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Research Article

Macular Thickness Evaluation in Different Grades of Myopia - A Spectral Domain Optical Coherence Tomography Study

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Abstract

Purpose: To study the correlation between macular thickness and different grades of myopia in their axial length and spherical equivalent refraction.

Methods: A total of 207 young myopes between the ages of 11 and 34 were selected. A comprehensive eye examination was done, including cycloplegic refraction, and measurement of axial length by A-Scan biometry. Subjects were categorized into low and medium (134 eyes), high (51 eyes) and super high (15 eyes) degrees of myopia. Foveal thickness assessment and macular evaluation was done by SD-OCT.

Results: The macular thickness in all the four quadrants of inner and outer circles significantly decreases as the degree of myopia increases. With an increase in the grade of myopia, the central foveal thickness has also increased. The central fovea and the temporal outer macula were thinnest of all areas in all the groups.

Conclusion: This study highlights the foveal and macular thickness changes as influenced by myopia progression and increases in the axial length.

Keywords: *Myopia; Refractive Error; Optical Coherence Tomography; Macular Thickness; Axial Length*

Abbreviations

OCT: Optical Coherence Tomography; SD: OCT Spectral Domain Optical Coherence Tomography; LMMG: Low to Moderate Myopia Group; HMG: High Myopia Group; SHMG: Super High Myopia Group; TAMT: Total Average Macular Thickness; CST: Central Subfield Thickness; BCVA: Best Corrected Visual Acuity; SIM: Superior Inner Macula; IIM: Inferior Inner Macula; NIM: Nasal Inner Macula; TIM: Temporal Inner Macula; SOM: Superior Outer Macula; IOM: Inferior Outer Macula; NOM: Nasal Outer Macula; TOM: Temporal Outer Macula; IOP: Intraocular Pressure

Introduction

Myopia is an important cause of visual disability in both the developed and the developing worlds. Its prevalence varies from different parts of the world, in different age groups and ethnic groups [1]. Myopia usually commences in the school age, 5 - 15 years, and becomes stable by the end of the second decade of life. Myopia may be associated with the occurrence of vitreous degeneration, posterior pole degeneration, peripheral retinal degenerations, retinal breaks and retinal detachment. Reports on Singapore-China study show that the frequency of occurrence of myopia in 7-9-year-old children to be around 37% in Singapore, 18.5% in Xiamen City southern China and around 7% in rural Xiamen [2]. The prevalence is high among Taiwanese high school children; it is reported to be above 80%. It is much less in East Asian countries [3]. The prevalence is much lower in some other countries in East Asia. The prevalence of myopia in India is reported as 4.9%; higher in urban population (6.9%) in comparison to rural population (2.77%). From the surveys conducted in the 1970s, the prevalence of myopia in India is reported as more than 4% among school children [4], Murthy., *et al*. reported a prevalence of 7.45% of myopia in the urban population of New Delhi [5]. Report from a rural location in Andhra Pradesh puts the prevalence at 4.1% [6]. Andhra Pradesh Eye Disease Study has shown the refractive error to be the main cause of moderate visual impairment in a younger population [7]. A correlation between macular thickness and different grades of myopia is reported by a number of studies [8,9]. Studies from South East Asian counties and some of the European countries have reported on macular thickness using OCT. There are very few reports on macular thickness measurement of OCT in myopia cases of Indian centers.

Purpose of the Study

The purpose of our study was to evaluate the variations in macular thickness in myopic patients in this south Indian population, at a Government Medical College tertiary eye hospital, with different diopter (D) degrees using spectral domain-OCT (SD-OCT).

Material and Methods

Study Design

It is an observational study. The study includes two hundred eyes of young myopic patients presenting to Sarojini Devi Eye Hospital for a period of seventeen months from December 2014 to April 2016. An informed consent was taken before subjecting each patient to required investigations. Basic demographic details, presenting complaints, duration of myopia, past history, and family history were documented. These patients were divided into three groups according to their refractive error/axial length as Low and medium myopia group (LMMG) (Refractive Error up to -6D/axial length 24 - 26 mm), High myopia group (HMG) (RE- 6 to -10D/axial length 26 - 28 mm) and Super high myopia group (SHMG) (RE >-10D/axial length > 28 mm).

SD-OCT was used to evaluate macula (TAMT, CST, inner/outer macular thickness and MV). The patients were subjected to detailed ophthalmological examination including BCVA using Snellens chart, refraction, slit lamp biomicroscopy, indirect ophthalmoscopy, gonioscopy and applanation tonometry. A-scan biometry was performed in each patient to determine the axial length. Fundus photographs were taken when needed.

Inclusion criteria: All myopes with Best Corrected Visual Acuity of at least 6/24.

Exclusion criteria

1. Macular edema due to Diabetes, Uveitis, Retinal vein occlusions, Postoperative cases and trauma
2. All diagnosed cases of open-angle glaucoma.
3. Any other macular pathologies like Choroidal Neovascular Membrane, Macular scars, Pigment Epithelial Detachments and Dystrophies.

OCT was performed with the Cirrus HD-OCT system (Carl Zeiss Meditec, Cirrus HD-OCT 5000-2408, and Soft version 6.5.0.772) and macular cube 512 × 128 protocol. This comprises of a cube of data in a6 mm square grid recording 128 horizontal scans having 512 A-scans. This protocol has a scan with signal strength more than 6 that correctly portray the retinal layers without any image artifacts that may be caused by eye movements. All the scans were performed by the same examiner under similar conditions. The chart has nine sectoral thickness measurements zones, bounded by three concentric circles with diameters of 6, 3 and 1 mm (Figure 1). The area bounded by the outer (6 mm) and middle (3 mm) circles forms the outer ring (OR) while the area bounded by the middle (3 mm) and inner circles (1 mm) forms the inner ring (IR). Each ring is divided into temporal, nasal, inferior and superior zones. CST stands for central subfield thickness, SIM, IIM, NIM, TIM stand for superior inner macula, inferior inner macula, nasal inner macula, and temporal inner macula respectively. The nine zones in the chart are hence labeled as; CST for central subfield thickness, TIM, NIM, IIM, and SIM represent temporal inner macula, nasal inner macula, inferior inner macula and superior inner macula respectively. Superior outer macula, inferior outer macula, nasal outer macula and temporal outer macula are indicated as SOM, IOM, NOM, TOM. Total macular thickness and macular volume over the 6 mm diameter circle, centered at the true fovea location were also obtained from the computational software output.

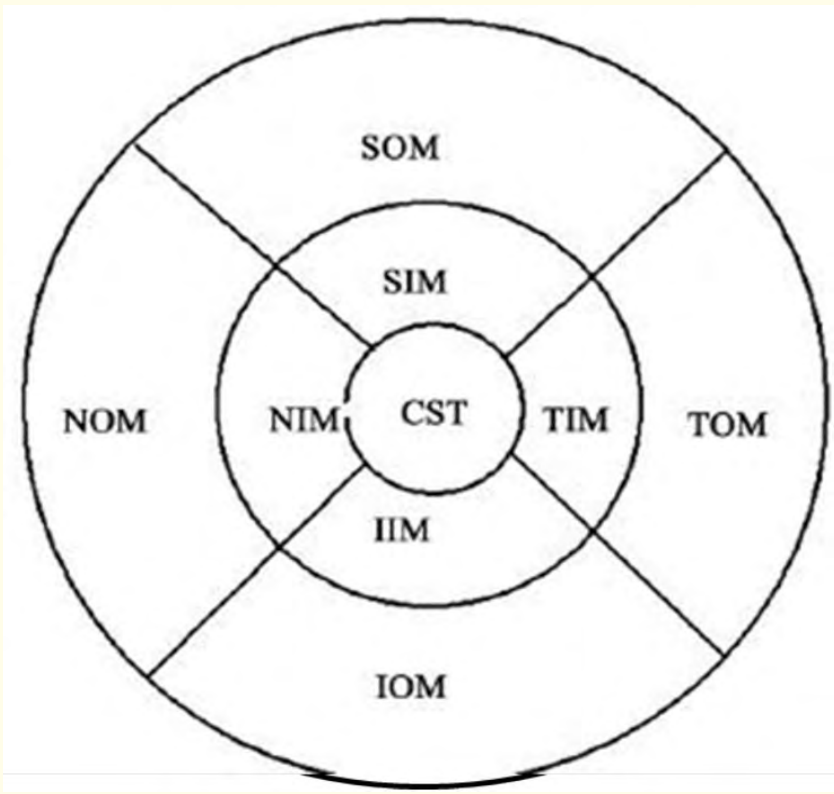

Figure 1: *Topographical map of macular thickness.*

Results and Analysis

Statistical analysis was performed and differences in macular measurements among the three diagnostic groups were evaluated by one-factor analysis of variance (ANOVA). (P-value < 0.05 is statistically significant). Student's unpaired t-test is used to calculate the difference between any two groups.

Demographic data: A total of 200 eyes of 100 subjects (36 and 64 females) were enrolled out of which 134 eyes are under LMMG, 51 under HMG and 15 under SHMG. Demographic profile, spherical equivalent, axial length, IOP and BCVA of the three groups of the patients are shown in table 1. The average age of the three groups was: LMMG - 20.81 ± 5.63, HMG - 20.92 ± 6.4, SHMG - 24.86 ± 6.93. Females are more in each group than males. There was no significant difference in the demographic profile and intraocular pressure among the three groups. The axial length and visual acuity were statically significant; with axial length increasing progressively with increase in the degree of myopia.

	LMMG	HMG	SHMG	P-value (ANOVA)
Sample	134	51	15	
Spherical equivalent (D)	- 4.29 ± 1.3	- 8.17 ± 1.6	- 14.2 ± 3.91	< 0.001
Axial Length (mm)	24.82 ± 0.73	26.7 ± 0.48	28.91 ± 1.38	< 0.001
Gender (M/F)	44/90	24/27	4/11	0.147
Age	20.81 ± 5.63	20.92 ± 6.4	24.86 ± 6.93	0.063
IOP(mm Hg)	13.59 ± 2.3	13.72 ± 2.4	14.93 ± 2.9	0.133
BCVA (logmar)	0.087 ± 0.13	0.112 ± 0.12	0.313 ± 0.19	< 0.001

Table 1: *Baseline data of three groups (mean ± standard deviation).*

Spherical equivalent: The mean and standard deviation of spherical equivalent among the three groups were -4.29 + 1.3, -8.17 + 1.6 and -14.2 + 3.91 respectively.

Axial length: The mean and standard deviation of axial length among the three groups was 24.82 + 0.73, 26.7 + 0.48 and 28.91 + 1.38 respectively.

BCVA (log MAR)

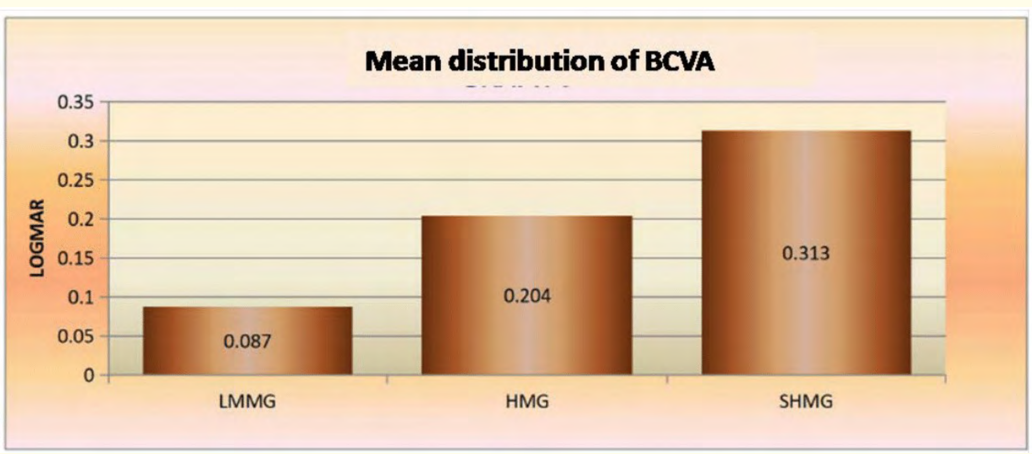

Figure 2: *Mean best corrected visual acuity distribution in the groups.*

LMMG group has BCVA in logMAR close to zero (i.e. good visual acuity on spectacle correction); as myopia is increasing, the logMAR values are also increasing (i.e. poor visual acuity even after spectacle correction). The central fovea and the temporal outer macula were thinnest of all areas in all the groups. The central foveal thickness is more in SHMG (though not statistically significant) compared to other groups. There is no uniformity in mean thickness across all the zones in the inner and outer regions. In the inner region, in LMMG and HMG groups, the nasal zone was the thickest, followed by that of the superior, inferior and temporal zones. In the SHMG group; all ETDRS subfields are thinner compared to LMMG and HMG, but central fovea is thicker compared to the other groups. Table 2 shows the gender difference in macular thickness measurement. The CST was significantly less in females compared to males. The TIM and TOM were also found to be significantly lower in females compared to males. With a progressive increase of myopia, the macular thickness got significantly thinner across all the regions, but paradoxically the central macula was thicker (Table 3). This was significantly different in all the zones among the three groups. The macular thickness in all the four zones of inner and outer circles is significantly decreasing as myopia is increasing. The total average macular thickness (TAMT) is decreasing as myopia is increasing. With progressive increase in the degree of myopia, the macular volume has decreased.

	Male	Female	P-value
Sample	72	128	
AXL	25.85 + 1.5	25.47 + 1.4	0.07
NIM	308.51 + 16.2	304.73 + 14.7	0.09
SIM	305.51	304.73 + 14.7	0.16
IIM	300.55 + 18.48	298.33 + 14.69	0.35
TIM	291.95 + 19.73	286.75 + 14.9	0.03
NOM	286.33 + 15.42	283.32 + 14.11	0.16
SOM	265.27 + 11.45	262.43 + 12.34	0.11
IOM	253.62 + 13.39	251.39 + 12.38	0.23
TOM	245.02 + 12.83	240.73 + 21.06	0.0015
CST	252.25 + 17.83	240.73 + 21.06	0.0001
TAMT	266.37 + 18.21	262.63 + 11.91	0.08
MV	9.47 + 1.22	9.45 + 0.43	0.866

Table 2: *Gender differences in macular thickness measurement.*

	LMMG	HMG	SHMG	P-value
NIM	309.35	304.15	286	< 0.001
SIM	305.64	300.88	282.4	< 0.001
IIM	301.44	289.25	275.86	< 0.001
TIM	292.85	280.98	265.33	< 0.001
NOM	288.04	284.7	276.2	< 0.001
SOM	265.49	261.52	254.06	< 0.001
IOM	254.73	247.35	241.4	< 0.001
TOM	243.79	236.27	229.33	< 0.001
CST	243.2	244	252	0.22
TAMT	266.2	264.2	243.7	< 0.001
MV	9.58	9.53	8.76	< 0.001

Table 3: *Macular measurements in three groups.*

Central Subfield Thickness (CST)

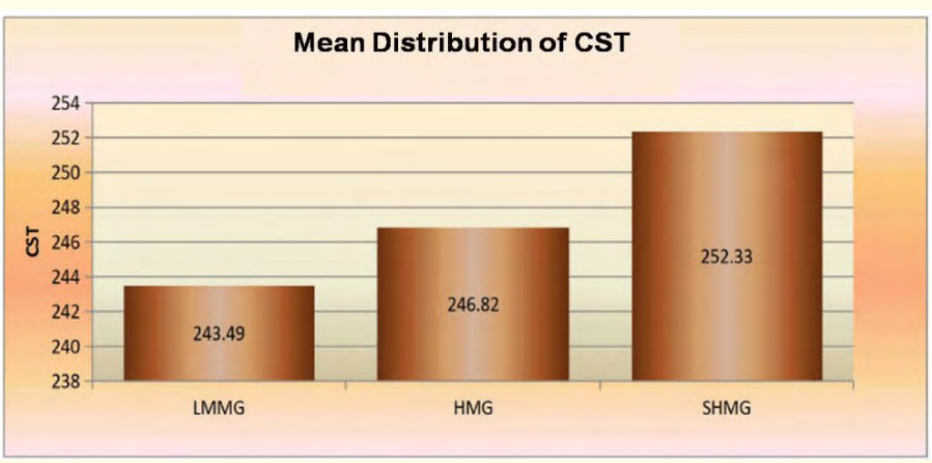

Figure 3: *Mean Central subfoveal thickness in the groups.*

The CST has increased with increase in the degree of myopia, but it is not significant. All the four zones of the inner circle show significantly less macular thickness as Myopia is increasing. All the four zones of the outer circle show significantly less macular thickness as myopia is increasing. Significant difference was found in BCVA, TAMT and MV when LMG was compared with SHMG and when HMG was compared with SHMG.CST was found to increase with increase in myopia but the difference is not statistically significant (Tables 4-6).

	NIM	SIM	IIM	TIM
LMMG and HMG	< 0.001	< 0.001	< 0.0001	< 0.0001
LMMG and SHMG	< 0.0001	< 0.0001	< 0.0001	< 0.0001
HMG and SHMG	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Table 4: *Comparison among any two groups for inner circle done using student's unpaired t-test.*

	NOM	SOM	IOM	TOM
LMMG and HMG	< 0.01	< 0.01	< 0.01	< 0.01
LMMG and SHMG	< 0.01	< 0.01	< 0.001	< 0.001
HMG and SHMG	< 0.01	< 0.01	< 0.001	< 0.001

Table 5: *Comparison among any two groups for outer circle done using student's unpaired t-test.*

	BCVA	CST	TAMT	MV
LMMG and HMG	0.23	> 0.05	> 0.05	> 0.05
LMMG and SHMG	< 0.0001	> 0.05	< 0.0001	< 0.0001
HMG and SHMG	< 0.0001	> 0.05	< 0.0001	< 0.0001

Table 6: *Comparison among any two groups for outer circle done using student's unpaired t-test.*

The p-value is calculated using student's unpaired t-test. The CST was significantly less in females compared to males. The TIM and TOM were also found to be significantly lower in females compared tomales.

Discussion

Myopia is a common refractive error, and the complications and degenerative conditions of the retina and choroid associated with higher grades of myopia may be contributory factors to blindness. High myopia with increased axial length and relatively enlarged eyeball may be associated with retinal and scleral thinning. Until recent past, assessment of macular thickness was subjective, relying on slit lamp stereoscopic biomicroscopy of the fundus. Presently, OCT makes this assessment objective and more reliable. The Spectral domain OCT gives highly accurate repeatable scans and detects subtle changes in the retina of myopic eyes [10,11]. The good resolution with OCT makes it the best method to measure the retinal thickness.

In the present study, females comprised 64% of the total population. The majority of the study population was between 15 - 25 years of age. The three groups were compared for the BCVA. The difference in BCVA among LMG and HMG was not significant (p-value > 0.05), but when it was compared between LMG and SHMG, the BCVA logMAR value decreased with increase in myopia and it was a statistically significant difference (p-value > 0.0001). Corrected visual acuity was significantly better in HMG when compared to SHMG. When all the zones of the inner circle (NIM, SIM, IIM, and TIM) and all the zones of the outer circle (NOM, SOM, IOM and TOM) are compared between the three groups (LMG, HMG, SHMG), the macular thickness was found to decrease with increasing myopia (p-value < 0.0001). When CST was compared among the three groups, it was observed that the CST increased with increase in myopia but the difference was not statistically significant. When the macular thickness measurements were compared among males and females, the CST, TIM and TOM were significantly less among females.

The variations in the thickness between the inner and outer circles were particularly affecting certain zones, regardless of the gender. The difference was more for the outer zones compared to inner zones and the nasal zone was significantly thicker than the other three zones within the outer region. These findings are similar to those found in other studies, and this is due to the pattern of converging retinal nerve fibers with the optic disc [12,13]. The papillomacular bundle is more plethoric in the nasal macula, and this makes nasal zones more significantly thicker than the other zones [14].

Ai-Ping song., *et al*. conducted a study on measurement of macular thickness in high myopic eyes using SD-OCT in 82 young and middle-aged Chinese myopic patients and the conclusion was with an increase in the degree of myopia and the axial length, the macular thickness decreased. They observed that the IIM, TIM, NOM, SOM, IOM, TOM, TAMT and MV decreased with an increase in myopia whereas the CST increased with increase in myopia. SIM, TOM, TIM and CST were significantly more in males than in females [8]. Similar results were observed in our study, the macular thickness of the inner and outer circles, the TAMT and MV were significantly decreased with an increase in myopia. The CST (foveal thickness) was found to increase with an increase in myopia but it was not statistically significant. This difference in our study might be due to the regional variation of the study population. Similar to the above study, we observed that the macular thickness in TIM and TOM including the CST were significantly lower in females compared to males [8]. With myopic progression and elongation of the axial length, a stretching effect causes a reduction in macular thickness and volume.

Minghui Zhao., *et al*. conducted a study on macular thickness assessment with Optical Coherence Tomography in 157 young Chinese myopic patients aged 18 - 30 years using time domain-OCT (TD-OCT) and inferred that with the increase in the degree of myopia and axial length, the central foveal thickness increases and the thickness in other zones of the macula decreases. They observed that the macular thickness in all the quadrants of the inner and outer circle and the TAMT decreased with an increase in myopia whereas the CST increased with an increase in myopia. They observed that the thickness of the central macula, inner region, and nasal outer region were significantly greater in men than in women [9]. The results were almost identical to the present study except that the CST in our study was not statistically significant. Our study showed a significant decrease in macular thickness of TIM, TOM and CST of females compared to males. In addition, we observed that the BCVA is significantly less in SHMG when compared to LMMG and HMG. This decrease in visual acuity might be due to the extensive chorioretinal atrophy that occurs in high myopia. We observed that the CST is significantly less in females compared to males. This finding is consistent with the study conducted by Ai-Ping Song et al where they found that the CST is about 12 μm thicker in males compared to females [8]. The thinness of the fovea in females may be the reason for them being more prone to develop macular holes [15,16].

Conclusion

This study highlights the foveal and macular thickness changes as influenced by myopia progression and increases in the axial length.

Conflict of Interest

The authors declare that there is no conflict of interest concerning this publication.

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