A STUDY TO CORRELATE THE AXIAL LENGTH OF THE EYE BALL AND THE CURVATURE OF THE CORNEA WITH THE AGE OF ONSET OF MYOPIA

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ABSTRACT

BACKGROUND
The study was designed to understand the morphological and anatomical changes in the eyeball that may directly affect the refractive (myopic) status. The role of the cornea in the appearance and progression of myopia has been the subject of study. This study is to correlate the axial length of the eyeball and curvature of the cornea with the age of the onset of myopia.

MATERIALS AND METHODS
In this prospective observational study, a total of 200 simple myopic eyes of 100 subjects with mean age of 20.06 ± 4.39 (range 10 to 30 years) consisting of 55 males and 45 females were recruited for the study. Careful history was taken in all the patients with particular attention to the age of onset of their myopic power. The patients were examined and refraction for the power, a scan biometry for axial length of the eyeball and the keratometry for the radius of curvature of the cornea were performed.

RESULTS
The maximum number (n=85) of eyes had myopic power less than -5.00 Dsph (Group A). Follower by 77 eyes, those belonged to the group of -5.00 Dsph to less than -10.00 Dsph (Group B). 26 eyes were selected within the range of -10.00 Dsph to <-15.00 Dsph (Group C). The high myopic power more than -15.00 Dsph were detected only in 12 eyes (Group D). The mean AL of whole study population was 24.9 ± 1.8 mm. The 111 (55.50%) number of myopic eyes had axial length within the range of 24 mm to less than 27 mm. The mean CR for the population was 7.55 ± 0.30 mm. The maximum number 179 of myopic eyes had moderate range (7.0-<8.0 mm) of radius of corneal curvature (CR). Myopia was classified as adult-onset (6-9 years) myopia in 88 eyes and as juvenile-onset (3-<6 years) myopia in 112 eyes. The values of mean AL/CR ratio obtained from this study was 3.12 ± 0.72 (Group A), 3.34 ± 0.75 (Group B), 3.57 ± 1.06 (Group C) and 3.71 ± 1.22 (Group D).

CONCLUSION
Axial lengthening is the main morphological factor in both juvenile and adult-onset types of myopia. The study observed a tendency towards smaller radii of curvature in moderate myopias. The AL and CR relation increased steadily from the lower to higher grades of myopes among the four refraction groups. The function of the cornea seems to compensate the possible myopising effects of slight increases in axial length. When increases in axial length are excessive, this effect of the cornea tends to disappear with the consequent appearance of myopia.

KEYWORDS
Myopia, Axial Length of the Eyeball, Curvature of the Cornea.

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BACKGROUND

The refractive state of the eye is determined by refractive components of the eyeball (corneal power, lens power, anterior chamber depth and axial length).[1] Those are interdependent rather than independent variables. The refractive status of the human eye is dependent on the balance of change in overall eye size and refractive components, namely, the cornea and the lens.[1,2] The Axial Length (AL) of eyeball is the distance between the anterior and posterior poles of the eyeball[2] and this is expressed in millimetres. Overall, the changes in AL appear to outweigh the progressive corneal flattening with age in normal eyes. The elongation of axial length usually takes place in the first 3 to 6 months of life and a gradual reducing rate of growth over the next two years.[2] By the age of 3 to 6 years, the adult eye size is attained.[3] The light converging power of the cornea depends upon its curvature. The interaction between axial length and corneal radius of curvature has played a major role in the compensatory adjustments of the optical components of the eyeball towards attaining normal refractive (emmetropic) state.[3] Both the axial length and Corneal Radius (CR) have been shown to give a better correlation with refractive error than is obtained with axial

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length alone. The process operating to produce greater frequency of normal refractive state than would be expected on the basis of chance alone is termed emmetropisation.[2,3]

The refractive error is the most common cause of ocular morbidity in India.[4] Myopia or short sightedness is a common cause of reversible blindness in India with a prevalence of 27%.[5] Increase in axial length[6] and decrease in radius of curvature of cornea[7] are considered as the two most significant factors associated with myopia. The progression of myopia depends upon the age of its onset. It has been classified accordingly into two main types- Juvenile or early and late onset.[8] The former usually initiates under the age of 6 years and slows down the progression at the end of adolescence when the body growth ceases.[9,10] The early onset is supposed to occur because the elongation of the eye is poorly compensated by corneal flattening.[7,10,11] The last variety starts after adolescence, does not progress as much as the first type. In both myopia types, it has been demonstrated that an increase in the Axial Length (AL) of the eyeball is the main factor related to its progression in children[10-12] and adults.[6,13]

The aim of this study is to determine the role of Axial Length (AL), Corneal Radius (CR) of curvature and the age of onset in relation to the power in myopia.

MATERIALS AND METHODS

After getting institutional ethical committee approval, the patients aged 10 to 30 years with simple myopia, range from -1.00 to -20.00 Dioptre Spherical (Dsph) were selected from the outpatient department. Pathological myopia, high astigmatism >1 dioptre, amblyopia or any other ocular diseases were excluded from the study. Before starting the study, informed consent was obtained from each subject.

Careful history was taken in all the patients with particular attention to the age of onset of their myopic power. The subjects were asked at which age their refractive defect appeared. If unsure, the subject was not included in this stratification.

The refractive status was obtained objectively (using streak retinoscope, Welch Allyn, USA) and subjectively (using trial lens set - American Optical). Spherical Equivalent Refractive (SER) status values in Dioptre Spherical (Dsph) were evaluated for individual eye of each subject. In case of associated astigmatism, <-1 Dioptre, SER was calculated by adding half the cylindrical component to the spherical component. Categorisation was done based on Myopia ≥ -1.00 Dsph.

The Bausch and Lomb keratometer (Bausch and Lomb Technology, USA) was used to measure the corneal radius (CR) of curvature. Average corneal curvature was obtained by the average of the horizontal and vertical corneal curvature. The keratometric reading (K value) for corneal curvature was measured in dioptre. The radius of corneal curvature (CR) in millimeter was obtained by converting the K value by using keratometry conversion table.

The Axial Length (AL) was measured with A-scan biometer (Appasamy) and the average of eight readings was calculated as the measured axial length. All measurements were taken between 9 a.m. and 12 noon.

The study population was characterised in terms of the factors CR and AL. These data were then stratified by myopic power group, the method most commonly used in this type of study[8] and by age of myopia onset, because according to some authors, the type and final amount of myopia depends upon its time of onset.[8]

RESULTS

In this prospective observational study 200 eyes of 100 patients with simple myopia were selected. Simple statistical principles of average and mean were used in this study.

The mean age of the patients was (mean ± S.D.) 20.06 ± 4.39 years with range 10-30 years and the median was 22.6 years. Proportion of males 55 (55.0%) was higher than that of females 45 (45.0%), but it was not significant ($Z=1.41$; $p=0.16$). Proportion of patients in the age group 15-25 years 70 (70.0%) was significantly higher than other age groups ($Z=5.65$; $p<0.0001$). 13 (13.0%) of the patients were between 10-15 years.

Results for the whole myopic eyes appear in Table 1. The mean power of the patients was -6.48 ± 4.21 D. Most of the power Dsph 162 (81.0%) was between -1.00 - 10.00, which was significantly higher ($Z=8.76$; $p<0.0001$). Only 6.0% had Dsph between -15.01 - 20.00. The mean refraction of males -6.89 ± 4.89 D was significantly higher than that of females -5.98 ± 3.14 D ($t_{98} = 2.14$; $p=0.034$).

In comparison with Axial Length (AL), it had been found that myopic power was far from normal (Table2). The mean AL of males 24.93 ± 1.91 mm was higher than that of females 24.86 ± 1.67 mm, but it was not significant ($t_{98} = 0.19$; $p=0.84$). The mean AL of the patients was 24.90 ± 1.80 mm. Most of the myopic eyes, 111 (55.5%) had axial length between 24-27 mm, which was significantly higher ($Z=3.71$; $p<0.001$). In only 29 (14.5%) of the myopic eyes had AL between (27-30 mm).

Among the groups, it had been found that majority of myopic eyes 50 (58.8%) of Group A belonged to smaller AL (21-24 mm), 61 (79.2%) of Group B belonged to middle order AL (24-27 mm), 24 (92.3%) of Group C belonged to AL (24-30 mm) and 8 (66.7%) of Group D belonged to longer order AL (27-30 mm). Also, a negative correlation between myopic power and AL was found ($r=0-71$; $p<0.001$). AL increased from low-to-high myopia.

Table 3 indicates a trend in the CR towards a smaller radius of curvature in moderate myopia.

The mean radius of corneal curvature (CR) was 7.55 ± 0.30 mm There was no significant difference in mean radius of corneal curvature (CR) of males (7.57 ± 0.29 mm) and females (7.52 ± 0.32 mm) ($p>0.05$). Also, a negative correlation between CR and AL was found ($r=0-67$; $p<0.001$), which established that there was an inverse relationship between these two factors.

The mean age of onset of myopia of the patients was 4.34 ± 0.37 years. Out of total 200 myopic eyes, the majority 84 had age of onset during 3 years to less than 5 years. 74 myopic had late onset, i.e. 7 years to 9 years. The rest 42 eyes were suffered during the age group of 7 years to 9 years (Table 4).

Myopia was classified as adult onset (6-9 years) myopia in 88 eyes and as juvenile onset (3-<6 years) myopia in 112 eyes. Table 5 shows the mean values obtained for the 4 variables considered (power, CR, AL and age) in the two sets of myopia.

The single morphometric variable most correlated with the refractive error was yet again the AL in both types. This relationship is again more intense in the juvenile onset myopia group. The CR continued to show a significant relationship with AL in the two groups of myopes that was somewhat higher in the adult onset myopia group than in the juvenile onset group. Slight differences emerged when we compared the CR values recorded in Table 5 for these two groups of myopic subjects (juvenile and adult onset). The values of mean AL/CR ratio obtained from this study was 3.12 ± 0.72 (Group A), 3.34 ± 0.75 (Group B), 3.57 ± 1.06 (Group C) and 3.71 ± 1.22 (Group D) (Table 6).

Group	Power Dsph	Number of eyes	%
A	-1.00 - -5.00	85	42.5
B	-5.01 - -10.00	77	38.5
C	-10.01 - -15.00	26	13.0
D	-15.01 - -20.00	12	6.0
Total		**200**	**100.0**

Table 1. Distribution of Myopic Eyes According to the Power Group

Myopic Power (Dsph)	Axial Length (mm)		
	21.0-24.0	24.1-27.0	27.1-30.0
A (1.0-5.0)	58.82%	41.18%	0.00%
B (5.1-10.0)	9.09%	79.22%	11.69%
C (10.1-15.0)	7.70%	46.15%	46.15%
D (15.1-20.0)	8.00%	25.00%	67.00%

Table 2. Percentage Distribution of AL in Relation to the Different Myopic Power Groups

Myopic Power (Dsph)	Radius (mm)		
	6.0-7.0	7.1-8.0	8.1-9.0
A (1.0-5.0)	3.53%	89.41%	7.06%
B (5.1-10.0)	1.30%	93.51%	5.19%
C (10.1-15.0)	15.38%	76.92%	7.70%
D (15.1-20.0)	8.33%	91.67%	0.00%

Table 3. Percentage Distribution of CR in Relation to the Different Myopic Power Groups

Myopic Power (Dsph)	Age of Onset (in Years)		
	3.0-5.0	5.1-7.0	7.1-9.0
A (1.0-5.0)	29 (34.12%)	17 (20.00%)	39 (45.88%)
B (5.1-10.0)	38 (49.35%)	16 (20.78%)	23 (29.87%)
C (10.1-15.0)	9 (34.61%)	8 (30.78%)	9 (34.61%)
D (15.1-20.0)	8 (66.67%)	1 (8.33%)	3 (25.00%)
Total (n=200)	**84**	**42**	**74**

Table 4. Percentage Distribution of Age in Relation to the Different Myopic Power Groups

Parameters (Mean ± S.D.)	Juvenile Onset (3-6 years)	Adult Onset (6-9 years)
Power (Dsph)	6.73 ± 4.36	6.16 ± 4.01
CR (mm)	7.52 ± 0.32	7.58 ± 0.27
AL (mm)	25.02 ± 1.86	24.75 ± 1.72
Age (Years)	3.73 ± 0.84	7.5 ± 0.87

Table 5. Comparison of Average Power, CR, AL and Age of the Juvenile and Adult Patients

Myopic Power (Dsph)	Power (Dsph)	CR (mm)	AL (mm)	AL/CR	Age (Years)
A (1.0-5.0)	3.13 ± 1.04	7.59 ± 0.31	23.68 ± 1.13	3.12 ± 0.72	5.78 ± 2.06
B (5.1-10.0)	6.52 ± 1.37	7.56 ± 0.23	25.28 ± 1.27	3.34 ± 0.75	5.09 ± 2.02
C (10.1-15.0)	12.60 ± 1.40	7.45 ± 0.40	26.56 ± 1.72	3.57 ± 1.06	5.38 ± 2.02
D (15.1-20.0)	16.75 ± 2.01	7.42 ± 0.29	27.52 ± 2.16	3.71 ± 1.22	4.58 ± 2.06

Table 6. Comparison of Average Power, CR, AL, AL/CR and Age of Onset of the Patients in Different Myopic Groups

DISCUSSION

This cross-sectional, observational study was conducted to establish the relationship between the anatomical variation in the morphology of the eyeball and the refractive (myopic) state and to determine the extent to which these observations contribute to the appearance and degree of myopia. The present study was also designed to evaluate to what extent the main ocular morphological components are related to the myopic error and secondly to investigate if the processes of myopisation could take place even at ages at which it is assumed that the body's structures have stopped growing.

In this study, the majority (70) of the myopic cases belonged to the age group of 15 to <25 years that was significantly higher than other age groups .The male candidates were greater (n=55) in number than the female (n=45). It may be due to the fact that the males have to do more outdoor works and need refractive correction. Another fact maybe the males are taller and have longer axial length 1. Most 162 (81.0%) of the myopic power was between -1.00 - -10.00. The mean refraction of males -6.89 ± 4.89 D was higher than that of females -5.98 ± 3.14 D, which was statistically significant (t_{98} = 2.14; p=0.034).

But, in our study, the difference in mean AL between males (24.93 ± 1.91 mm) and females (24.86 ± 1.67 mm) was not statistically significant.

The anatomical axial length has been found to be one of the key variables used in assessing the refractive status of the eye.[2,3] The increase in AL causes gradual increase in myopic power. The radius of corneal curvature (CR) was found maximum within the range of 7.00-8.00 mm in the entire power group. It was clear from this study that the radius of corneal curvature was longer in low power group and gradually shorter in higher power group. So, the radius inversely relates with the myopic power.

The AL and CR values observed in our study population are in general agreement with those provided by other authors for similar population.[3,14-17] The value of mean AL/CR ratio (Group A) obtained from this study was 3.12 ± 0.72 mm. This was comparable with 3.16 (SD 0.12) for myopes.[18] The value is also in agreement with low myopes, 3.01 (SD 0.07) and 3.10 (SD 0.11) for moderate myopes reported by Yebra-Pimentel et al.[19] The inverse relationship between axial length and corneal radius of curvature supports the mechanism of emmetropisation.

The axial length increases tending to bring about myopia, the cornea tend to flatten bringing a decrease in myopia.[18,20] This mechanism brings about a greater frequency of emmetropia than is expected on the basis of chance alone. The inverse correlation between axial length and corneal radius of curvature demonstrates the eye's ability to compensate for normal physiologically driven axial length changes. The course of myopia differs depending on the moment in time the eye starts to become myopic.

Myopia can be classified into two main categories according to the age of its appearance as juvenile-onset myopia or adult-onset myopia. The former usually starts below the age of 6 years and stops or slows down its progression as soon as the general physical growth stage ceases at the end of adolescence. This type of myopia is thought to occur because the elongation of the eye is insufficiently compensated by the flattening of the cornea. The late onset myopia initiates after adolescence and does not progress as much as the early type such that a considerable number of persons develop myopia or experience an increase of their myopia after this age.

CONCLUSION

A greater AL of the eye was observed in all the types of myopia examined irrespective of other factors such as changes in CR. Hence, axial lengthening is the main morphological factor related to myopia whether low or moderate in both juvenile and adult onset myopes.

The CR is not a determining factor of the myopia, although we observed a tendency towards smaller radii of curvature in moderate myopias.

The cornea seems to play an emmetropising role in preserving emmetropia or low myopia. This emmetropising capacity could be insufficient when there is excessive axial lengthening of the ocular globe with the consequent appearance of myopia.

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