than the mere presence of retinal edema (8–11).

The introduction of Optical Coherence Tomography (OCT) has revolutionized retinal imaging by enabling high-resolution, cross-sectional visualization of retinal layers in a rapid and non-invasive manner. OCT allows accurate measurement of retinal and macular thickness and has become an indispensable tool in modern ophthalmology (7).

Several studies have reported that OCT-derived retinal measurements are significantly influenced by refractive error and axial length. Retinal nerve fiber layer thickness, macular thickness, and other retinal parameters may vary according to refractive status. Consequently, understanding physiological variations in retinal thickness among emmetropic, myopic, and hypermetropic eyes is important to avoid diagnostic errors and improve clinical interpretation of OCT findings (8).

METHODS

Study Design and Setting

A hospital-based analytical observational study was conducted in the Department of Ophthalmology, Jawaharlal Nehru Medical College, Ajmer, Rajasthan, India. The study was carried out from June 2024 to May 2025 after obtaining approval from the Institutional Ethics Committee.

Study Population

A total of 180 participants aged 10–40 years were enrolled and categorized into three equal groups:

- Group A: Emmetropia (n=60)
- Group B: Myopia (n=60)
- Group C: Hypermetropia (n=60)

Patients diagnosed with emmetropia, myopia, or hypermetropia who provided informed consent were included in the study.

Inclusion Criteria

- Diagnosed cases of emmetropia, myopia, and hypermetropia
- Age between 10 and 40 years
- Willingness to provide informed consent

Exclusion Criteria

- Retinal diseases, glaucoma, or other ocular pathology
- Previous ocular surgery
- Contact lens users
- Diabetes mellitus, uncontrolled hypertension, or autoimmune disorders

Ophthalmic Evaluation

All participants underwent detailed ophthalmic examination including:

- Best-corrected visual acuity (BCVA)
- Auto-refraction
- Cycloplegic retinoscopy
- Subjective refraction
- Slit-lamp examination
- Fundus examination
- Optical Coherence Tomography (OCT)

Macular thickness (MT) and central retinal thickness (CT) were recorded using OCT.

Statistical Analysis

Data were analyzed using SPSS version 26. Quantitative variables were expressed as mean ± standard deviation and qualitative variables as frequency and percentage. Intergroup comparisons were performed using Student's t-test, Chi-square test, and ANOVA. A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

A total of 180 participants were included in the study. Gender distribution was comparable among groups (p=0.258). Mean age was 24.1 ± 8.15 years in emmetropic subjects, 21.6 ± 7.10 years in myopic subjects, and 24.0 ± 8.61 years in hypermetropic subjects (p=0.131).

Table 1. Demographic Characteristics

Variable	Emmetropia	Myopia	Hypermetropia	P value
Male (%)	58.3	43.3	51.7	0.258
Female (%)	41.7	56.7	48.3	
Mean Age (years)	24.1 ± 8.15	21.6 ± 7.10	24.0 ± 8.61	0.131

Table 2. Refractive Status

Parameter	Emmetropia	Myopia	Hypermetropia	P value
Auto-refraction (D)	-0.087 ± 0.194	-2.66 ± 2.32	+2.79 ± 1.45	<0.001
Subjective Refraction (D)	0.00 ± 0.00	-2.15 ± 2.32	+2.20 ± 1.47	<0.001

All emmetropic participants demonstrated BCVA of 6/6. Reduced visual acuity was observed predominantly among myopic and hypermetropic subjects.

Table 3. Macular Thickness Measured by OCT

Group	Mean MT (µm)	SD
Emmetropia	291	1.49
Myopia	279	8.17
Hypermetropia	294	1.49

ANOVA p <0.001

Table 4. Central Retinal Thickness Measured by OCT

Group	Mean CT (µm)	SD
Emmetropia	246	3.0
Myopia	235	13.6
Hypermetropia	246	3.24

ANOVA p <0.001

The myopic group demonstrated significantly lower macular and central retinal thickness than the emmetropic and hypermetropic groups.

Table 5. Relationship between Severity of Refractive Error and OCT Measurements

Refractive Group	Subgroup	Central Thickness (µm)	Macular Thickness (µm)
Myopia	0 to -3D	240.73 ± 13.7	282.2 ± 8.16
Myopia	>-3D	217.9 ± 13.9	268.85 ± 8.8
Hypermetropia	0 to +3D	244.7 ± 3.2	293.9 ± 1.48
Hypermetropia	>+3D	250.2 ± 3.5	294.2 ± 1.41

Increasing myopia was associated with significant reduction in macular thickness ($p<0.001$), whereas increasing hypermetropia did not significantly affect macular thickness ($p=0.543$).

DISCUSSION

The present study evaluated macular thickness among emmetropic, myopic, and hypermetropic individuals using Optical Coherence Tomography. OCT has emerged as an important imaging modality for quantitative assessment of retinal architecture and has improved understanding of structural changes associated with refractive errors (13,14).

Visual acuity findings revealed normal BCVA among emmetropic subjects, whereas reduced visual acuity was more common in myopic and hypermetropic participants. Similar observations have been reported by Lim et al. and Lam et al., who demonstrated that refractive error significantly influences retinal morphology and visual performance (13,14).

Fundus examination findings were predominantly normal across all groups. However, a small proportion of myopic eyes demonstrated tessellated fundus changes, indicating retinal and choroidal alterations associated with axial elongation. Previous studies have shown that progressive myopia is accompanied by structural retinal remodeling that may influence OCT-derived retinal measurements (13,14).

The principal finding of the present study was the significant variation in macular thickness among different refractive states. Mean macular thickness was lowest in myopic eyes and highest in hypermetropic eyes. These findings are consistent with the observations of Salehi et al., Choudhary et al., and Raja et al., who reported significant differences in retinal thickness among various refractive groups (9,10,12).

Myopic eyes demonstrated significantly thinner macular architecture than emmetropic eyes. Lim et al. and Lam et al. similarly reported reduced retinal thickness in myopic eyes, attributing these findings to retinal stretching secondary to axial elongation (13,14). Structural expansion of the globe results in redistribution and thinning of retinal tissues, particularly in the posterior pole.

Central retinal thickness also differed significantly among groups. The myopic group demonstrated the lowest mean central retinal thickness, whereas emmetropic and hypermetropic groups showed comparable values. These findings agree with those reported by Yau et al., who observed significant differences in OCT-derived central macular thickness among myopic, emmetropic, and hypermetropic eyes (15).

The present study further demonstrated that increasing severity of myopia was associated with progressive reduction in both central retinal thickness and macular thickness. Eyes with refractive error greater than −3D exhibited significantly thinner retinal measurements than eyes with lower degrees of myopia. These observations support the concept that retinal thinning progresses with increasing axial elongation and severity of myopia (15).

CONCLUSION

Macular thickness varies significantly among different refractive states. Myopic eyes demonstrate significantly lower macular thickness and central retinal thickness compared with emmetropic and hypermetropic eyes. Hypermetropic eyes tend to exhibit relatively thicker retinal architecture.

Increasing myopia is associated with progressive retinal thinning, whereas hypermetropia does not appear to significantly influence macular thickness. Refractive status should therefore be considered when interpreting OCT findings in clinical practice.

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