The axial length and corneal radius of curvature ratio in Sudanese adult myopes

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Abstract

Purpose: Evaluating association of axial length and corneal radius of curvature ratio (AL/CR) with myopia among Sudanese adults.

Methods: The Observational, cross sectional study was conducted at Makka Eye complex Omdurman and University Eye complex clinic from March to July 2015. Corneal radius of curvature, axial length and the degree of myopia of 200 myopic eyes and 60 emmetropic eyes were measured and the axial length/ corneal curvature radius AL/CR ratios calculated.

Results: The mean AL/CR ratio for myopic subjects was 3.14 ± 0.164 ranging from 2.86 to 3.71. There was a positive correlation between AL/CR and age in myopes ($r = 0.31$, $p < 0.0001$). The mean CR and AL of myopic subjects were 7.57 ± 0.32 mm, and 26.18 ± 0.96 mm, respectively. Myopic eyes had a shorter CR ($t= 18.5$, $p< 0.0001$), a longer AL ($t= 11.00$, $p< 0.0001$) and thus, a higher AL/CR ratio ($t= -8.19$, $p< 0.0001$) than the emmetropic eyes.
Linear regression indicated a 11.9D shift in myopia with each 1 unit change in AL/CR ratio ($r2 = 58\%$, $p < 0.0001$), a 1.6 D shift in myopia with each 1mm change in AL ($r2 = 37\%$, $p < 0.0001$), and a 3.3 D shift in myopia with each 1 mm change in CR ($r2 = 22\%$, $p < 0.0001$).

Conclusion: The study shows that myopic adults had shorter CR, longer AL and higher AL/CR ratio when compared with emmetropic subjects.

Keywords: Axial length/corneal radius of curvature ratio AL/CR; axial length AL; corneal radius of curvature CR; refractive state in SE.

Introduction

Myopia or nearsightedness is one of the most important causes of blindness and low vision [1-3]. Both genetic and environmental factors appear to contribute to the development of myopia [4-10].

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Myopia results from either the eye having a relatively long axial length or an increased dioptric power of one or more of the refractive media. Many studies on the relationship between refractive error and ocular axial length (AL), anterior chamber depth, corneal radius of curvature (CR), keratometric readings as well as other ocular biometric variables such as lens thickness and vitreous chamber depth, the most important biometric variable that affected final refractive status was found to be AL[1-4]. The axial length is defined as the distance from the anterior corneal surface to the retina measured along the visual axis. Studies [11, 12] have shown that axial length is strongly related to the degree of refractive error. Corneal curvature is important for corneal refractive surgery as well as diagnoses and management of corneal pathological conditions such as keratoconus, contact lens fitting and management, ocular aberration analysis, and it is an important biometric factor affecting refractive errors, myopia inclusive [5]. The relationship between CR and refractive status has been conflicting. Some researchers reported flatter cornea to be associated with increasing myopia[13,14], while others observed no correlation between refractive error and CR in different refractive groups [15], in contrast to this, myopic subjects were found have a smaller CR than emmetropes [16, 17]. All previous studies have revealed AL has a larger effect on inducing refractive errors as compared to CR. While many studies have shown a more important role for the AL/CR ratio than for AL alone, furthermore, the correlation between spherical equivalent (SE) refractive error and this variable was stronger than that with each of its components alone. Subsequently, other studies have pointed that the AL/CR ratio as the most important biometric factor in myopia, especially high myopia [18-21].

As it is very much clear that the great effect of AL/CR ratio on refractive errors, so determining its association to refractive error among studied group is very useful because it will open a number of gates in future for study on this important topic. However, many researches have been done so far globally but not been carried out in Sudan, hence the need for data from Sudan to aid in global comparison.

Methods

The research was an observational cross-sectional study; involving 100 consecutive myopes (200 eyes) and 30 emmetropes (60 eyes). The participants were all patients from University Eye Hospital clinic and Makka eye complex Omdurman located in Khartoum state. The participants were free from ocular and systemic diseases and had bilateral myopia. Ethical clearance was obtained from the Ethical and Research Committee of the Hospitals, Informed consent from all the participants was obtained. Refraction in the spherical equivalent and corneal curvature was measured using Auto-keratorefracto-meter (Topcon KR.880, version 1.25). The greatest and least corneal radii of curvature were measured for each eye, and the average was recorded as the corneal radius of curvature in millimeters. All participants underwent systematic axial length AL measurements by A-scan ultrasonography. Pearson correlation coefficient was used to correlate the parameters. A two-tailed probability of 0.05 was considered statistically significant. Linear regression was used to relate AL/CR ratio, AL, and CR and the refractive power of myopes in adults Sudanese

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Results:

There was a total of 100 participants (200 myopic eyes), between the ages of 16 to 35 years old. The myopic power ranged from -1.00D to -11.00D with a mean of -4.79± 2.55 D and 30 emmetropic (60 eyes). Of the 100 myopes, 57 were females; and 43 were males. The mean axial length AL was 23.7±26mm. This ranged from 21.5mm to26.2mm (table.1); whereas the mean corneal radius of curvature CR was 7.57±0.32 mm and it ranged from 6.78mm to 8.03 mm. In the myopes, the mean AL/CR was 3.14±0.164, this ranged from 2.86 to 3.71. The AL/CR ratio increase with age (r =0.31; p < 0.0001), with a significant difference with sex (t = 1.87; p = 0.05). From table3; males had a shorter CR (t= - 2.57: p = 0.011, and are more myopic than females (t = 3.00; p = 0.003).The axial length of the less than 25 years old was shorter (t = -2.86; p = 0.005), they had a flatter curvature of the cornea (t = 3.35; p = 0.001), and a lesser degree of myopia (t = -5.5; p < 0.0001). The AL/CR ratio is lower in the less than 25 years olds (t = - 5.2; p < 0.0001) (Table.5). Myopic adults had a longer axial length (t = 11.00; p < 0.0001), a higher AL/CR ratio (t = 18.5; p < 0.0001), and steeper corneal curvature (t = - 12.4; p < 0.0001) than emmetropes. Furthermore, linear regression revealed 1.6, -3.3, and 11.9 diopter shift in myopia for each 1 unit change in axial length, corneal radius of curvature, and AL/CR ratio respectively (R2= 37; 22; 58 %) (Figures 1,2,3). T-test showed that adults with mild myopia had a significantly shorter mean AL, a longer CR, and a lower AL/CR ratio compared with marked myopes (Table. 6).refractive power of myopes in adults Sudanese

Discussion:

The mean myopic correction was – 4.80 D; this ranged from -1.00D to -11.00D. The mean AL/CR ratio for myopic adults was 3.14±0.164; this ranged from 2.86 to 3.71. Lower results (3.08, 3.09) have been reported in similar studies [3, 22], while higher result (3.16) has been observed in other studies [23, 24]. These differences in results might be due to the differences in the refractive error ranges, age groups, sample size, ethnicities, and methods of measurement of ocular parameters. There was a significantly higher AL/CR ratio in myopes than emmetropes (p< 0.0001). Similar results have been found in several studies[3, 20, 23, 25]. Furthermore, there is an association between AL/CR ratio and age (r=0.31, p< 0.0001); and males had higher AL/CR ratio than females (t= 1.87, p= 0.05) with an overall mean difference of 0.043. Similar results were found by Chang et al. [2] in Chinese schoolchildren who reported that the mean AL/CR ratio increased with age, and with a gender bias.

The mean axial length for the study group was 23.7 ± 0.96, this finding was found to be slightly lower than what was reported by several studies [2, 3, 22] AL was found to be 24.09, 24.2, and 24.29 mm respectively. These differences in results might be due to the differences in the refractive error ranges, age groups, sample size, ethnicities, and methods of measurement of ocular parameters. The mean AL had a weak positive correlation with age (r = 0.17; p = 0.015), Independent t-test showed a significant difference (t=7.4; p< 0.0001) between myopic and emmetropic axial lengths with an overall difference of 1.78 mm; however myopic participants had a longer axial and an increased radius of curvature. There was no significant difference in axial length in males and females (t= 0.22; p= 0.83). These findings disagreed with studies [20, 26]- that women tend to have a shorter AL. A similar study in Sudan observed by Alsamani AI, Mohamed Ali AB [27] reported that high myopes have longer axial length (AL) compared to low myopic subjects. Chen et al. [28] also reported that eyes with more myopic refractive error tended to have greater axial length.

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The corneal radius curvature of studied group had a mean value of 7.57 ± 0.32 mm, higher results have been pointed in other studies [3, 19, 22, 29] CR was reported to be 7.85, 7.719, 7.68, and 7.69 respectively. In the study, females had a flatter corneal curvature, that is a longer CR; (t =2.49, p= 0.005) with an overall difference of 0.095 mm. A different result were observed by Scheiman M et al [29] who reported that females had steeper corneal curvature than males. The reasons for these discrepancies might be due to ethnicity, anatomical differences between races Furthermore, in the study, myopes had steeper curvature than emmmtropes t= 18.5, p< 0.0001) and the corneal curvature becomes steeper with increasing power (t= 6.62, p< 0.0001). These findings agree with Lam et al 30 who pointed that myopes usually have steeper corneas, followed by the emmetropes and that the hyperopes tend to have less steep corneas. Similar results were found by Iyamu et al [22] reported a significantly steeper cornea in myopes, and Xiangui He et al [2] they reported that CR for myopes and emmetropes were found to be 7.82 and 7.86 mm respectively. In contrast another study [3] found that the myopes have flatter cornea as CR for myopes and emmetropes were found to be 7.85 and 7.82 mm respectively. The reason for this discrepancy may need to be verified by further studies, which could be due to ethnicity or anatomical differences.

In the study, contribution of AL to the variability of myopia SE was found to be 37%, while AL/CR ratio accounted for about 58% of the variation, and CR accounted for about 22% of the variation in myopia SE. These results are in agree with previous studies [2,3, 28] reported AL/CR ratio and AL contribution on SE variability was found to be 51%, 39%; 65.7%, 43.1%; 56%, 35.1% respectively. Moreover, linear regression in the current study showed for each 1 unit change in AL/CR ratio there was 11.9 diopters myopia shift (Fig.1). These results are in agree with previous studies[2, 3, 18]. They found -10.72, and -12.10 D shift for each 1 unit change in AL/CR ratio. As soon as for each 1 mm change in AL, CR there was -3.30, -1.60 diopters shift in myopia which is very low compared with AL/CR ratio effect. These results are in agreement with previous studies[2, 3, 21, 22, 25, 28] where they reported AL/CR ratio was the prominent determinant for SE compared with AL and CR (CR had the least effect), hence confirmed the important of AL/CR ratio as the most effective factor in determining refractive state SE for myopia so it can be used in estimating refraction especially when it is impossible to obtain refraction or in serious cases as in cycloplegic refraction for children or any other critical case.

Conclusion

Study concluded that AL/CR ratio has a strong determinant than AL or CR separately. Myopic adults had shorter CR, longer AL and higher AL/CR ratio compared with emmetropic subjects. AL/CR ratio can be used to determine refractive state SE in cases when refraction is difficult to assess.

No Conflicts of interest

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Table.1 Characteristics of myopic and emmetropic participants

Characteristic		No of eyes	Minimum	Maximum	Mean	SD
AL in mm	Myopes	200	21.5	26.2	23.7	0.96
	Emmetropes	60	22.0	23.5	22.4	0.54
CR (mm)	Myopes	200	6.78	8.03	7.57	0.32
	Emmetropes	60	7.78	8.03	7.96	0.082
AL/CR ratio	Myopes	200	2.86	3.71	3.14	0.164
	Emmetropes	60	2.74	3.02	2.81	0.076
SE (diopters)	Myopes	200	1.0	11.0	4.8	2.6
Age (yrs)	Myopes	200	16	35	22.4	3.6

AL= axial length, SE=Spherical Equivalent, CR= corneal curvature.
N (200 myopic, 60 emmetropic eyes).

Table.2 Distribution of adult myopes by gender and age

	Ages		Total	
Gender	less than 25	25 and above		%
Male	68	18	86	43
female	106	8	114	57
Total	174 (87%)	26(13%)	200	100

Most of Sudanese adults' myopes were females (females, 57%; males, 43%; =3.92, p= 0.04), 87% of subjects were less than 25 years of age (=109.5; p < 0.0001).

Table.3 Mean differences in myopic variables between males and females and p-value.

Characteristic	Male	Female	t	p-value
AL (mm)	23.71	23.68	0.195	0.85
CR (mm)	7.5	7.6	-2.57	0.011
AL/CR ratio	2.86	3.71	1.87	0.05
SE (diopters)	-5.40	-4.33	3.00	0.003

AL= axial length, SE=Spherical Equivalent, CR= corneal curvature

Table.4 Myopic measurements correlation

Variable pairs	R	p-value	R^2
SE and CR	0.42	< 0.0001	22
SE and AL/CR	0.76	< 0.0001	58
SE and AL	0.61	< 0.0001	37
Age and CR	-0.28	< 0.0001	8
Age and AL/CR	0.31	< 0.0001	10
Age and AL	0.17	0.015	3

AL= axial length, SE=Spherical Equivalent, CR= corneal curvature

Table.5 myopic age groups comparison of parameters

Variable	Less than 25	25 and above	t	p- value
AL	23.6	24.2	-2.86	0.005
CR	7.6	7.4	3.35	0.001
SE	-4.43	-7.19	-5.5	< 0.0001
AL/CR	3.11	3.28	-5.2	< 0.0001

AL= axial length, SE=Spherical Equivalent, CR= corneal curvature

Table.6 shows myopic groups parameters mean:

Class	AL in mm	CR in mm	AL/CR ratio	N
Mild	23.25± 0.67	7.66± 0.19	3.04± 0.10	110
Marked	24.23± 0.99	7.43± 0.30	3.26± 0.16	90
Total	23.7± 0.96	7.57± 0.32	3.14± 0.15	200

AL= axial length, SE=Spherical Equivalent, CR= corneal curvature
T-test showed adults with mild myopia had significantly shorter mean AL, longer mean CR, and lesser mean AL/CR ratio compared with marked myopes (t= -8.38, 6.62, and - 12.72; p-value < 0.0001, < 0.0001, and < 0.0001 respectively).

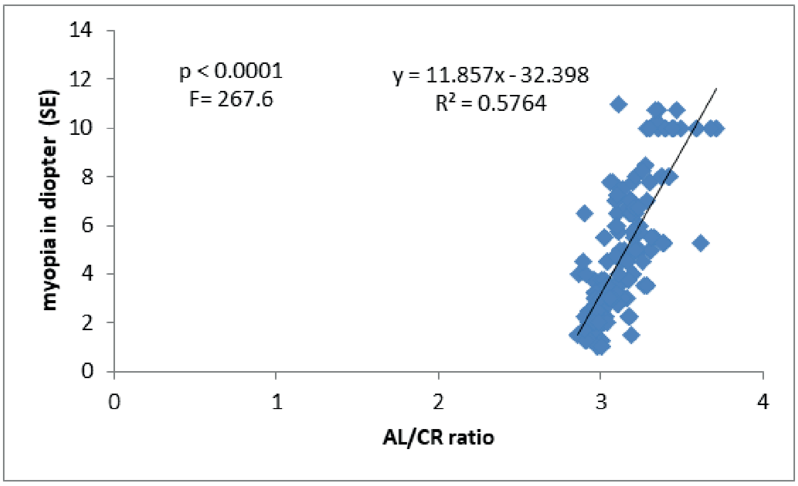

Figure.1 Shows linear regression of SE and AL/ CR ratio of myopic adults' subjects

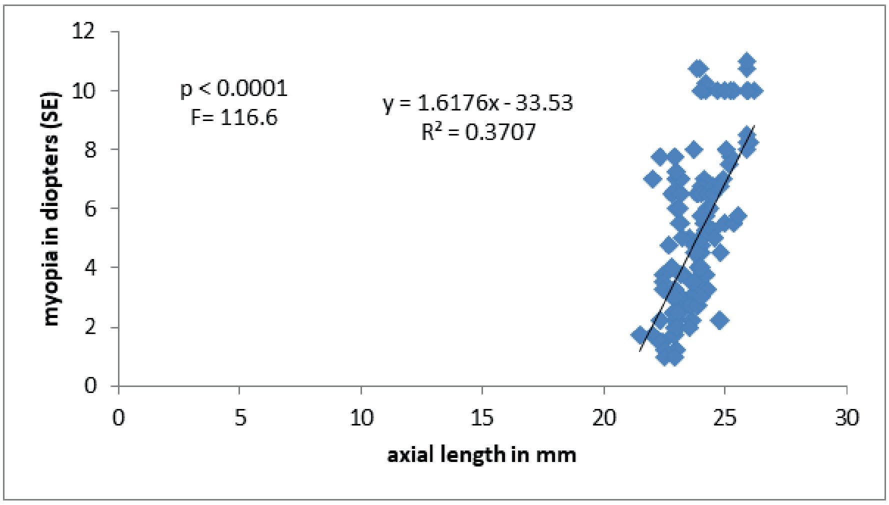

Figure.2 Shows linear regression of SE and AL of myopic adults' subjects

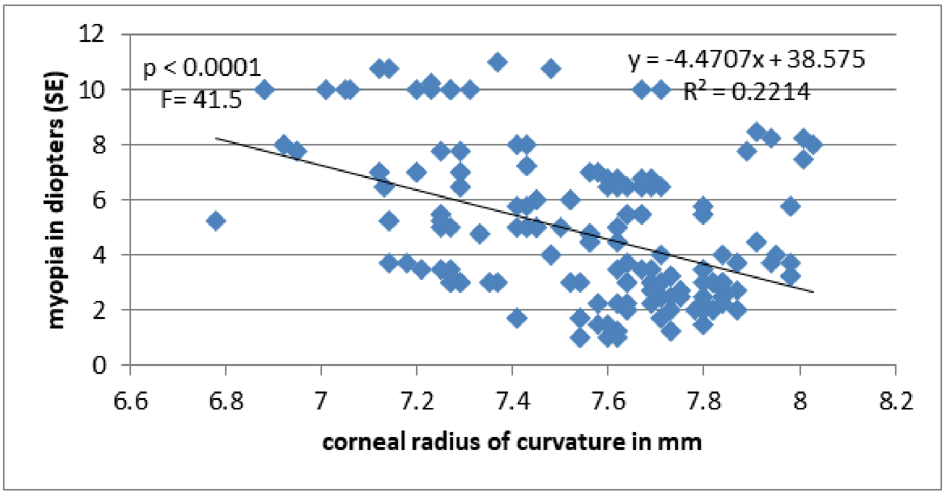

Figure.3 Shows linear regression of SE and CR ratio of myopic adults' subjects