ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 8.4
IJAR 2022; 8(2): 482-485
www.allresearchjournal.com
Received: 05-12-2021
Accepted: 09-01-2022

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Study of association between axial length and macular thickness in myopic adult population in western India

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Abstract
Purpose: This observational study was conducted to determine the association between axial length and central macular thickness in high myopic adults.
Method: After a routine eye examination on myopic adults (SE ≤ -6.00D) without any fundus pathology and age matched controls (SE = 0.00D), their axial length was measured with A-scan ultrasonography and their central macular thickness was obtained by OCT measurements (NIDEK RS-3000 ADVANCE) via macular map.
Results: 300 eyes of 150 subjects and 200 eyes of 100 controls were evaluated NIMS University Ophthalmology OPD over a period of one and a half year from January 2020 to June 2021. There was a positive association between values of spherical equivalent and axial length (*p*-value 0.00001, t- value 35.006051). Also, a positive correlation was noted between values of spherical equivalent and central macular thickness (p-value 0.00001, t-value 22.853918). This increase was specifically noted after axial length values of 24.5 mm (*p*-value < 0.00001, t- value 5.524218).
Conclusion: Thus, we conclude that with increasing degrees of myopia, there is axial elongation of the eye ball and also increase in the central macular thickness which should be kept in mind while evaluating high myopes for other macular and glaucomatous diseases.

Keywords: Axial length, macular thickness, myopic adult, population

Introduction

Myopia is a common cause of visual impairment. The worldwide prevalence of myopia threatens to double by the year 2050 from the current 22.9% [1]. Myopia is considered an epidemic in the Asian countries owing to the significantly high prevalence [2]. Etiology of myopia is multifactorial and can be classified using different criteria [3].

High myopia according to WHO is defined as spherical equivalent where the amount of myopia is more than 5D [4, 5]. With such determinants, progressive retinal degeneration and visual impairment are also observed. Degenerative myopia accounts for nearly one third of low vision cases in an Asian study [6]. Myopic retinopathy refers to a spectrum of changes ranging from tessellated fundus, diffuse or patchy chorioretinal atrophy and macular atrophy based on the International META-PM classification [7]. It affects 0.2% of the general population in Central India.

Degenerative myopia is associated with longer axial lengths and lower best corrected visual acuity [8]. Thus, establishing correlation between high myopia and axial length is significant. As early as the mid last century, researchers found that AL showed a bimodal distribution in an adult myopic population [9]. Visual acuity in high myopia may be subnormal even before advanced myopic maculopathy sets in. One of the reasons behind this may be the alteration in the arrangement of photoreceptors (Stiles- Crawford effect) and thus changes in the macula which can be assessed by optical coherence tomography (OCT).

Various studies have been performed to demonstrate the changes in macula in various degrees of myopia, but the results are invariable. Thus this study has been planned to investigate the effect of spherical equivalent on axial length and on macular thickness and simultaneously the effect of axial length changes on macular thickness which are measured by Nidek echo scan 800 a-scan ultrasonography and Nidek RS 3000 Advance respectively. Thus, in view of the high and increasing prevalence of high myopia in Asia, its multifactorial etiologies, irreversible progressive degenerations, complications, visual impairment and

health burden, this study was designed to understand the clinical profile and visual impairment in high myopia.

Methodology

All patients presenting to eye OPD of NIMS Medical College with complaints of diminution of vision underwent detailed history and examination. Detailed history including basic demographic data, presenting complaints, duration of myopia, past history and family history was noted for all patients. Detailed examination including BCVA using Snellen's chart, refraction, slit lamp bio microscopy, indirect ophthalmoscopy, and IOP measurement by Schiotz tonometer was performed. Those patients diagnosed as myopia after complete history and examination were selected. Inclusion and exclusion criteria was applied on the selected patients. Those patients fulfilling the Inclusion and Exclusion criteria were enrolled in the study and written informed consent was taken from each patient. Axial length of all patients was measured by A-scan ultrasonography [NIDEK ECHO SCAN 800]. Macular thickness of each patient was measured by OCT [NIDEK RS-3000 ADVANCE]. And horizontal scans (9mm* 9mm) in the MACULA MAP X-Y mode were taken for each patient. All the scans were taken by the same examiner under the same conditions. A group of 100 patients- age matched and non-myopic, were included as controls. Detailed history was taken and examinations were performed on controls. Collected data was presented in appropriate charts and tables.

Inclusion criteria

1. Patients of age group 20-40 years, of either gender, coming to Ophthalmology OPD in NIMS hospital diagnosed with myopia.
2. Patients who are willing to give written informed consent for the study.

Exclusion criteria

1. Any other ocular disease or ocular trauma.
2. Patients with history of intraocular surgery or refractive surgery.
3. Patients with macular pathologies.
4. Patients with history of systemic diseases like diabetes mellitus, hypertension.
5. Patients with any structural deformity who couldn't participate for OCT evaluation.
6. Un-cooperative patients.

Results and Observations

Demography

This study included 300 eyes of 150 subjects with high myopia with spherical equivalent being -6.00D or above and 200 eyes of 100 emmetropes (0.00 D).

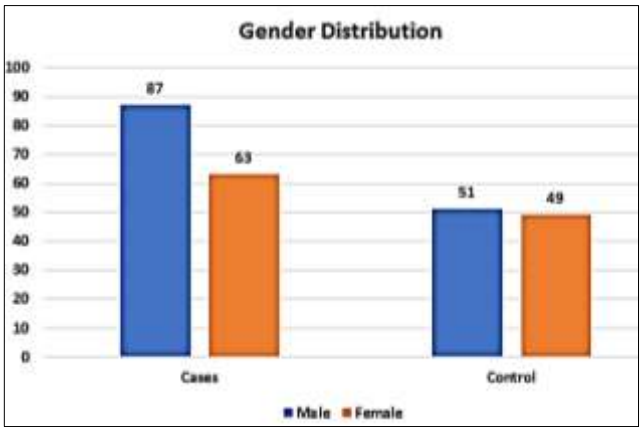

Fig 1: Gender Distribution

Correlation between spherical equivalent and axial length

The mean (±SD) axial length of the study population was 25.69(±1.83) mm with a range of 22 to 30.15mm in cases and 21.99(±0.84) mm with the range being 21 to 23 mm in controls as shown in table 4. There is a strong positive association between SE and AL (p- value 0.00001, t- value 35.006051) signifying that in higher degrees of myopia, the AL elongation is a higher possibility.

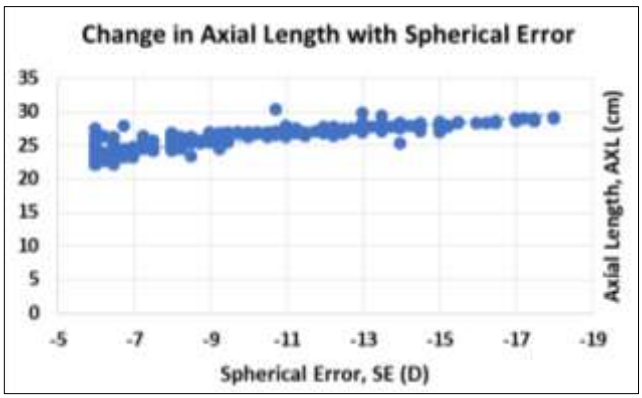

Fig 2: Change in axial length with spherical error

Correlation between spherical equivalent and central macular thickness

The mean (+-SD) central macular thickness of the study population was 285.13(±60.46) micro metres in cases with the range being 40 to 400 micrometres and 205.00 micrometres in controls with the range being 172 to 242 micrometres as shown in table 5. The association value between SE and CMT is quite strong (*p*-value 0.00001, t-value 22.853918) denoting that with increasing order of degree of myopia, thickness of central macula increases.

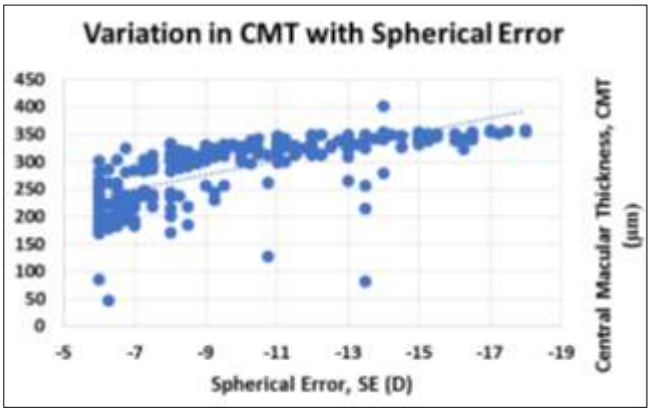

Fig 3: Correlation between spherical equivalent and central macular thickness

Correlation between axial length and central macular thickness

There is a strong positive association between values of SE and AL as well as values of SE and CMT (p-values for both <0.00001) indicating that with increasing degrees of myopia AL and CMT both show and increasing trend. An observation also states that trend in the values of CMT is flat until 24.5 mm AL after which only it begins to steepen indicating that increase in CMT begins only after elongation of AL is 24.5mm or more irrespective of the SE (*p*-value < 0.00001, t- value 5.524218).

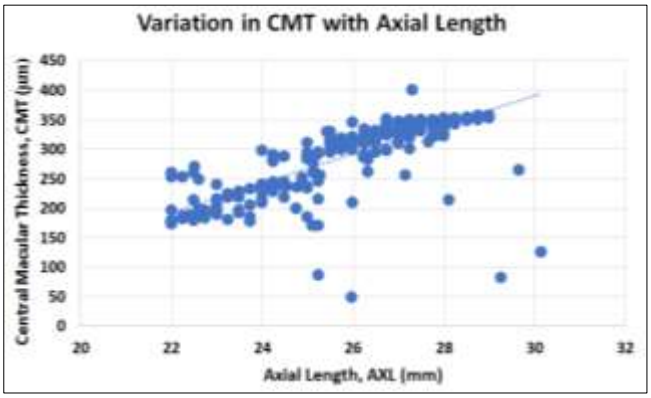

Fig 4: Correlation in central macular thickness and axial length

Discussion

Demographic data

In our study, we included age matched cases and controls where the age ranges from 20 to 40 years as age could be a confounding factor for determination of axial length and central macular thickness. Wu, P-C *et al* [10]. Conducted a similar comparative study with two groups: high myopic and non-myopic population with mean age 29.6 and 27.5 years respectively.

Association with spherical equivalent

Predetermined inclusion criteria were -6.00D or more and subjects with no refractive error (0.00D) were taken as controls to abolish instrument error in values of observed variables. The mean spherical equivalent observed was -9.48D (±3.82D) in cases and controls were emmetropes (0.00D). Flores-Moreno, Ignacio *et al.* [11] also performed an analysis of relationship between thickness of retina and choroid and tried to correlate them with visual acuity where the mean value of SE was -12.05±5.02 D (range -6 to -26). Whereas Chen, Si *et al.* [12] evaluated the macular thickness or volume in 194 Chinese myopic children where they divided them into subgroups as emmetropia (-0.5 diopters [D] < SER ≤ 0.5 D), low myopia (-3.0 D < SER ≤ -0.5 D), and moderate to high myopia (SER ≤ -3.0 D).

Association between ocular/systemic disorders

In the current study, we have excluded eyes with any ocular disease including macular pathology or any systemic disease like diabetes mellitus and hypertension which may or may not have an influence on the values of central macular thickness of cases. Then the values observed solely may be influenced by the spherical equivalent or the axial length of the subjects. Nishida, Yasunori *et al.* [13] conducted an identical study measured choroidal thickness as a predictor of visual acuity in high myopes (≥6 diopters [D]) in 2 retina centers, one in the United States and the other in Japan. As a similarity, no other pathology such as CNV (choroidal neovascularization), foveal lacquer cracks or myopic macular schisis was included. Whereas, in a study by El Matri, L *et al.* [14]. they analyzed 64 highly myopic eyes with choroidal neovascularization (CNV) and 64 highly myopic eyes without CNV.

Association between axial length

This study, on the basis of the observed values in high myopic eyes (-6.00D or more), concludes that elongation in axial length is seen with progressive values of spherical equivalent (*p*- value <0.00001, t- value 22.853918). In similarity, Lam, Dennis Shun Chiu *et al.* [15] concluded a positive correlation between the axial length and the average foveal thickness (r = 0.374, *P* < 0.001) when they tried to establish regional variations between foveal thickness in myopic population. Also, Harb, Elise *et al.* [16]. in an ethnically diverse 'Correction of Myopia Evaluation Trial (COMET)' cohort found that axial length was significantly associated with mild thickening of central fovea (*p* = 0.001).

Association between central macular thickness

The study analysis showed that central macular thickness was significantly positively associated with increase in the refractive error in high myopic subjects (*p*- value <0.00001, t- value 22.853918). Also, increase in CMT was seen only after increase in axial length values beyond 24.5mm (*p*-value 0.00001, t- value 5.524218). Similar results were found in a study conducted by Yeon Woong chung *et al.* [17] with the trend of central foveal thickness being relatively flat at value of AL below 25.5mm and beyond which a positive association is seen with increasing values of AL. Lam, Dennis Shun Chiu *et al.* [15] in their study concluded similar results that there was a positive correlation between the axial length and the average foveal thickness (r = 0.374, *P* < 0.001).

Similarly, Wu, P-C *et al.* [10]. concluded that high myopia group had significantly higher values of mean retinal thickness in the foveola and fovea 1 mm area than the emmetropic group (166 vs149 micron, $P<0.0001$, 199 vs188 micron, P=0.0063, respectively). Even, Harb, Elise *et al.* [16] proved in their study that increased AL was significantly associated with slightly thicker central foveal ($p = 0.001$) and thinner parafoveal ($p = 0.02$) and perifoveal ($p < 0.0001$) regions. Song, Ai-Ping *et al.* [18] again found similar results where it increases with increasing values of AL and SE (p- value <0.001).

On the contrary, Sato, Atsuko *et al.* [19] showed that foveal thickness was negatively correlated with the RE and positively correlated with the AL (p<0.01 for both). As contrasting conclusions, in each group, New York and Japan, in the study by Nishida, Yasunori *et al.* [13] subfoveal choroidal thickness showed a strong negative correlation when analyzed by increasing myopic refractive spherical equivalent

Limitations of the study

1. The study included subjects only from Jaipur and neighbouring district. Therefore, regional and ethnical variations couldn't be analyzed.
2. A-scan ultrasonography was used to measure axial length values which could have been more accurate with the advent of newer instruments.

Conclusion

In our study we found statistically significant increase in the average axial length and central macular thickness with increasing degrees of myopia. It is important because, these observations suggest that there might be presence of early anatomical changes in the retinas of population with axial myopia which can be detected with the help of advanced OCT systems. In the evaluation of macular pathologies and diseases like glaucoma, values of macular thickness should be interpreted only in the context of refractive errors and measurement location.

We recommend careful interpretation of central macular thickness values on high myopic individuals (particularly those with axial length >24.5mm) when applying the current available OCT nomograms in suspects of macular diseases and glaucoma.

These changes might even be early predictors of degenerative changes in pathological myopia which needs more evidence-based studies and data yet.

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