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**Dr. Farhat Abrar**
Associate Professor, Department of Ophthalmology, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

**Dr. Juhi Garg**
JR-3, Department of Ophthalmology, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

**Dr. Shashwat Singh**
JR-3, Department of Ophthalmology, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

**Dr. Kainat Chaudhary**
JR-3, Department of Ophthalmology, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

**Corresponding Author:**
**Dr. Juhi Garg**
JR-3, Department of Ophthalmology, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India

# Choroidal thickness in patients with different refractive status measured by spectral-domain optical coherence tomography

**Dr. Farhat Abrar, Dr. Juhi Garg, Dr. Shashwat Singh and Dr. Kainat Chaudhary**

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**Abstract**
**Aim:** To evaluate the choroidal thickness in patients with different refractive status measured by spectral-domain optical coherence tomography.
**Material and methods:** This cross-sectional observational study consisted of 60 subjects, who visited the out-patient department of Ophthalmology, Chattrapati Shivaji Subharti Hospital, Meerut, India and were randomly selected over a period of 1 year. Subjects were classified into three groups based on refractive error: those with a +1 diopter or greater refractive power were assigned to the hyperopia group; those with a diopter lower than +1 and greater than –1 were assigned to the emmetropia group; and those with a –1 diopter or lower diopter were assigned to the myopia group. All patients underwent a clinical history taking and a complete ophthalmic examination. OCT scanning was performed using Optovue RTvue 100 which utilises spectral domain (SD)-OCT. The choroid was visualized by enhanced depth imaging (EDI) technique. Choroidal scans were obtained for all the eyes using enhanced depth imaging (EDI) using spectral-domain optical coherence tomography (SD-OCT). Data was recorded in excel sheet and subjected to statistical analysis.
**Results:** Compared to emmetropic participants, myopic subjects had significantly thinner choroid in all the regions. Choroid of hyperopic subjects was significantly thicker than that of emmetropic subjects in most regions. Linear correlation testing revealed a close correlation between refractive error and choroidal thickness in all of the regions.
**Conclusion:** High myopes have significantly thinner choroids than the emmetropic controls at all the retinal points studied, with the thinnest choroid at 1.5 mm nasal to the fovea.

**Keywords:** Myopia, choroidal thickness, OCT

## Introduction

The choroid plays a crucial role in maintaining retinal and visual functions, such as providing nutrients to the external retina and the retinal pigment epithelial cells and supplying blood to the anterior layer of the optic nerves [1]. The development of optical coherence tomography (OCT) has enabled direct observation of the choroid in vivo, and allows quantitative observations, such as measuring its thickness. As a result, OCT has been used in many studies [2-6].

The choroidal thickness is known to vary with factors including ethnicity, age, and time of day and with ocular factors including axial length and refractive errors [7-9]. Various studies have reported that greater axial length and myopia are associated with a thinner choroid [10].

Few studies have investigated the distribution of the choroid thickness according to refractive error in children of a similar age, and no such study has been conducted in children.

Morphologic changes in the choroid and retina of myopic eyes have been well studied in adults, but they are poorly understood in children [11–16]. Few studies have described retinal and choroidal thickness in children with different refractive states [17–19], but none have studied both characteristics in the same cohort. Hence this study was conducted to compare the distribution of choroid thickness in patients with refractive errors, such as hyperopia or myopia, with that in people without refractive errors, using Spectral-Domain imaging OCT. The objectives of the study are as follows:

1. To study changes in the choroid by measuring the choroidal thickness in myopic, hypermetropic and emmetropic eyes.
2. To correlate the choroidal thickness with the refractive error and the axial length.

## Materials and Methods
This cross-sectional observational study consisted of 60 subjects, who visited the out-patient department of Ophthalmology, Chattrapati Shivaji Subharti Hospital, Meerut, India and were randomly selected over a period of 1 year. Prior approval from the institutional review board of the institute was taken and informed consent was obtained from each subject. The subjects were recruited according to the following inclusion and exclusion criteria:

### Inclusion criteria
All non smokers participants having no history of ocular or systemic pathology and were not using any medications. Participants had normal levels of stereo-acuity and healthy cornea with no contraindication to contact lens wear based on slit lamp bio-microscopy. None of the myopic participants were under any myopia control treatment (e.g atropine, multi-focal spectacle or contact lenses).

### Exclusion criteria
Eyes with any previous retinal or choroidal pathology, with severe media opacities preventing fundus assessment, intra-ocular pressure (IOP) > 21 mmHg or with any one characteristic glaucomatous disc change, patients on medications known to cause maculopathy, patients with known neuro-ophthalmological diseases, patients of diabetes, hypertension and/or Koch's disease were excluded.

Subjects were classified into three groups based on refractive error: those with a +1 diopter or greater refractive power were assigned to the hyperopia group; those with a diopter lower than +1 and greater than –1 were assigned to the emmetropia group; and those with a –1 diopter or lower diopter were assigned to the myopia group.

A written informed consent was obtained from all subjects before acquisition of the OCT scan. All patients underwent a clinical history taking and a complete ophthalmic examination. OCT scanning was performed using Optovue RTvue 100 which utilises spectral domain (SD)-OCT. The choroid was visualized by enhanced depth imaging (EDI) technique. Choroidal scans were obtained for all the eyes using enhanced depth imaging (EDI) using spectral-domain optical coherence tomography (SD-OCT). The retina crossline scan has 32 frames averaged, 16 per direction, with tracking in the horizontal and vertical macular scans. Measurements of choroidal thickness were performed manually using the calipers provided by the software at the center of the fovea 500 and 1000 μm away from the fovea in the cardinal directions. Choroidal thickness was measured from the outer limit of the retinal pigment epithelium to the choroid–scleral junction. Macular thickness was evaluated using macular maps (EMM5).

In addition, subjects underwent a slit lamp examination, cycloplegic refraction, best-corrected visual acuity assessment, fundoscopy, and measurement of axial length and posterior choroidal thickness. For cycloplegic refraction, 1% cyclopentolate hydrochloride was administered dropwise, twice or more, into each eye at 5-minute intervals; 30 to 40 minutes after its administration, refractive errors were measured when pupil dilation and loss of light reflex were confirmed.

### Statistical analysis
Data was analysed using SPSS version 24. Continous data was presented as mean±SD. Categorical and continuous data between the groups was compared using chi square and anova test respectively. Intergroup comparison was done by t test and the level of significance (p value) was set at <0.05.

## Results
The mean age among the myopic, emmetropic and hyperopic was 28.91±6.78, 30.43±7.22 and 29.87±5.69 years respectively. All the variables viz. BMI (kg/m$^2$), axial length (mm) and intraocular pressure (mm Hg) was comparable among the groups as p>0.05. Mean refractive error was -1.75±1.05, 0.20±0.25 and 1.12±0.62 among the myopic, emmetropic and hyperopic respectively with statistically significant difference (table 1).

**Table 1:** Characteristics of the study population

| Parameters | Myopic (N=20) | | Emmetropic (N=20) | | Hyperopic (N=20) | | p value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Age (in years) | 28.91 | 6.78 | 30.43 | 7.22 | 29.87 | 5.69 | 0.54 |
| BMI (kg/m$^2$) | 23.38 | 4.56 | 22.29 | 3.71 | 22.87 | 3.92 | 0.32 |
| Axial Length, mm | 24.06 | 0.77 | 23.24 | 0.72 | 22.79 | 0.83 | 0.11 |
| Intraocular Pressure, mm Hg | 17.58 | 2.32 | 17.09 | 2.51 | 18.10 | 2.79 | 0.16 |
| Male, N (%) | 9 | 45 | 12 | 60 | 8 | 40 | 0.38 |

*: statistically significant

The thickness of the choroid was more in horizontal scans as compared to vertical scans in all the three groups. Compared to emmetropic participants, myopic subjects had significantly thinner choroid while choroid of hyperopic subjects was significantly thicker than that of emmetropic subjects (table 2).

**Table 2:** Topographic characteristics of choroidal thickness in Myopic, Emmetropic, and Hyperopic Subjects

| Choroid Thickness | Myopic (N=20) | | Emmetropic (N=20) | | Hyperopic (N=20) | | p value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Horizontal | 223.49 | 47.81 | 237.92 | 42.38 | 268.76 | 45.17 | <0.01* |
| Vertical | 221.55 | 46.14 | 234.09 | 43.57 | 265.18 | 40.39 | <0.01* |

*: statistically significant

Axial length and refractive error were independently related to central fovea choroidal thickness. The correlation $R^2$ of the regression model was 0.18 (*P*< .05). According to the model, every 1-mm increase in axial length is associated with a 14.49 mm decrease in central foveal choroidal thickness. Linear correlation testing revealed a close correlation between refractive error and choroidal thickness (table 3).

**Table 3:** Systematic/ocular independent variables associated with choroid layers

| Variables | Axial Length | Refractive Error |
|---|---|---|
| Unstandardized Coefficients | -14.49 | 9.47 |
| Standardized Coefficients | -0.24 | 0.20 |
| p value | 0.03 | 0.18 |
| $r^2$ | 0.18 | |

## Discussion

Our results indicated that myopic subjects had a thinner choroid. Central foveal choroidal thickness was closely correlated with axial length and refractive status. To the authors' knowledge, this study is one of the scarce studies to investigate the Spectral-Domain Optical Coherence Tomography findings of choroidal thickness together in adult age groups of different refractive status.

In our study, compared to emmetropic participants, myopic subjects had significantly thinner choroid. Choroid of hyperopic subjects was significantly thicker than that of emmetropic subjects in most regions. Similarly in a study by Sumeet Chopra *et al.* [20], the choroidal thickness in high myopic eyes was significantly less and in high hypermetropic eyes significantly more than in the controls and the thickest choroid present subfoveally in high hypermetropic eyes. This was in accordance with the previous studies conducted on hypermetropic anisometropic amblyopic subjects by Mori *et al.* [21], Tenlik *et al.* [22] and Tomo Nishi *et al.* [23], in which SFCT was significantly greater than in the normal fellow eyes. The greater values of mean CT in these previous studies might be because they had taken 'amblyopic' subjects, in contrast to our study in which high hypermetropic subjects, with a BCVA of 6/9 or better, were included.

According to results from some animal studies, changes in choroidal thickness may be due to the maintenance of clear vision. Previous studies in chicks, marmosets and macaques have led to the hypothesis that induced myopic defocus leads to choroidal thickening due to adjustment of the retina location and to maintain clear vision. This could result because in myopic defocus the image plane is in front of the retina so that a thickening of the choroid pushes the retina forward the image plane. Data from previous studies have shown that choroidal thickening, as a part of this compensation, inhibits the penetration of various growth factors that function as mechanical barriers and slows the growth of sclera [24, 25]. Thus, results from these studies are consistent with data from this study showing that refractive error leads to choroidal thickening in hyperopia in order to maintain clear vision and to choroidal thinning in myopia [3].

In the present study, there was negative correlation between choroidal thickness and axial length. Tomo Nishi *et al.* [23] also found a statistically significant negative correlation between the CT and the AL. Similarly Sumeet Chopra *et al.* [20] too revealed strong negative correlation between the axial length (AL) and the CT.

This study was limited by its cross-sectional design, as changes over time could not be investigated. Thus, future longitudinal studies are needed to measure changes over time to determine whether changes in the choroid occur due to refractive power.

## Conclusion

High myopes have significantly thinner choroids than the emmetropic controls. With an increase in the degree of myopia, the choroidal thickness decreases. High hypermetropes on the other hand, have significantly thicker choroids, as compared to the emmetropic controls. To the best of our knowledge, this is one of the fewest study, at least in the Western UP, Indian population, that has compared the changes in choroidal thickness in high myopic and high hypermetropic eyes, with emmetropic healthy control eyes, together, in the same study. However, further longitudinal studies are required to be conducted to evaluate the changes in choroidal thickness with time, that is, whether the choroidal thickness changes with increasing age and the changing refractive error.

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