A STUDY OF A-SCAN BIOMETRY AND KERATOMETRY IN DIFFERENT REFRACTIVE STATES AT A TERTIARY CARE CENTRE

Shyam Savith Varanasi[1], Lakshmoji Naidu Kotipalli[2]

[1]Assistant Professor, Department of Ophthalmology, Rangaraya Medical College, Kakinada, Andhra Pradesh.
[2]Assistant Professor, Department of Ophthalmology, Rangaraya Medical College, Kakinada, Andhra Pradesh.

ABSTRACT

BACKGROUND

Uncorrected refractive error is the second largest cause of treatable blindness after cataract. The purpose of this present study is to describe the relationship between refractive errors, axial ocular dimensions, anterior chamber depth and corneal curvature, specifically to determine whether the refractive associations of these biometric variables are mutually related.

The aim of the current study is to determine the relationship between axial length, anterior chamber depth and keratometry in different refractive states.

MATERIALS AND METHODS

A cross-sectional study of 250 patients attending the Government General Hospital of Rangaraya Medical College, Kakinada, from October 2014 to August 2016 with defective vision, headache and asthenopia are recruited.

RESULTS

Out of 250 patients, 52 (20.80%) are found to be emmetropic (taken as controls), 83 patients (33.20%) myopes and 115 patients (46.00%) hypermetropes. More of myopes are seen in 10-19 years of age group when compared to hypermetropia, which is common in 30-40 years age group in this sample.

CONCLUSION

Axial length of the eyeball determines the refraction many a times. Corneal curvature (radius of curvature of the cornea) is important in causing astigmatic error.

KEYWORDS

Refraction, Astigmatism, Myopia, Hypermetropia.

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BACKGROUND

Uncorrected refractive error is a leading cause of visual impairment, and if uncorrected, refractive error would become the second largest cause of treatable blindness after cataract. As refractive errors are a major cause of mild-to-moderate visual impairment in the population, knowledge of the prevalence of refractive errors would be helpful in planning public health strategy.

As people age, the refractive status of their eyes also changes. This is predominantly attributable to changes in the crystalline lens. Several other factors including genetic and environmental influences (near work, night lighting and UV exposure) are also believed to play a role in determining the refractive status of the eye.

The aetiology of refractive error cannot be fully understood without examination of biometric data such as lenticular power. In children and younger adults, AL of the globe and, in particular, Vitreous Chamber Depth (VCD) account for most of the variation in refraction. In older adults along with the changes in lenticular power that accompany nuclear sclerosis of the lens, AL variation has also been shown to cause refractive change. McBrien and Adams demonstrated a longitudinal increase in AL (especially VCD) accompanied with a myopic shift in refractive error. The reasons for the increased AL and refractive change have not been adequately explained. However, it has been proposed that the increasing time spent on near-work activity maybe a risk factor in the development of myopia in a population susceptible to myopic change.

The purpose of this present study is to describe the relationship between refractive errors, axial ocular dimensions, anterior chamber depth and corneal curvature, specifically to determine whether the refractive associations of these biometric variables are mutually related.

Common refractive errors are hypermetropia, myopia and astigmatism.

Determinants of Refraction- A combination of corneal power, lens power, anterior chamber depth and axial length determines an individual's refractive status. All four elements change continuously as the eye grows. Corneal and lenticular powers change markedly during the first 2 years

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Corresponding Author:
Dr. Lakshmoji Naidu Kotipalli,
Assistant Professor, Department of Ophthalmology,
Rangaraya Medical College, Kakinada-533001,
East Godavari District, Andhra Pradesh.
E-mail: lakshmojinaidu@gmail.com, savithshyam@gmail.com
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of life as does the axial length. By the second year, the anterior segment attains adult proportions. However, the curvatures of the refracting surfaces continue to change measurably.

Axial length of the eye, curvature of the cornea and the depth of anterior chamber may influence on occurrence of different types of refractive errors.[1]

Axial length is longer in myopia and the smaller axial length may result in hypermetropia.

Increase in curvature of cornea leads to myopia and a flattened cornea results in hypermetropia. A conical and irregular cornea can cause astigmatism.

Anterior chamber depth is comparatively shallow and angle is narrow in hypermetropic eye and deeper in myopic eye.

MATERIALS AND METHODS

A cross-sectional study of 250 patients attending the Government General Hospital of Rangaraya Medical College, Kakinada, from October 2013 to August 2015 with defective vision, headache and asthenopia are recruited over a period of time. A combination of random and systematic sampling is used. Every subject is informed the nature, purpose of the study and assured that the information revealed would be kept confidential and would be used only for the scientific purpose to seek their cooperation.

Inclusion Criteria

Patients of age ranging from 5-40 years, patients who were literate and co-operative with no history of diabetes and hypertension.

Exclusion Criteria

Cases of aphakia, PC and ACIOLs, nuclear sclerosis, posterior subcapsular cataracts and posterior segment pathology.

Meticulous case history has been elicited. Visual acuity with the naked eye and with pinhole have been recorded using Snellen's chart under standard illumination and reading conditions. Cycloplegic refraction with Homide 2% has been done in all these 250 cases. Subject's eyes are refracted with streak retinoscope at one meter distance by the same observer to avoid bias. Subjective verification has been done immediately to confirm the findings of refraction. Post mydriatic test is performed for these patients after the pupil attaining its normal size and shape preferably after 72 hours to 1 week.

The determinants of refraction, viz. corneal curvature, axial, length, anterior chamber depth for both eyes are recorded using keratometer and A-scan biometry (Appasamy) using 10 MHz solid probe. Data on right and left eyes were analysed separately. The results thus obtained are analysed and discussed in comparison with the existing studies in the literature.

RESULTS

Age Group	Emmetropes		Myopes		Hypermetropes		Total	
	(n)	Percentage	(n)	Percentage	(n)	Percentage	(n)	Percentage
5-9 years	2	0.79%	3	1.19%	6	2.39%	11	4.40%
10-19 years	24	9.58%	46	18.40%	32	12.79%	102	40.80%
20-29 years	18	7.19%	28	11.19%	38	15.21%	84	33.60%
30-40 years	8	3.20%	6	2.40%	39	15.60%	53	21.20%
Total	**52**	**20.80%**	**83**	**33.20%**	**115**	**46.00%**	**250**	**100%**

Table 1. Age Structure in the Present Sample (n=250)

Subjects of various refractive states as per age group distribution of the present sample are presented in Table No. 1. It is obvious from the table and figure that maximum number of myopics 18.40% are in the 10-19 year age group, followed by 11.19%, 20-29 years age group. However, HyperOps occurring at little higher age, maximum being in the age group of 30-40 years, 15.60%. It can further be noted that hyperopes makeup the maximum number 46.00%, followed myopes 33.20%. A small group 20.80% who are screened for asthenopia and for headache serve as controls for the comparison of various descriptive statistics.

The different refractive errors of the subjects of the current sample ate depicted in Table No. 2. It can be inferred that the prevalence of hypermetropia is more when compared to myopia in this sample.

Type of Refractive Error	(n)
Emmetropes	52
Myopes	83
Hypermetropes	115

Table 2. Prevalence of Various Refractive Errors in Current Sample

Gender distribution with respect to various refractive errors is shown in Table No. 3. Females make up larger portion of all types of refractive errors. However, compound myopic astigmatism is more prevalent in males, whereas compound hypermetropic astigmatism is almost equal in both sexes.

Refractive Error	Male		Female		Total	
Type	Numbers	Percentage	Numbers	Percentage	Numbers	Percentage
Emmetropia	16	6.39%	36	14.35%	52	20.80%
Myopia	17	6.80%	22	8.79%	39	15.60%
SMA	11	4.40%	17	6.80%	28	11.20%
CMA	12	4.80%	4	1.60%	16	6.40%

Hypermetropia	30	12.00%	34	13.60%	64	25.60%
SHA	12	4.80%	19	7.60%	31	12.40%
CHA	10	4.00%	10	4.00%	20	8.00%
Total	**108**	**43.20%**	**142**	**56.80%**	**250**	**100%**

Table 3. Gender Distribution Refractive Error Wise

Sex	Total
Male	108
Female	142
Total	**250**

Table 4. Gender Distribution in Current Sample

Gender distribution of the present sample of subjects is shown in Table No. 4. Females make up the larger part of the sample when compared to males.

Type of Refraction	OD	OS
Emmetropia	2.71 ± 0.07	2.75 ± 0.04
Myopia <3.00 D	2.88 ± 0.06	2.81 ± 0.06
Myopia >3.00-6.00 D	3.18 ± 0.11	3.29 ± 0.22
Myopia >6.00D	3.60 ± 0.32	3.70 ± 0.31
Hypermetropia <2.00 D	2.51 ± 0.05	2.54 ± 0.21
Hypermetropia >2.00 D	2.48 ± 0.33	2.51 ± 0.44

Table 5. Mean ACD (in mm) of the Eyeball

Table No. 6 shows the distribution of mean ACD (anterior chamber depths) in various refractive states of the present sample. The chamber depth increases as the myopia increases especially in high myopia (deep AC 3.60 ± 0.32) and the same decreases in hypermetropia (shallow AC, 2.48 ± 0.33). The normal chamber measures 2.71 ± 0.07 mm in this sample.

	N	Minimum	Maximum	Mean	Standard Deviation	S.E.
K1 (OD)	52	7.51	8.34	7.81	0.32113	0.14
K2 (OD)	52	7.24	8.36	7.82	0.26452	0.08
K1 (OS)	52	7.14	8.35	7.84	0.24599	0.07
K2 (OS)	52	7.12	8.29	7.83	0.24601	0.07
Axial length (OD)	52	21.16	23.64	22.51	0.56818	0.14
Axial length (OS)	52	21.20	23.77	22.41	0.62498	0.17
ACD in mm (OD)	52	2.14	2.98	2.72	0.14952	0.04
ACD in mm (OS)	52	2.44	2.96	2.74	0.12285	0.03

Table 6. Descriptive Statistics of Emmetropes in the Sample

	N	Minimum	Maximum	Mean	Standard Deviation	S.E.
K1 (OD)	26	7.31	8.61	7.83	0.32614	0.13
K2 (OD)	26	7.35	8.62	7.84	0.32514	0.13
K1 (OS)	26	7.22	8.89	7.90	0.41425	0.16
K2 (OS)	26	7.37	8.67	7.84	0.32240	0.13
Axial length (OD)	26	21.96	24.21	22.76	0.57161	0.22
Axial length (OS)	26	21.71	24.31	22.81	0.61421	0.23
ACD in mm (OD)	26	2.26	2.96	2.74	0.15612	0.06
ACD in mm (OS)	26	2.37	2.99	2.77	0.14312	0.05

Table 7. Descriptive Statistics of Simple Myopic Astigmatism

	N	Minimum	Maximum	Mean	Standard Deviation	S.E.
K1 (OD)	18	7.12	8.25	7.70	0.32334	0.28
K2 (OD)	18	7.11	8.31	7.71	0.31317	0.29
K1 (OS)	18	7.15	8.24	7.72	0.27671	0.25
K2 (OS)	18	7.15	8.21	7.70	0.29714	0.26
Axial length (OD)	18	22.81	30.11	26.28	2.15041	1.88
Axial length (OS)	18	22.15	32.31	26.15	2.24121	1.86
ACD in mm (OD)	18	2.87	4.34	3.71	0.54061	0.46
ACD in mm (OS)	18	2.91	4.44	3.74	0.52431	0.46

Table 8. Descriptive Statistics of Compound Myopic Astigmatism

DISCUSSION

Refraction is an imperfect summary measure of different biometric components of the eye. Uncorrected refractive error is the most common cause of reversible blindness in India. As people age, the refractive status of their eyes also changes. The refractive power of the human eye depends on three factors- the power of the cornea, the power of the lens and the length of the eye and are called determinants of refraction. Data on right and left eyes were analysed separately. This approach is statistically valid, easy to interpret and does not result in substantial loss of power when the correlation between eyes for the parameters concerned are high.

As refractive errors are a major cause of mild-to-moderate visual impairment in the population, knowledge of the determinants of refractive errors would be helpful in planning surgery and public health strategy. With this backdrop, the results of present study are analysed and discussed as under in the light of available literature.

Age and Prevalence- Dandona et al (1999)[1] studied an urban population in south India and reported that 42.16% of the population had refractive errors with a prevalence of 17.8% and 18.8% for myopia and hyperopia, respectively, in the 40 to 49 year age group, 29.6% and 39.6% in the 50 to 59 year age group, 44.8% and 29.7% in the 60 to 69 year age group and 50% and 30.4% in the >70 year age group.

In the present study, its 198 patients out of 250 subjects are found to be having refractive errors with a prevalence of 18.4% and 12.8% for myopia and hypermetropia respectively in the 10 to 19 year age group, 11.19% and 15.21% in the 20 to 29 year age group, 2.4% and 15.6% in the 30 to 40 year age group. The prevalence is more in younger age group in this sample. This is because all immature cataracts and nuclear cataracts are excluded from the study. Hyperopia is more common than myopia (Vide Table No. 1, 2; Ref. No. 1, 2).

Sex Ratio- Hyperopia was more common among women than men. The prevalence of hyperopia increased until the age of 60 years and then decreased. It was interesting to note that similar patterns have been observed in other studies performed in tropical regions of the world, whereas those observed in temperate regions were different. This difference leads us to believe that environmental influences may play an important role in the prevalence of refractive errors in the older population. Andhra Pradesh Eye Disease Study (APEDS), this finding maybe related to the fact that women have shorter axial length than men in a subset of our population (Seah SKL, 2002[2]). The other study from urban India by Dandona et al showed a similar prevalence of myopia in the 40 to 49 year age group with a lower prevalence of myopia and a higher prevalence of hyperopia in every older age group.

Females are more affected with hypermetropia (25.20%) than males (20.80%) in all age groups even in the subjects of present investigation with a sex ratio of 1:1.3. This female preponderance is due to increased asthenopia, headache in female population. Further men are busier with earning and education and may not find time to attend hospital for their visual complaints when compared to females. However, there is minor increase in the occurrence of hyperopia and decrease in myopia in females.

Refractive States- Approximately, a third of the population aged more than 40 years has myopia, (Dandona R. et al, 1999 and Wu SY[1] 1999). Emmetropia was defined as a spherical equivalent between -0.50 and +0.50 Dioptre Sphere (DS) (Wong TY et al, 2000). Myopia was defined as a spherical equivalent less than -0.50 DS (Attebo K et al, 1999). Astigmatism was defined as a cylindrical error less than -0.50 Dioptre Cylinder (DC) in any axis (Wu SY et al, 1999).

Prema Raju[3] S et al (2004) in their study found that the prevalence of emmetropia (Spherical Equivalent (SE), -0.50 to +0.50 Dioptre Sphere (DS)), myopia (SE <-0.50 DS), high myopia (SE <-5.00 DS) and hyperopia (SE >0.50 DS) were 50.60%, 26.99%, 3.71% and 18.70% and age and gender adjusted for the rural Tamil Nadu population were 46.77%, 30.97%, 4.32% and 17.94%, respectively. The prevalence of emmetropia decreased significantly with age (P <0.0001) and the prevalence of myopia and high myopia increased significantly with age (P <0.001) and were significantly associated with nuclear sclerosis (P <0.001). The prevalence of hyperopia increased until 60 years of age and then decreased. Hyperopia was more common among women than men (P <0.001) and was negatively associated with nuclear sclerosis (P <0.001) and positively with diabetes mellitus (P=0.008). Of the participants with astigmatism (cylindrical error greater than 0.50 DC), 9.80% had With-The-Rule (WTR) and 77.44% Against-The-Rule (ATR) astigmatism. The prevalence of WTR and ATR astigmatism significantly decreased (P <0.001) and increased (P=0.006) with age, respectively.

The prevalence of emmetropia and other refractive errors are as follows- Emmetropia of ±0.5D has accounted for 52 out of 250 subjects (20.80%). This group is mostly constituted by females with complaints of asthenopia and headache. This group is also included in the current study to serve as control for comparison of various determinants of refraction with other groups of refractive error. The prevalence of mild myopia (<3.00 D) is 9.40%, moderate myopia (3.00-6.00 D) 2.80%, high myopia of (>6.00 D) 3.20%, mild hypermetropia (<2.00D) 25.60% and moderate hyperopia (>2.00 D) 1.6%.

Curvature Aberrations (Astigmatism)- Shu-Wen Chang[4] et al (2001) found that the anterior corneal surface was flatter in eyes with longer axial length. Changes in the anterior segments as the eyeball elongates in myopia progression included flatter corneal curvature.

In the present study, changes in the corneal curvature caused astigmatism and the radius of curvature correlated well with amount of astigmatism. In myopic astigmatism, there is increase in the radius of curvature making the cornea flat. Thus, the increase in radius of curvature in one meridian in myopic astigmatism ranged from a mean of 7.83 ± 0.13 to 7.90 ± 0.16 depending on the degree of astigmatism. Similar decrease is noticed when the shift of refraction towards hypermetropia and the mean values ranges from 7.71 ± 0.09 to 7.72 ± 0.10. However, there is no change in axial lengths reaffirming the fact that astigmatism is only curvature aberration.

But, in compound astigmatism, change in both curvature and axial length is observed.

Anterior Chamber Depth- Hosny M, Alio JL, Claramonte P, Attia WH, Perez-Santonja JJ[5] (2000) studied the relationship between anterior chamber depth, refractive state of the eye, spherical equivalent refraction, axial length of the globe, corneal diameter and keratometry in 211 eyes. They concluded that the anterior chamber depth was found to correlate significantly with both the average corneal diameter and the axial length of the globe (0.744, 0.531, P <0.01) and was also found to correlate through an inverse relation with both age and spherical equivalent refraction (-0.391, -0.623, P <0.01). They further opined that most parameters (axial length, corneal diameter, spherical equivalent refraction, patient age) affected anterior chamber depth.

In the current study, the ACD (anterior chamber depth) correlated well with the type and amount of refraction. It is deepest in myopia (>6.00 D) (3.60 ± 0.32) and shallow in hyperopes especially >2.00D (2.48 ± 0.33).

AL/CR Ratio- Grosvenor T, Scott R,[6] 1994, in their study on the ratio between axial length and corneal radius (the AL/CR ratio) on 194 young adults between the ages of 18 and 30 years found that the AL/CR ratio was found to be approximately 3.00 for emmetropic eyes ranging from 2.60 for the most highly hyperopic eye to 4.10 for the most highly myopic eye. They further opined that the variance in refraction could be accounted for by variance of the AL/CR ratio. The results of their study suggest that for a given amount of ammetropia, an eye having a relatively high AL/CR ratio would tend to have a low-powered lens (indicating that the lens had "emmetropized"), whereas an eye having a relatively low AL/CR ratio would tend to have a high-powered lens. The AL/CR ratio can provide information concerning the extent to which the lens has emmetropized by reducing its power concurrent with axial elongation.

Somewhat similar results are obtained in the present study also. The AL/CR ratio is 2.87 ± 0.02 in emmetropes, 2.55 ± 0.13 for hyperopes of >2.00 D and 3.60 ± 0.10 for myopes of >6.00 D (Vide Table No. 19 and Figure No. 9).

Axial Length of the Eyeball- Tien Yin Wong, Paul J. Foster, Gordon J. Johnson and Steve K. L. Seah in their study in 2003 described the relationship of refractive errors and axial ocular dimensions and age-related cataract. It was a population-based, cross-sectional survey of ocular diseases among Chinese men and women aged 40 to 81 years (n=1232) living in the Tanjong Pagar district in Singapore.

They described the relationship between refractive errors, axial ocular dimensions and age-related cataracts and specifically to determine whether the refractive associations of these cataract are axial (i.e. related to axial length or vitreous chamber depth) in nature.

In this study, refraction was categorised as follows- high myopia as a spherical equivalent of greater than -6.00 D, moderate myopia between -5.99 and -3.00 D, mild myopia between -2.99 and -0.51 D, emmetropia between -0.50 and +0.50 D and hyperopia as greater than +0.50 D. The mean refraction was -0.51 ± 2.67 D (SD) distributed as follows- 48 (4.9%) had high myopia, 85 (8.6%) moderate myopia, 207 (20.9%) mild myopia, 301 (30.4%) emmetropia and 348 (35.2%) hyperopia.

Ulvik, Solveig[7] et al (2005) in their study found that there was a statistically significant sex difference in axial length and refraction where women had shorter axial lengths and were more hypermetropic than men. Myopic changes of the eyes include elongated axial length, deeper anterior chamber and vitreous depth (Curtin BJ, 1985) and (Lin LL et al, 1999).[8]

In the current study, the mean axial length for emmetropia is 22.48 ± 0.15 for RE and 22.46 ± 0.16 for LE. It ranged from 22.97 ± 0.30 to 27.69 ± 1.43 in myopia according to the degree of myopia indicating increase in the axial length is the prime factor in causing myopia. Similar decrease in axial length is observed for hypermetropia ranging from 22.08 ± 0.20 to 21.53 ± 0.51 (Vide Table No. 5). Axial length correlated well with the type of refraction and degree of ammetropia.

Thus, the readings and results of various parameters of refraction in the present study are in accordance with the studies mentioned above showing good correlation with the cycloplegic refraction. Any minor deviation is due to sampling errors, small size of the sample, ethnic and geographical variations.

Summary- Out of 250 patients, 52 (20.80%) are found to be emmetropic (taken as controls), 83 patients (33.20%) myopes and 115 patients (46.00%) hypermetropes. More of myopes are seen in 10-19 years of age group when compared to hypermetropia, which is common in 30-40 years age group in this sample. The sample is made up of 108 male patients (43.20%) and 142 female patients (56.80%) with a sex ratio of 1:1.3. This female preponderance is due to increased asthenopia headache in female population. Further, men are busier with earning and education and may not find time to attend hospital for their visual complaints when compared to females. The mean axial length ranged from 22.97 ± 0.30 to 27.69 ± 1.43 for myopia and it is 22.08 ± 0.20 to 21.53 ± 0.51 for hypermetropia, which confirms that an increase in axial length causes myopia and decrease hypermetropia. Myopia and hyperopia are the two ends of bell-shaped Gaussian curve of axial lengths. Similar curvature changes are noticed for astigmatic errors. A good correlation between AL/AC ratios are observed.

The present study reaffirms that net refraction of the eye is a summary of various biometric components of eye like axial length, corneal curvature and anterior chamber depth and determination of the same is crucial in planning surgery and treating them with visual aid is essential to improve patients visual disability.

CONCLUSION

1. Axial length of the eyeball determines the refraction many a times.
2. Corneal curvature (radius of curvature of the cornea) is important in causing astigmatic error.
3. Anterior chamber depth determination is important as it modifies the postoperative refraction.
4. There is a good correlation between Axial Length (AL) and Corneal Radius (CR) and the ratio is approximately equal to ACD.
5. However, each of these determinants does not cause the ammetropia, but is a sum effect of all these biometric components.
6. Aberrations in these biometric components per se does not cause ammetropia. Aberrations in these biometric components in a prone individual coupled with the

environmental factors fail to achieve emmetropization resulting in a refractive error (ammetropia).

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