

Role of Axial Length and Corneal Radius of Curvature Ratio in Determination of Refractive Status of Eye in North-West Indian Population

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Received: 04-11-2021 / Revised: 23-12-2021 / Accepted: 10-01-2022

Abstract

Introduction: The prevalence of refractive error defects has been extensively studied in several geographical areas on different ethnic population, because the eye anatomy varies so the effect of different ethnicity results in slight variation in different average parameters. This study is undertaken to know the correlation between axial length, corneal curvature and refractive state of eye in North-West Indian population. **Materials and Methods:** The present study is a cross-sectional observational study and was carried out in the department of Anatomy and a private eye hospital of the north western Indian region. Study group consists of 78 male and 72 female subjects between the age group of 18 to 70 years. The axial length was measured through A-scan ultrasound and Nikon NRK 501 refractometer was used for taking the measurement of corneal radius of curvature. The AL/CR ratio calculated and subjects were categorized into three groups- Emmetropes, Hypermetropes and Myopes according to measured refractive status. **Statistical Analysis:** The Pearson correlation analysis was performed using SPSS software. A p-value < 0.05 was considered statistically significant. **Results:** The Mean axial length (AL) and corneal radius of curvature (CL) found to be 23.453 ± 0.88 mm 7.79 ± 0.22 mm respectively. AL/CR ratio found as 3.01 ± 0.17; Strong inverse correlation of axial length and corneal radius of curvature ratio (AL/CR) was found with refractive state in males (r= -0.980) and females (r= -0.984). **Conclusion:** Study reports significant correlation between AL/CR ratio and refractive state of the eye. Thus, findings support the AL/CR ratio as a better index for categorizing the refractive status of an individual than axial length alone.

Keywords: Eye Axial Length, Keratometry, Refractive Errors.

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Introduction

The structure of the eye is complex. Changes in shape and size of elements of eye results in many disorders, most important disorder in these is Refractive error. For the vision, important phenomenon is refraction of light. Refractive components such as cornea, lens, axial length and anterior chamber depth are inter-dependent and responsible for refractive state of the eye.

Corneal Radius of Curvature (CR)

Centre of the cornea is considered as most refractive part of the eye. For the cornea average anterior radius is 7.8 mm and posterior radius of curvature is 6.5 mm when measured from central area. 45 Dioptre considered as average refractive power of cornea and the total refractive power of the eye average is (60D)[1].

Axial Length (AL)

Axial length is measured from the anterior pole to posterior pole of eye. On subjects it can be measured with the help of ultrasonography. This measurement is precisely measured between the anterior pole and the Bruch's membrane. The axial length of the eye grows from 17mm to 24 mm approximately; birth to adulthood. Myopes shows longer axial length whereas hypermetropes shows shorter axial length from the reference point of 24 mm[2].

Refractive Errors

Light focusing error of the eye results in visual power reduction this defect of focusing is called as refractive error. The reporting of refractive errors is subjective to the definition of the refractive errors[3].

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For all blindness causes the refractive errors stands out as second most common cause in India[4]. The prevalence of refractive error defects has been extensively studied in several geographical areas on different ethnic population including various age groups because the eye anatomy varies so the effect of different ethnicity results in slight variation in different average parameters[5-7].

A study in Norway has found prevalence rate of 13% -17% in the condition of hypermetropia and 30%-35% of myopia[8]. In India a population-based study has reported that in children's less than 15 years of age prevalence of myopia is 3.19% and hypermetropia is 62.62% when compared to 15 years above population the data came out as 19.45% for myopia and 8.38% for hypermetropia[9].

An eye which is in emmetropic condition corrective lenses are not required. Emmetropization is a continuous process observed by eye since birth; act as fine adjustment in ocular components and the axial length of eye. When the parallel rays of light fail to focus exactly on retina in resting state, this results in refractive error and the condition is called as in Ammetropia[10]. Ammetropia can result in two ways; a) Myopia or near sightedness, b) Hypermetropia or farsightedness.

Calculative ratio between axial length and corneal radius of curvature (AL/CR) gives better correlation with the refractive status of eye than it is obtained by both of these variables independently[11]. In present study two refractive components were selected that is axial length and corneal radius of curvature. Interaction between these two is helpful in emmetropisation. Both these components have an independent role in development of refractive error. Morphometric changes in axial length and curvature results in axial and curvature ametropia respectively.

In the view of the importance of assessing refractive error in different populations, this study is undertaken to know the correlation between axial length, corneal curvature and refractive state of eye in North-West Indian population.

Aims and Objectives

To find out correlation between axial length and corneal radius of curvature ratio (AL/CR) and refractive error in North-West Indian population.

Materials and Methods

The present study is a cross-sectional observational study and was carried out in the department of Anatomy and a private eye hospital of the northwestern Indian region. The study group consists of 78 male and 72 female subjects between the age group of 18 to 70 years. The study was conducted in compliance with ethical standards and written informed consent was obtained from all the study participants. Random and convenient sampling method were adopted for selection of study subjects from outpatient department of tertiary eye hospital.

Inclusion Criteria

No history of ocular trauma or surgery, No contact lens wear, No fundus infection and age 18 years or above.

Measurement of Axial Length (AL)

Axial length is distance between anterior and posterior pole of eye. The axial length was measured through A-scan ultrasound with the help of probe which was sterilized with 70% alcohol and air-dried. A drop of Procaïn (topical anaesthetic) was instilled in subject's eye. The axial length as displayed on screen taken and at least three readings average value considered for final axial length in mm.

Measurement of Corneal Radius of Curvature (CR)

Average corneal radius of curvature (CR) measurement has important aspect of reflection in clinical setup, it is approximately 7.7 mm in healthy eye, measured through keratometry. Nikon NRK 501 refractometer was used for taking the measurement of corneal radius of curvature. For keratometry, the eyepiece was adjusted for the optometrist's refractive status. Three measurements are taken and the average values for vertical and horizontal corneal curvature is recorded along the appropriate meridians. The average of both values is taken as the average Corneal radius of curvature[12].

Measurement of Axial Length and Corneal Radius of Curvature Ratio (AL/CR Ratio)

The AL/ CR ratio for each subject was obtained by dividing the axial length by the corneal radius of curvature.

Refractive Status of the Eye

Refractive status of eye was measured by automatic refractometer and subjectively with the trial lens set. Subjects were categorized into three groups- Emmetropes +/- 0.50 D (Dioptre), Hypermetropes > + 0.50 D, Myopes > - 0.50 D according to their measured refractive status.

Statistical Analysis

As indicated in previous studies (4,6) analyses were performed on right eye only. Descriptive analysis as Mean, Range and t -test was

performed. The pearson correlation analysis was performed using SPSS software. A p-value < 0.05 was considered statistically significant.

Results

A total 150 subjects out of which 78 males and 72 females were selected for Measurement. Out of three refractive statuses, myopes were reported in large numbers and least number of subjects recorded in emmetropes. In refractive status myopes females were reported more than myopes males (Table 1).

The Mean axial length found to be 23.453 ± 0.88 mm, in males it is 23.49±0.86 mm and in females it is 23.46 ± 0.90 mm. There is no statistically significant (p=0.370) difference was found in males and females' axial length Mean values, although males have slightly larger axial length than the females (Table 2). Effect of age on axial length is also not statistically significant (P >0.05) when compared in various age groups. Mean axial length in emmetropes, myopes and hypermetropes recorded as 23.42 ± 0.44 mm, 24.30 ± 0.57 mm and 22.61 ± 0.49 mm respectively. Strong inverse correlation was found between axial length and refractive state in males (r= -0.901) and females (r= -0.900) (Table 3).

Mean corneal radius of curvature is 7.79 ± 0.22 mm. In males it is 7.81 ± 0.21 mm and in females it is 7.78 ±0.23 mm. There is no statistically significant (P = 0.414) difference was found in males and females mean values (Table 2). Effect of age on corneal radius of curvature is also not statistically significant (P > 0.05). Mean corneal radius of curvature in emmetropes, myopes and hypermetropes recorded as 7.81 ± 0.11 mm, 7.62 ± 0.19 mm and 8.01 ± 0.09 mm respectively. There is strong inverse correlation (r= -0.81) found between axial length and corneal curvature, which shows change in axial length is overcome by corneal curvature. Positive correlation between corneal radius of curvature and refractive state was found in males (r=0.772) and females (r= 0.851) (Table 3).

Mean axial length and corneal radius of curvature ratio is calculated as 3.01 ± 0.17; in males and females it is 3.01 ± 0.16 and 3.0 ± 0.18 respectively. On statistical analysis we found that there is no statistically significant (P=0.726) difference in males and females (Table 2). Effect of age on axial length and corneal radius of curvature ratio (AL/CR) is also not statistically significant (P > 0.05).

Mean axial length and corneal radius of curvature ratio (AL/CR) in myopes it is 3.18 ± 0.09 and in emmetropes it is 2.99 ± 0.22, where as in hypermetropes it is 2.81 ± 0.08. Strong inverse correlation of axial length and corneal radius of curvature ratio (AL/CR) was found with refractive state in males (r= -0.980) and females (r= -0.984) (Table 3)Fig. 1. AL/CR ratio shows highly significant corelation with refractive state than axial length alone (Table 3).

Table 1: Distribution of the subjects according to gender and refractive state

Sr. No.	Refractive status	Male		Female		Total	
		Number of subjects	%	Number of subjects	%	Number of subjects	%
1	Emmetropes	22	28.2	18	25	40	26.66
2	Hypermetropes	26	33.33	22	30.55	48	32
3	Myopes	30	38.46	32	44.44	62	41.33
	Total	78	100	72	100	150	100

Table 2: Statistical significance of various parameters in male and female groups

Parameters	Groups	Mean	SD	T-Value	P-Value
Axial length (AL) (mm)	Total	23.453	±0.88	-	-
	Male	23.49	±0.86	0.899	0.37
	Female	23.46	±0.909		
Corneal curvature of radius (CR) (mm)	Total	7.79	±0.22	-	-
	Male	7.81	±0.217	0.818	0.414
	Female	7.78	±0.232		
AL/CR ratio	Total	3.01	±0.17	-	-
	Male	3.01	±0.166	0.351	0.351
	Female	3.0	±0.182		

p-value < 0.05 was considered statistically significant.

Table 3: Correlation of axial length (AL), corneal radius of curvature (CR) and AL/CR ratio with Refractive Error

S. No.	Parameters	Males (78)	Females (72)
		r- Value	r- Value
1	Corneal radius of curvature	0.772*	0.851*
2	Axial length	-0.9014 [†]	-0.9006 [†]
3	AL/CR	-0.98 [†]	-0.984 [†]

*Significant, [†]highly significant, r- Pearson’s correlation coefficients, p-value < 0.05 was considered statistically significant.

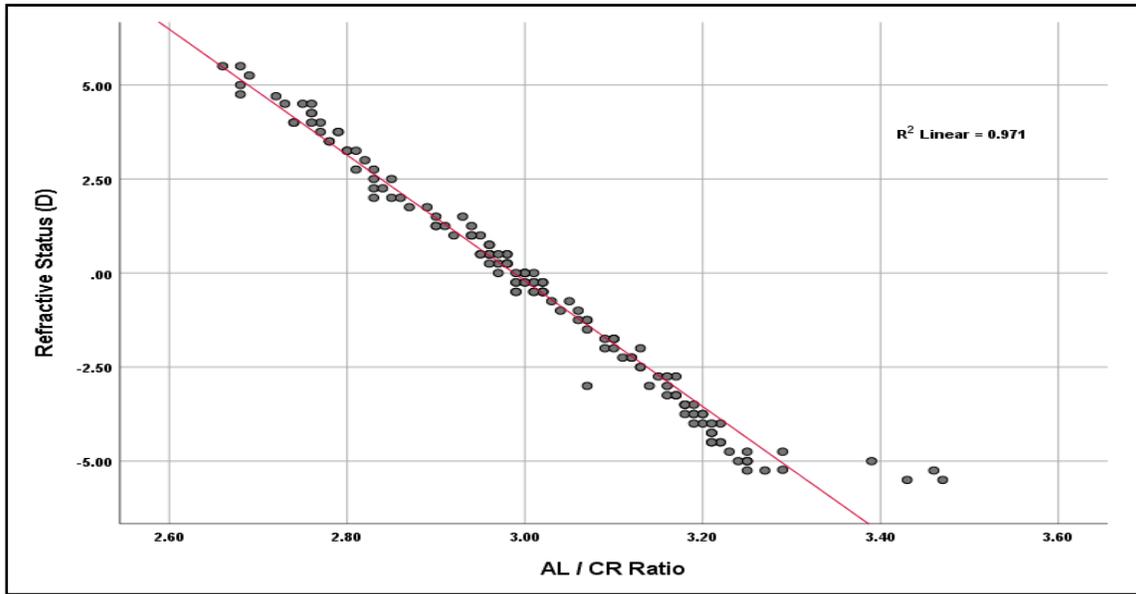


Fig. 1: Axial Length and Corneal radius of curvature Ratio

Discussion

Axial length and corneal curvature are important predictors of the Progression of the refractive errors[13]. As refractive errors are the commonest optical defect; In the whole world around 180 million blinds reported and refractive errors stands at second most common cause of the blindness in India[2].India contributes up to 60% in the blind population, Blindness due to refractive errors shows that there is a lack of awareness about the refractive errors. Axial length and corneal curvature both plays an important role in refractive status of the eye. Interaction between axial length and corneal curvature have

played a role in compensatory adjustments of the optical components of the eye towards emmetropic state[14]. According to a study reported that there was a significant association present between axial length and corneal radius of curvature and spherical equivalent refraction (SER) and it is a better index for categorizing the refractive status of an individual than axial length alone[12].Instead of axial length alone the axial length and corneal radius of curvature ratio (AL/CR) has been shown to give a better correlation with refractive error[4,15].

Table 4: Studies Reporting AL, CR, and AL/CR Ratio

Author's Names	Study Population	Number of Subjects	Mean ± SD Age (y) or Age Range	AL/CR Ratio or Mean ± SD Ratio	Mean AL or Mean ± SD AL (mm)	Mean CR or Mean ± SD CR (mm)
Wong TY,(24) 2001	China	1717	40-84	3.04	23.23 ± 1.17	7.6 ± 0.27
Mallen EA,(21) 2005	Jordan	1093	17-40	3.00 ± 0.13	23.13 ± 1.00	7.7 ± 0.30
Elvis Ojaimi,(11) 2005	Mixed population	1724	6.68	2.906 ± 0.002	22.61 ± 0.02	7.85 ± 0.01
Warrier S, (28)2008	Myanmar	1498	56.2 ± 11.5	2.99	22.76 ± 1.05	7.6 ± 0.50
Gonzalez Blanco F,(18) 2008	Spain	583	20.32 ± 2.82	3.05 ± 0.14	23.61 ± 1.05	7.7 ± 0.25
Lee DW,(17) 2010	Korean subjects	314	49.35		24.34 ± 1.42	
Pan CW,(4) 2011	India	2785	57.8 ± 10.1	3.08 ± 0.13	23.45 ± 1.10	7.61 ± 0.26
Eghosasere Iyamu,(12) 2011	Nigeria	70	27.9	3.03 ± 0.14	23.74 ± 0.70	7.84 ± 0.19
Hashemi H,(23) 2013	Iran	4820	40-64	3.03	23.14	7.63
Cao X,(5) 2015	China	3728	69.5 ± 8.05	3.03 ± 0.12	23.04 ± 1.49	–
Badmus SA,(6) 2017	Nigeria	350	34.8 ± 11.2	3.04 ± 0.10	23.78 ± 0.91	7.8 ± 0.28
He J,(16) 2017	China	6099	62.56 ± 8.00	3.08 ± 1.07	23.53 ± 1.34	–
Elmadina A M,(27) 2019	Sudanese adults	60	16 to 35	2.81 ± 0.076	22.4 ± 54	7.96 ± 0.082
Omoto MK,(7) 2020	Japan	1135	73.1 ± 7.78	3.15 ± 0.19	24.00 ± 1.53	7.6 ± 0.25
Current Study 2022	North western India	150	43	3.01 ± 0.14	23.52 ± 0.884	7.79 ± 0.224

AL = axial length; AL/CR = axial length to Corneal radius of curvature ratio; CR = Corneal radius of curvature; SD = standard deviation.

Axial Length (AL)

Mean axial length is obtained in present study is 23.52 ± 0.88 mm. similar mean value (23.53 ± 1.34 mm) is also reported by other studies[16] and (24.34 ± 1.42 mm)[17] (Table 4). The difference in the mean AL between males and females is not statistically significant (Table 2). The males showed slightly longer axial length than female. Similar finding also reported by other author, that male had significantly longer axial length[18]. We found significant inverse correlation between axial length and corneal radius of curvature ($r = -0.81$). Our results are consistent with the results of a study[19] in which an inverse correlation ($r = -0.75$) between axial length and corneal radius of curvature was found. A strong correlation was also reported between corneal radius and axial length in emmetropic eyes ($r = 0.63$, $p < 0.001$)[20]

Axial Length and Refractive Error

We studied the correlation of axial length and different refractive errors of the eye in males and females ($r = -0.9014$ and $r = -0.9006$). Negative correlation with refractive error is strong and significant which shows that elongation of axial length shifted the refractive status of eye towards myopic side. Axial length in different refractive status groups was statistically significant[19].

Corneal Radius of Curvature

The average value of Corneal Radius of Curvature 7.79 ± 0.224 mm obtained from this study, can be considered to be same with the average value reported by the previous studies[10,12] (Table 4). Central Corneal curvature in emmetropic group is 7.81 ± 0.16 mm, On the other hand following values were found by some more studies (7.7 ± 0.30)[21] and (7.7 ± 0.25 mm)[18]. The difference between corneal radius of curvature in males and females was not statistically significant (Table 2) as also reported in other study[19] (CR males 7.82 ± 0.19 and females 7.85 ± 0.19 mm).

Correlation of Corneal Radius of Curvature (CR) and Refractive Error

We found that myopes have small radius of curvature 7.62 mm than emmetropes, it is statistically significant ($p < 0.001$) and hypermetropes have CR mean of 8.01 mm and it is also statistically significant ($p < 0.001$). In an Indian study[22] it was also reported that change in mean CR in between different refractive status group was statistically significant with myopes having steeper corners than in emmetropes and hypermetropes had flatter corners.

Axial Length and Corneal Radius of Curvature Ratio (AL/CR)

The mean AL/CR value of 3.01 ± 0.14 found in present study is also reported by other authors[5,7,11,12,21,23,24] (Table 4). The difference in Mean (AL/CR) ratio in males and in females was not statistically significant ($p = 0.726$) as also reported by previous studies[11,19]. Interaction between axial length and corneal radius of curvature ratio can give better correlation with the refractive state of eye than is obtained by axial length or by corneal curvature alone[25,26]. There is not significant correlation between axial length and corneal radius of curvature persists ($P > 0.05$)[19].

Correlation of AL/CR Ratio and Different Refractive Errors Groups

We studied correlation between axial length and corneal radius of curvature ratio (AL/CR) and different refractive status groups in males and females. The AL/CR ratio had the significant correlation with refractive error ($r = -0.78$, $P < 0.0001$) (12). In the previous studies^{6,7} the correlation coefficient of the AL/CR ratio with the SER was greater than that of the AL with the SER; therefore, the AL/CR ratio may explain the total variation in the SER better than the AL alone. It is proposed that the relation between the (AL/CR) ratio and refractive error may be a useful predictor of future refractive status, also the eye having a high AL/CR ratio is at risk for the development of myopia. The inverse relationship between axial length and corneal radius of curvature supports the mechanising of emmetropization[19]. Another study[27] 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 SER

($r = 0.76$) in cases when refraction is difficult to assess. Refractive error was negatively correlated with the axial length-central corneal radius ratio ($r = -0.91$; $p < 0.001$) findings are similar to the present study ($r = -0.98$)[28]. AL/CR ratio can be considered as better index for categorizing the refractive status of an individual than axial length alone.

Conclusion

In conclusion there is a statistically significant correlation between AL/CR ratio and refractive state of the eye. Thus, findings support the AL/CR ratio as a better index for categorizing the refractive status of an individual than axial length alone. Higher AL/CR ratio is a risk factor for the myopia.

Acknowledgments

We are grateful for the support and guidance provided by the department of Ophthalmology. Dr Pankaj Dhaka Senior Surgeon Ophthalmology, ASG eye hospital.

References

- Grosvenor T, Goss Da. Role of the Cornea in Emmetropia and Myopia. *Optometry and Vision Science*. 1998; 75(2):132-45.
- Goswami A, Ahmed E, Saha PL, Roy IS. An epidemiological pattern of cases of refractive errors. *Journal of the Indian Medical Association*. 1979; 72(10):227-38.
- John H Kempen, Paul Mitchell, Kristine E Lee, James M Tielsch, Aimee T Broman, Hugh R Taylor. The Prevalence of Refractive Errors Among Adults in the United States, Western Europe, and Australia. *Archives of Ophthalmology*. 2004; 122(4):495-505.
- Pan C-W, Wong T-Y, Chang L, Lin X-Y, Lavanya R, Zheng Y-F et al. Ocular Biometry in an Urban Indian Population: The Singapore Indian Eye Study (SINDI). *Investigative Ophthalmology & Visual Science*. 2011; 52(9):6636.
- Cao X, Hou X, Bao Y. The Ocular Biometry of Adult Cataract Patients on Lifeline Express Hospital Eye-Train in Rural China. *Journal of Ophthalmology*. 2015; 2015:1-7.
- Badmus S, Ajaiyeoba A, Adegbehingbe B, Onakpoya O, Adeoye A. Axial length/corneal radius of curvature ratio and refractive status in an adult Nigerian population. *Nigerian Journal of Clinical Practice*. 2017; 20(10):1328-34.
- Omoto MK, Torii H, Hayashi K, Ayaki M, Tsubota K, Negishi K. Ratio of Axial Length to Corneal Radius in Japanese Patients and Accuracy of Intraocular Lens Power Calculation Based on Biometric Data. *American Journal of Ophthalmology*. 2020; 218:320-9.
- Midelfart A, Kinge B, Midelfart S, Lydersen S. Prevalence of refractive errors in young and middle-aged adults in Norway. *Acta Ophthalmologica Scandinavica*. 2002; 80(5):501-5.
- Dandona R, Dandona L, Srinivas M, Giridhar P, McCarty CA, Rao GN. Population-based assessment of refractive error in India: the Andhra Pradesh eye disease study. *Clinical & Experimental Ophthalmology*. 2002; 30(2):84-93.
- Waltman SR, Hart WM Jr. Adler's physiology of the eye: clinical application The cornea. In: Moses R.A., Hart W.M. Jr. 8th ed. Moses R.A., Hart W.M. Jr., editors. St. Louis: CV Mosby Coy, 1987, 36-59.
- Ojaimi E, Rose KA, Morgan IG, Smith W, Martin FJ, Kifley A, et al. Distribution of Ocular Biometric Parameters and Refraction in a Population-Based Study of Australian Children. *Investigative Ophthalmology & Visual Science*. 2005; 46(8):2748-54.
- Iyamu E, Iyamu J, Obiakor CI. The Role of Axial Length-Corneal Radius of Curvature Ratio in Refractive State Categorization in a Nigerian Population. *ISRN Ophthalmology*. 2011; 2011:1-6.
- Meng W, Butterworth J, Malecaze F, Calvas P. Axial length: An underestimated endophenotype of myopia. *Medical Hypotheses*. 2010; 74(2):252-3.
- Young TL. Complex Trait Genetics of Refractive Error. *Archives of Ophthalmology*. 2007; 125(1):38-48.

15. Ip JM, Huynh SC, Kifley A, Rose KA, Morgan IG, Varma R et al. Variation of the Contribution from Axial Length and Other Oculometric Parameters to Refraction by Age and Ethnicity. *Investigative Ophthalmology & Visual Science*. 2007; 48(10):4846–53.
16. He J, Lu L, He X, Xu X, Du X, Zhang B et al. The Relationship between Crystalline Lens Power and Refractive Error in Older Chinese Adults: The Shanghai Eye Study. *Plos One*. 2017; 12(1):e0170030.
17. Lee DW, Kim JM, Choi CY, Shin D, Park KH, Cho JG. Age-related changes of ocular parameters in Korean subjects. *Clinical Ophthalmology*, 2010, 725–30.
18. González Blanco F, Sanz Fernández JC, Muñoz Sanz MA. Axial Length, Corneal Radius, and Age of Myopia Onset. *Optometry and Vision Science*. 2008; 85(2):89–96.
19. Grosvenor T, Scott R. Role of the Axial Length/Corneal Radius Ratio in Determining the Refractive State of the Eye. *Optometry and Vision Science*. 1994; 71(9):573–9.
20. Touzeau O, Allouch C, Borderie V, Kopito R, Laroche L. Correlation between refraction and ocular biometry. *J Fr Ophthalmol*. 2003; 26(4):355–63.
21. Mallen EAH, Gammoh Y, Al-Bdour M, Sayegh FN. Refractive error and ocular biometry in Jordanian adults. *Ophthalmic and Physiological Optics*. 2005; 25(4):302–9.
22. Pan C-W, Wong T-Y, Lavanya R, Wu R-Y, Zheng Y-F, Lin X-Y et al. Prevalence and Risk Factors for Refractive Errors in Indians: The Singapore Indian Eye Study (SINDI). *Investigative Ophthalmology & Visual Science*. 2011; 52(6):3166–73.
23. Hashemi H, Khabazkhoob M, Miraftab M, Emamian MH, Shariati M, Abdolahi-Nia T et al. Axial length to corneal radius of curvature ratio and refractive errors. *Journal of ophthalmic & vision research*. 2013; 8(3):220–6.
24. Wong TY, Foster PJ, Ng TP, Tielsch JM, Johnson GJ, Seah SK. Variations in ocular biometry in an adult Chinese population in Singapore: the Tanjong Pagar Survey. *Investigative ophthalmology & visual science*. 2001; 42(1):73–80.
25. Flitcroft DI, Knight-Nanan D, Bowell R, Lanigan B, O’Keefe M. Intraocular lenses in children: changes in axial length, corneal curvature, and refraction. *British Journal of Ophthalmology*. 1999; 83(3):265–9.
26. Alhussain SHA, Mallen EAH, Strang NC, Jonuscheit S. The role of peripheral ocular length and peripheral corneal radius of curvature in determining refractive error. *Journal of Optometry*, 2021.
27. Elmadina A. The axial length and corneal radius of curvature ratio in Sudanese adult myopes. 2019; 21(1):43–8.
28. Warrier S, Wu HM, Newland HS, Muecke J, Selva D, Aung T, et al. Ocular biometry and determinants of refractive error in rural Myanmar: the Meiktila Eye Study. *British Journal of Ophthalmology*. 2008; 92(12):1591–4.

Conflict of Interest: Nil

Source of support: Nil