Ocular Biometrics: Study of Myopia, Using A - Scan and Keratometer

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ABSTRACT

Introduction: Myopia is a form of refractive error which is a leading cause of visual disability throughout the world. The purpose of this study was to determine the variations in ocular biometric parameters in various degrees of myopia i.e. low myopia (<-3D), moderate myopia (-3D to -6D) and high myopia (>-6D).

Method and Materials: 200 eyes of 100 myopia patients were examined. Keratometer and A-scan was done to measure the corneal curvature and other biometric parameters like axial length, anterior chamber depth, lens thickness and vitreous depth respectively. Comparison of ocular components with age, gender and family history was done. One way ANOVA was done to compare biometric parameters with refractive states.

Results: In our study, axial length(AL) (*P*=0.001), axial length to corneal curvature ratio(AL:CRC) (*P*=<0.001), anterior chamber depth(ACD) (*P*=<0.001) and vitreous depth(VD) (*P*=<0.001) were statically significant as compared to corneal curvature(CC) (*P*=0.56) and lens thickness (*P*=0.64) which were statically insignificant.

Conclusion: AL:CRC and AL had more effect on high myopia group as compared to corneal curvature. AL:CRC ratio was a better index for categorizing the refractive status of an individual as compared to axial length alone. This ratio can be considered at a cutoff point to categorise myopia into degenerative myopia.

Keywords: Myopia, Ocular Biometrics, AL:CRC, Corneal Curvature, Axial Length

INTRODUCTION

In India, uncorrected refractive errors are the most common cause of visual impairment and second major cause of avoidable blindness. The most common complication of high myopia is myopic retinopathy, which is a major cause of irreversible vision loss and blindness. For these reasons, there is an extreme need to control the onset and progression of myopia.

Ocular biometrics are among the most important factors affecting refractive errors. Current knowledge on emmetropization indicates that individual biometric components are not important by themselves and that emmetropization is a result of a balance among these components.

Grosvenor[1] was one of the first researchers to study AL:CRC and refractive error. Once AL matches CC, an emmetropic refraction is produced, and as it grows further, refractions become myopic and the AL:CRC starts to exceed about 3.0. Therefore, AL:CRC can be a useful marker for the onset and progression of myopia. In case of emmetropia, the cornea becomes flatter as the eye develops and increases in size. Whereas, in myopia, the cornea cannot continue to flatten and may even curve because of stretching of the eye.

Current research aimed to study the optical and anatomical factors in patients with myopia viz. corneal curvature and axial length with the objectives to evaluate optical and anatomical factors in patients with myopia, to determine the correlation of axial length and corneal curvature in various degrees of myopia, to determine the correlation of axial length and corneal curvature ratio (AL:CRC) in various degrees of myopia.

MATERIAL AND METHODS

This cross sectional study was carried out in the tertiary care centre, Karad, Maharashtra from November 2016 to may 2018. This study was approved by Institutional Ethical Committee. 200 eyes of 100 patients were taken from the age of 10 to 40 years of age who were myopes more than -2D. Patients with irregular astigmatism, corneal lesion, ocular surface diseases, lens defects, uveitis and other infection of the eye, who have undergone refractive surgeries, who has undergone any intraocular surgeries were excluded.

Informed written consent was obtained. A detailed history, examination of visual acuity for distance using snellen's chart with pinhole improvement was taken. Aided and unaided vision was taken along with auto refractometer readings. Vertical and horizontal keratometer values were taken and the average was calculated in dioptres (D) to get the corneal curvature. This value was converted to millimetres (mm) using the formula 337.7/D = mm. Immersion Ascan biometry was done to calculate the axial length, anterior chamber depth, lens thickness and vitreous chamber depth. All values were obtained in millimetres (mm). Every patient underwent retinoscopy with appropriate cycloplegic and mydriatic according to age, in a dark room. Patients were reviewed later for post mydriatic refractive correction. Patients under the age of 18 years underwent retinoscopy with cyclopentolate(1%) eyedrops, whereas those above the age of 18 years underwent retinoscopy

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with tropicamide(0.8%)+phenylephrine hydrochloride (5%) eyedrops. The retinoscopy was done according to appropriate working distance. A detailed examination was performed using slit-lamp biomicroscopic and fundus examination using direct and indirect ophthalmoscope respectively. AL:CRC was calculated. Patients were divided on the basis of the degree of myopia i.e. low myopia (<-3D), moderate myopia (-3D to -6D) and high myopia (>-6D).

RESULTS

Mean age group was 10 to 18 years (38), 19 to 26 years (25), 27 to 33 years (21), and 34 to 40 years (16).

It was a male predominant study (61), females (39). Family history was positive in 67% of the patients and negative in 33% (table-1).

In our study, most of study population had low degree of myopia : < -3D (40%) followed by moderate degree of myopia : -3D to -6D (35%) and high degrees of myopia : >-6D (26%) (figure-1).

Mean axial length was 25.84 ± 1.43 mm. Based on the various degrees of myopia, low myopia: < -3D had a mean axial length of 23.90 ± 1.15 mm, moderate myopia: -3D to -6D had mean axial length of 24.77 ± 1.29 mm and high myopia : >-6D had mean axial length of 26.66 ± 1.90 mm.

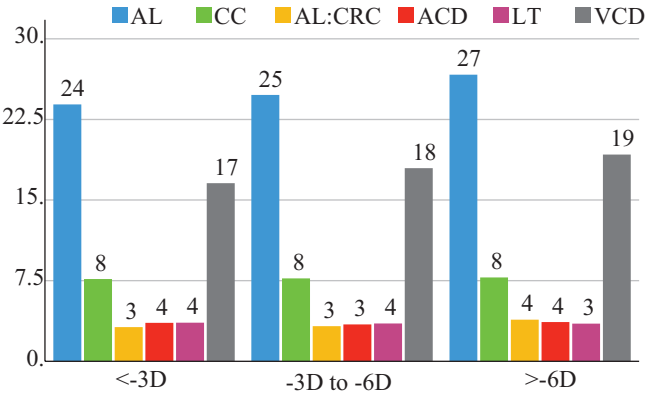

Figure-1:

Degree of myopia	Frequency	Percentage
Low : < -3D	80	40
Moderate : -3D TO -6D	69	35
High : >-6D	51	26
Total	200	

Table-1: Myopia degree

This variant was significant (P value 0.001) (table-2).

DISSCUSSION

In our study, the most common age group amongst study population was 10 to 18 years (38%) followed by 19 to 26 years (25%), 27 to 33 years (21%) and 34 to 40 years (16%). A study in Taiwan, in 1995, based on ocular refraction among school children reported myopic rate to be 12% at the age of 6 years which increased to 56% at the age of 12 years and 76% at the age of 15 years. However, myopic rate was 84% for the age range from 16 to 18 years.[2] This study is in correlation with our study. Sperduto et al. reported increase in prevalence of myopia from 24% among 12 to 17years of age to 27.7% among 18 to 24years of age, followed by a drop to 24% in the older age groups.[3] However, this study is not in correlation with our study.[3]

61% of the study population were males as compared to females which were 39%. This finding was concurrent to the study conducted by Das, et al. in which out of 100 patients, 51 were male and 49 were female.[4]

67% of the study population had a positive family history. Mutti and colleagues[5] in their study reported that the distribution of myopia was 6.3% in school children aged 13.7±0.5 years whose both parents were emmetropic, whereas, 18.2% children had myopia with one myopic parent, and 32.9% in children whose both parents are myopic.

Xiangui He[6] and others in 2015 studied myopia in Chinese school children from age 6 to 12 years and found the axial length to be <-3D was 24.99±0.85, >-3D was 23.93±0.77, which is not in correlation with our study, corneal curvature to be <-3D was 7.78±0.24, >-3D was 7.82±0.25, which was parallel to our study and AL:CRC ratio to be <-3D was 3.21±0.09, >-3D was 3.06±0.08, which is not in correlation with our study.

Majumdar and Tan[7] in 2015, studied comparison of ocular biometry and corneal curvature among Malaysian emmetropes and myopes, from age 18-35 years and found the axial length to be 24.12 ± 0.70 in low myopia, 24.82 ± 0.65 in moderate myopia and 25.50 ± 0.42 in high myopia which was parallel to our study. He found the corneal curvature to be 7.81±0.21 in low myopia, 7.69±0.12 in moderate myopia and 7.61±0.10 in high myopia which was not in correlation with our study. He found AL:CRC ratio to be 3.09±0.07 in low myopia, 3.23±0.07 in moderate myopia and 3.35±0.07 in high myopia which was parallel to our

	Axial length Mean ± SD)	Corneal curvature Mean ± SD)	AL:CRC Mean ± SD)	Anterior chamber depth Mean ± SD)	Lens thickness Mean ± SD)	Vitreous depth Mean ± SD)
Low <-3D	23.90 ± 1.15	7.65 ± 0.71	3.18 ± 0.3	3.57 ± 0.12	3.59 ± 0.5	16.56 ± 2.4
Moderate -3D TO -6D	24.77 ± 1.29	7.71 ± 0.81	3.26 ± 0.5	3.43 ± 0.16	3.51 ± 0.6	17.96 ± 2.2
High >-6D	26.66 ± 1.90	7.80 ± 0.84	3.86 ± 0.7	3.64 ± 0.2	3.49 ± 0.9	19.23± 1.9
Total mean ± SD	25.84 ± 1.43	7.64 ± 0.79	3.31 ± 0.4	3.51 ± 0.15	3.50 ± 0.7	18.01 ± 2.1
p value	0.001	0.5627	0.0001	0.0001	0.6378	0.0001

Table-2:

study. ACD to be 3.51±0.31 in low myopia, 3.52±0.22 in moderate myopia and 3.52±0.22 in high myopia which was not in correlation with our study and lens thickness to be 3.52±0.21mm in low myopia, 3.57±0.21mm in moderate myopia and 3.50±0.15mm in high myopia which was not parallel to our study.

In our study, mean corneal curvature was 7.64 ± 0.79 mm. Based on the various degrees of myopia, low myopia: < -3D had mean corneal curvature of 7.65 ± 0.71 mm, moderate myopia: -3D to -6D had mean corneal curvature of 7.71 ± 0.81 mm and high myopia: >-6D had mean corneal curvature of 7.80 ± 0.84 mm. This variant was statistically insignificant (P value 0.5627). Touzeau O et al[8] in their study releaved that there was no significant variation in corneal curvature between emmetropia and different refractive states. However, multiple studies have shown no relationship between relationship between degree of myopia and corneal curvature.

Mean AL:CRC amongst our study population was 3.31 ± 0.4. Depending upon various degrees of myopia, low myopia : < -3D had mean AL:CRC of 3.18 ± 0.3, moderate myopia: -3D to -6D had mean AL:CRC of 3.26 ± 0.5 and high myopia : >-6D had mean AL:CRC of 3.86 ± 0.7. The variant was highly significant (P value 0.0001). AL:CRC 3.86 ± 0.7 (≅3.9) in high myopia is the ratio which shows to be more significant than the AL alone. Therefore, it can be utilised for evaluation of early degenerative myopia. However, further research needed to be done by evaluating for progression of myopia after a few years as ours was a cross sectional study. Grosvenor et al[1] demonstrated that AL:CRC ratio played an important role when studied in 194 young adults between 18 to 30 years of age. The ratio played a stronger role than axial length and corneal curvature alone. Also, Gonzalez Blanco et all[9] and Goss DA, Jackson TW[10], studied the AL:CRC ratio and concluded that this ratio was the most important biometric factor in myopia, specially high myopia. Grosvenor's hypothesis[1]; found a linear increase in AL:CRC from high hyperopia toward high myopia. Every 0.1 unit of increase in AL: CRC was associated with approximately 1D of myopic shift. Overall, in light of results from different studies chances of emmetropia are highest when the AL:CRC ratio is close to 3. Any disturbance in this ratio, in any age group, can be recommended as a sign portending refractive errors.

In children, in particular, a ratio that differs from 3 can be indicative of disruption in the emmetropization process, and therefore assessment of anisometropia and amblyopia becomes crucial. Although emmetropization is a slower process in adults, the fact that the AL:CRC ratio remains constant becomes important in interpreting the pathogenesis of pathologic conditions. Although clinical application of the ratio fades in the presence of advanced clinical tests such as electrophysiologic tests, retinal imaging, imaging of optic nerve head and optical coherence imaging, it is still an important predictive index for children at risk of progressive myopia and adults at risk of primary open angle glaucoma. One major clinical application would be in refractive and cataract surgery; corrections should be designed to keep this ratio near 3 to achieve emmetropia.

In our study, mean ACD amongst study population was 3.51 ± 0.15 mm. Depending on the various degrees of myopia, low myopia : < -3D had mean ACD of 3.57 ± 0.12 mm, moderate myopia: -3D to -6D had mean ACD of 3.43 ± 0.16 mm and high myopia : >-6D had mean ACD of 3.64 ± 0.2 mm. The difference was statistically highly significant (P value 0.0001). Yebra-Pimentel E, et al.[11] 2008 studied the relationships between ocular optical components and implications in the process of emmetropization reported that ACD in low myopia was 3.56±0.27 mm, moderate myopia: 3.66±0.32mm and high myopia: 3.52±0.30mm which was not in correlation with our study. Similarly, Chen MJ et al.,[12] found that eyes with more myopic refractive error tends to have deeper anterior chamber (r= 0.651,.p<0.001).

Mean lens thickness amongst study population was 3.50 ± 0.7 mm. Depending on various degrees of myopia, low myopia : < -3D had mean lens thickness of 3.59 ± 0.5 mm, moderate myopia : -3D to -6D had mean lens thickness of 3.51 ± 0.6 mm and high myopia : >-6D had mean lens thickness of 3.49 ± 0.9 mm. The difference was statistically insignificant (P value- 0.6378). Shih et al,[13] also projected that the lens thinned (until about the age of 11 years in myopes) and then grew thicker, but the lack of longitudinal data was a limitation. They accounted that the eyes of myopic children initially showed a sequence of lens thinning, with the lens reaching its thinnest value between 10 and 11.5 years of age, and then grew thicker up to the age of 18 years, after which it was known that the lens continues to thicken from 18 to 75 years. Yebra-Pimentel E, et al.,[11] reported that lens thickness in low myopia was 3.56±0.18 mm, moderate myopia: 3.64±0.23mm and high myopia: 3.81±0.26mm which was not in correlation with our study.

Mean vitreous depth amongst study population was 18.01 ± 2.1 mm. Depending on the various degrees of myopia low myopia : < -3D had mean vitreous depth of 16.56 ± 2.4 mm, moderate myopia: -3D to -6D had mean vitreous depth of 17.96 ± 2.2 mm and high myopia : >-6D had mean vitreous depth of 19.23± 1.9 mm. The difference was highly statistically significant (P value 0.0001). Brown N.[14] reported that the depth of the vitreous decreases as age increases. Comparison of eyes with emmetropia and myopia, showed a more significant correlation between the vitreous depth and myopia than between the vitreous depth and emmetropia, by most investigators. The growth of the AL and the increase of the depth of the vitreous is the main factor with regard to the development of myopia. Yebra-Pimentel E, et al,[11] 2008 reported that vitreous depth in low myopia was 16.43±0.74 mm, moderate myopia: 17.02±0.77mm and high myopia: 17.92±1.10mm which was parallel to our study.

In 2006, Chua et al., published the results of Atropine in the Treatment Of Myopia (ATOM) study, daily 1% atropine eye drops were instilled for slowing down myopia progression in younger children over a period of 24 months. This reduced the progression of myopia by 77% compared with the untreated eye. The primary effect of atropine appeared to be

by slowing the growth of vitreous chamber depth, which in turn decelerate axial length increase. Therefore, new research on low strength atropine affects the biometrics of the eye.[15]

Limitation

Follow up of patients to check for degenerative changes in the eye was not possible as this was a cross sectional study. Further research needed to predict factors responsible for development of myopia and onset of myopia in order to design new ways to manage the burden of myopia.

CONCLUSION

Myopia is a complex entity with various risk factors including genetic, ethnic, environmental and biological determinants. Despite enormous research, etiology of myopia is still a matter of debate. Ocular growth is the vital cause responsible for refractive states of the eye.

As a result of combined efforts of multiple optical elements of the eye, refractive error is determined, axial length being one of the most important component related to myopia. The function of the cornea seems to compensate the possible myopizing effects of a slight increase in the axial length. When increase in the axial length is excessive, the effect of cornea tends to disappear.

Axial length to corneal curvature ratio (AL:CRC) which was 3.86 ± 0.7 in high myopia was a better index of categorisation of myopia followed by axial length as a single component. This ratio can be considered as a cutoff point to categorise myopia into degenerative myopia. It can also be used to regularize the follow ups of these patients to check for degenerative changes. To further authenticate this mathematical ratio a larger sample size would have been helpful, including hereditary and environmental factors. The association between AL:CRC and refraction is linear; the ratio is highest in high myopia and lowest in high hyperopia. However, this ratio can be used for evaluation of degenerative myopia.

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