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A Study on Ocular Biometric During Accommodation

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Abstract

We performed a biometric study that used A-mode ultrasonography on 75 young subjects during ocular accommodation. The subjects between the age group of 18 to 30 years were divided into three groups depending upon their refractive status. Group A comprised of patients with no refractive status (Emmotropes), Group B included patients suffering from Myopia less than -5.0 DSph and Group C includes patients of Hypermetropia less than + 5.0 DSph . After carrying out initial evaluation, A Scan Ultrasonography was performed on the right eye while left eye wearing full refractive correction for distance was focused at a distance of 6 m, 33 cm, 12.5 cm and 33 cm with additional +3 D correction to offset any accommodative effect. The parameters measured were AC depth, lens thickness and axial length in all the Groups A, B & C in the right eye while the left eye, wearing corrective spectacles, focused at distances of 6 m, 33 cm, and 33 cm with an additional correction of +3 D to offset any accommodative effect..In Group A, we measured the same parameters i.e. AC depth, lens thickness, and axial length in the right eye while the left eye, wearing full corrective spectacles during all procedures, focused at distances of 6 m, 33 cm, and 33 cm with an additional correction of +3.0 D to offset any accommodative effect. During accommodation, decreased AC depth and thickening of the lens with increasing level of accommodation were noted in all Groups A, B and C cases. In group A, axial length significantly increased an average of 0.06 +/- 0.01 mm (P < .0005) while the left eye focused at a distance of 33 cm. There were no significant changes with the additional +3.0 D (P < 0.05). In group B & C, axial length significantly increased an average of 0.05 +/- 0.01 mm (P < .0005) when the left eye focused at a distance of 33 cm, and there was further significant elongation of 0.05 +/- 0.01 mm when the left eye focused at a distance of 12.5 cm. Collectively, these results suggest that axial length increases along with changes in the lens and AC depth during ocular accommodation.

Keywords: Accommodation, Anterior Chamber (AC), Emmotropes, A-Scan, Ultrasonography, Myopes, Hypermetropes.

Introduction

Human eyes have been provided with a unique mechanism by which we can focus the diverging rays coming from a near object on the retina in a bid to see clearly. The mechanism is called as accommodation. This is achieved by changing thickness of lens by action of ciliary muscles and zonules upon it. [1] The exact mechanism of accommodation and role of various ocular structures in bringing about this change have remained a controversial matter for a long period. In 1801, Thomas Young presented a classical demonstration of principal importance of the crystalline lens in accommodation. [2] Tscherning proposed theory of increased tension. It stated that contraction of the ciliary muscle during accommodation pulls on the zonules directly and increases the tension on the lens capsule. This results in compression of the capsule at the equator of the lens so that the poles bulge. [3]

The most accepted theory for accommodation is Helmholtz theory of relaxation. In this ciliary zonules are kept under tension by a pull exerted on them by elastic choroid and relaxation of ciliary muscle fibers. During accommodation, contraction of ciliary muscle causes the ciliary ring to shorten and move forwards the equator of lens. It also pulls the choroid forwards. As a result, the zonules are relaxed relieving the tension on the lens capsule and the lens attains a more spherical shape. The increasing convexity of the lens increases its dioptric power allowing the near objects to be focused clearly on the retina.[4] Fincham reviewed and added that it is the non uniform thickness of the lens capsule, which causes the changes in lens curvature during accommodation. [5]

Various methods like slit-lamp photography, optical pachymetry, A-scan ultra-sonography, M-mode ultra-sonography, partial coherence interfero-metry have been used to observe the changes in ocular structures during accommodation.[6-10] Out of these, A-scan ultrasonography is widely available and provides reliable information on the position of major refractive surfaces of the eye. In A-scan, the space between the echo-spikes depends upon the time it takes for the sound beam to reach a given interface and for its echo to return to the probe. Thus, the axial length of the eye is determined by measuring the sound transmission time between each major interface of anterior chamber, lens and vitreous and multiplying the appropriate transmission time by the velocity of sound in that tissue. The axial length is the sum of anterior chamber depth, lens thickness and vitreous length. In ultra-sonographic parlance, the anterior chamber depth refers to distance between the spikes of cornea and anterior capsule of lens. By measuring the change in position of echo spikes A-scan ultrasonography can be used to study changes in anterior chamber depth, lens thickness and axial length during accommodation.

Problem faced during ultra-sonographic study might arise from microfluctuations during accommodation and accommodative convergence of the eyes that may cause the misalignment of the probe. Van der Heijde et al studied the microfluctuations with continuous ultrasonography and demonstrated that these are physiological and help the image to be focused on the retina. They may be neurological origin and some of them are related to arterial pulse.[11] Mcbrien et al reported that amplitude of accommodation differs according to the refractive error. They have reported higher amplitude of accommodation in myopes as compared with emmetropes.[12] Hence, the ocular changes during accommodation may differ according to refractive status of the eye. As no study has been carried out to compare these changes in between emmetropes and hypermetropes, this study will be carried out on them as well as on myopes with the help of A-scan ultrasography. This study will help to know biometric ocular changes during accommodation and their relation with the refractive status of the eye.

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Aims and Objectives

1. To study changes in axial length, anterior chamber depth and lens thickness during accommodation.
2. To compare these biometric changes in emmetropes, myopes and hypermetropes.

Material and Methods

This study was carried out in the Department of Ophthalmology, Pt. B. D. Sharma PGIMS, Rohtak on 150 subjects divided into three groups designated as Group A consisted 50 emmetropes, Group B consisted of 50 myopes with myopia <5 D while Group C consisted of 50 hypermetropes with hypermetropia <5 D.

Exclusion criteria: Patients age less than 18 years or more than 30 years, Convergence insufficiency, Amblyopia, Strabismus and other disease affecting visual acuity e.g. any media opacity, corneal surface irregularities, uveitis and macular diseases. Maximum corrected visual acuity <6/6, Myopia >5D; hypermetropia >5D and intraocular pressure > 24mm Hg.

Methodology

Keratometry was done with Bausch and Lomb Keratometer. Average corneal power was calculated with that of the opposite eye of the same subject with unpaired‘t’ test. One drop of 4% Xylocaine was put in both eyes and then Intra Ocular Pressure (IOP) was measured with Schiotz tonometer. Comparison was done between two eyes with unpaired ‘t’ test.

Slit lamp examination was done in these subjects to exclude anterior segment disorder. Fundus examination of both eyes was done. One drop of 1% Cyclopentolate instilled in both the eyes every 10 minutes for 3 times to attain cycloplegia. Retinoscopy was carried out for determine refractive error after one and half hours of instillation. The subjects were called after 2 days, subjects were made to sit upright and used left eye for fixation and the right for biometric studies.

Biometric Enchorule A-scan ultrasonography machine was used in this study. Right eye was anaesthetized using topical 4% Xylocaine eye drops. The subject was asked to focus on 6/6 line of Snellen’s chart kept at a distance of 6 meter with full refractive correction on the left eye. Lids of the right eye were gently separated with fingers without applying any pressure on the globe. A-scan probe tip was gently put on the center of cornea with its direction along the visual axis i.e. perpendicular to cornea. Before proceeding further it was ensured that the subject has sharp image of 6/6 line of Snellen’s chart with left eye.

Fig 1.Photograph of Biomedix Echorule A-scan Ultrasonography machine

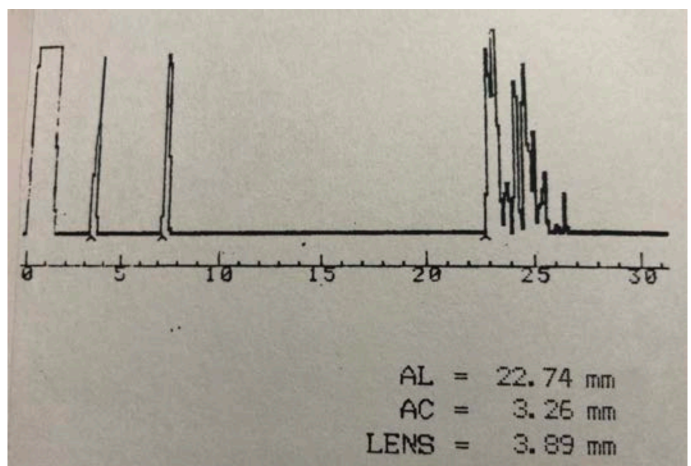

Fig 2. A-scan printout with the left eye focused at 6 m

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The echo-spikes were observed for height of echoes indicating amplitude and sharpness. Readings were taken by freezing the A-scan by pressing the foot-pedal and probe was aligned along the visual axis.

- Tall and sharp echoes from cornea, anterior lens surface, posterior lens surface and vitreoretinal surface.
- The retinal echoes should be steeply rising without any steps, humps or jags.
- Presence of scleral echoes.

Three readings of anterior chamber depth, lens thickness and axial length were taken and the mean values of these readings were calculated. Similar procedure was repeated after accommodation. Accommodation was achieved by asking the subjects to focus on N/6 line of near vision chart (Roman Test Types) held at distance of 33 cm with left eye with full refractive correction on the left eye. It was ensured that the subjects had clear and sharp image of letters of N/6 line of Near Vision Chart. Biometry was performed on the right eye simultaneously and readings of anterior chamber depth, lens thickness and axial length were taken. Then, the subjects were asked to focus N/6 line of near vision chart held at 12.5 cm to increase the amplitude of accommodation and similar procedure was repeated.

The accommodation was relaxed by adding +3D to the refractive correction on the left eye. The subjects were then asked to focus at N/6 line of near vision chart held at 33 cm with left eye. Biometric procedures were done on the right eye. The findings were recorded in proforma attached. Statistical analysis of the above readings was carried out by using paired and unpaired‘t’ tests.

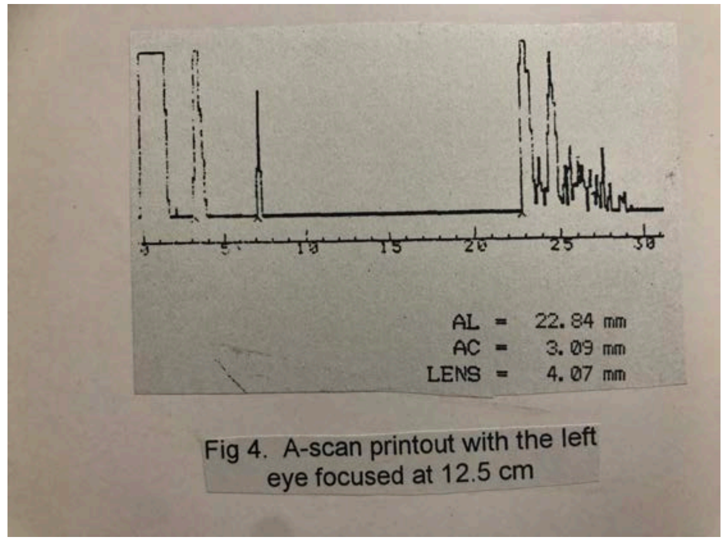

Fig 4. A-scan printout with the left eye focused at 12.5 cm

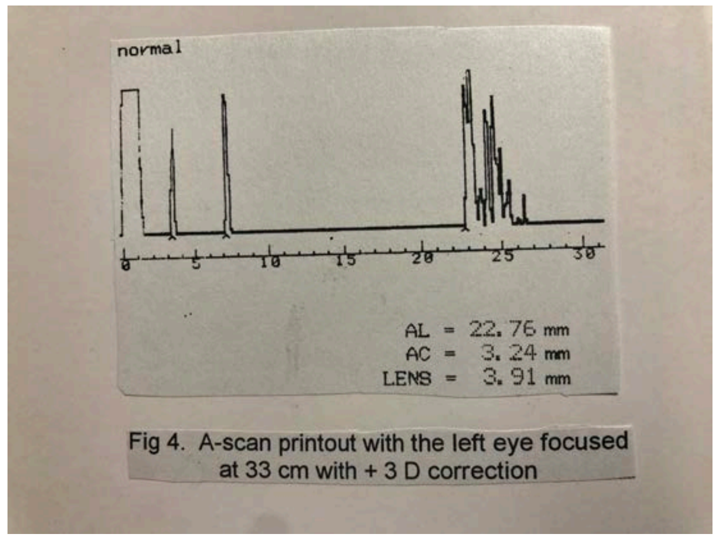

Fig 4. A-scan printout with the left eye focused at 33 cm with + 3 D correction

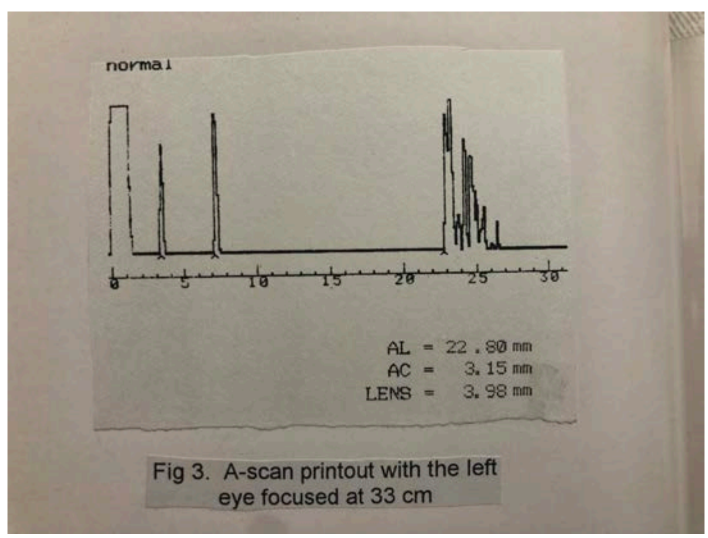

Fig 3. A-scan printout with the left eye focused at 33 cm

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Observations and Results

The present study included 150 subjects in the age group of 18 to 30 years attending the outdoor patients. These patients were divided into three groups depending upon their refractive status into 50 subjects in Group A of emmetropes while Group B and C consisted of 50 myopes and 50 hypermetropes respectively.

Table 1: Age & Sex Distribution

In our present study, subjects of 18 to 30 years of age were included. Mean age was 21.56 ±2.38 in Group A, 22.04 ±2.97 in Group B and 24.20 ±2.79 in Group C.

Group	No. of Subjects	No. of males	No. of females	Mean age [years]
A	50	26	24	21.56±2.38
B	50	32	18	22.04±2.97
C	50	28	22	24.20±3.79

In this study, Group A comprised of 26 males and 24 females. There were 32 males and 18 females in group B while group C consisted of 28 males and 22 females.

Table 2: Refractive Status

The subjects were divided into three groups based on their refractive status, which was determined objectively by doing retinoscopy under cycloplegia with 1% Cyclopentolate eye drops.

Group	No. of Subjects	Mean refractive error (Spherical component)	
		Right eye	**Left eye**
A	50	Emmetropes	Emmetropes
B	50	-1.93±1.39	-2.03±1.09
C	50	+1.9±1.28	+1.69±1.21

Group A comprised of emmetropes only whereas Group B consisted of myopes with mean refractive error of -1.93±1.39 in right eye and -2.03± 1.09 in left eye. The mean refractive error of Group C subjects was +1.9±1.28 in right eye +1.69± 1.21 in left eye.

Table 3: Kerotometery Reading

The mean keratometry readings in left and right eyes were 42.97±1.09 and 43.09±1.03D respectively in group A. While the mean keratometry readings in left and right eyes were 43.49±1.17 and 43.44±1.17D and 42.48±1.11 and 42.56±0.98D in group B and C patients respectively. Keratometry readings of left and right eye in the same groups were statistically insignificant as found with unpaired't'.

Group	No. of Subjects	Average Keratometry Readings in Diopters	
		Right Eye	**Left Eye**
A	50	42.97±1.09	43.09±1.03*
B	50	43.49±1.17	43.44±1.17*
C	50	42.48±1.11	42.56±0.98*

* P >0.1 on comparison of keratometry reading of left and right eye of same groups was statistically insignificant

Table 4: Intraocular Pressure

The intraocular pressure (IOP) of both the eyes of the subjects in all the groups was measured with Schiotz tonometer. The mean readings of intraocular pressure in right and left eyes were 14.18±2.84 mm of Hg and 14.62±3.08 mm of Hg in Group A while mean readings of IOP in right and left was 14.20± 3.20 mm of Hg and14.66± 2.99 mm of Hg, in Group B and 14.40 ± 3.29 mm of Hg and 14.80± 2.07 mm of Hg in right and left eye respectively in Group C. Difference between IOP readings in between right and left eye of same group was found to be statistically insignificant as found with unpaired 't'.

Group	No. of Subjects	Average Intraocular Pressure in mm of Hg	
		Right Eye	**Left Eye**

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A	50	14.18±2.84	14.62±3.08*
B	50	14.20±3.20	14.66±2.99*
C	50	14.40±3.29	14.80±2.07*

* p >0.1 on comparison of Intra Ocular Pressure (IOP) of right and left eye of same group was statistically insignificant.

Table 5: Biometric Measurement of Anterior Chamber Death in Right Eye

Sr. No.	Focusing Distance of Left Eye	Anterior Chamber Depth of Right Eye (mm)		
		Group A	Group B	Group C
1.	6m	3.325±0.301	3.452±0.269	3.000±0.240
2.	33cm	3.238 ±0.297	3.352±0.271	2.905±0.221
3.	12.5cm	3.203±0.319	3.334±0.290	2.872±0.214
4.	33cm with +3D correction	3.318±0.302	3.446±0.270	2.999±0.235
5.	Difference between (2) and (1)	-0.087±0.014*	-0.100±0.011*	-0.095±0.01*
6.	Difference between (3) and (1)	-0.122±0.021*	-0.118±0.018*	-0.128±0.01*
7.	Difference between (4) and (1)	-0.007±0.003#	-0.006±0.003#	-0.001±0.005#

* p < 0.01 was statistically significant. # p < 0.01 was statistically significant.

In group A, the anterior chamber depth decreases with accommodation in 42 out of 50 subjects. The mean anterior chamber depth of right eye was 3.325±0.301mm with the left eye focused at a distance of 6 meters. It became 3.238_±0.297mm with left eye focused at a distance of 33 cm. It further decreased to 3.203±0.319mm when the left eye was focused at a distance of 12.5 cm. When +3 D correction was added to the left eye, the anterior chamber depth became 3.318±0.302mm. Statistical analysis was carried out by using paired‘t’ test. ‘p’ value was found to be < 0.01 i.e. statistically significant when anterior chamber depth with focus at 6 m was compared with that of 33cm and 12.5 cm. ‘p’ value was found to be > 0.05 [statistically insignificant] when anterior chamber depth at 6 m was compared with that at 33 cm with +3 D correction.

In group B, the mean anterior chamber depth of right eye was 3.452 mm with left eye focused at a distance of 6 meters after addition of refractive correction of distance to it. It became 3.352 mm with the eye focused at distance of 33 cm. It further decreases to 3.334 mm when the left eye was focused at a distance of 12.5 cm. When +3 D correction was added to the left eye, the anterior chamber depth became 3.446 mm. ‘p’ value was found to be less than 0.01 i.e. statistically significant when anterior chamber depth with focus t 6 m was compared with that of 33 cm and 12.5 cm. ‘p’ value was found > 0.05 when anterior chamber depth at 6 m was compared with that at 33 cm with +3 D correction. The anterior chamber depth decreased with accommodation in 23 out of 25 subjects.

In group C, the mean anterior chamber depth of right eye was 3.00 mm with the left eye focused at a distance of 6 meters after addition of refractive correction for distance to it. It became 2.905 mm with the left eye focused at a distance of 33 cm. It further decreased to 2.872 mm when the left eye was focused at a distance of 12.5 cm. When +3 D correction was added to the left eye, the anterior chamber depth became 2.999 mm. ‘p' value was found to be less 0.01 i.e. statistically significant when anterior chamber depth with focused at 6 m was compared with that of 33 cm and 12.5 cm. ‘p’ value was found > 0.05 [statistically insignificant] when anterior chamber depth at 6 m was compared with that at 33 cm with +3 D correction. Anterior Chamber depth was found to be decreased in 22 out of 25 subjects in group C with accommodation.

Table 6: Biometric measurements of lens thickness in mm in Right Eyes

Sr. No.	Focusing Distance of Left Eye	Lens Thickness of Right Eye (mm)		
		Group A	Group B	Group C
1	6 m	3.889±0.224	3.924±0.232	4.009±0.208
2	33 cm	3.986±0.247	4.006±0.220	4.108±0.199
3	12.5 cm	4.032±0.255	4.043±0.220	4.135±0.202

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4	33 cm with +3 D correction	3.893±0.231	3.929±0.231	4.015±0.196
5	Difference between [2] and [1]	0.097±0.0167	0.082±0.0129*	0.099±0.015*
6	Difference between [3] and [1]	0.143±0.022*	0.119±0.0198*	0.126±0.020*
7	Difference between [4] and [1]	0.004±0.002#	0.005±0.003#	0.006±0.004#

In group A, the mean lens thickness of right eye increased from 3.889 to 3.986 mm when the focus of the eye was shifted from 6 m to 33 cm. It further increased to 4.032 mm with focus at 12.5 cm. It returned to 3.893 mm when +3 D correction was given to the left eye. The mean increase in lens thickness was 0.097 mm when the focus of the left eye was shifted from 6 m to 33 cm. On further increasing the accommodation by shifting the focus of the left eye to 12.5 cm, the lens thickness increased by 0.143 mm. ‘p’ value was found to be less than 0.01 when lens thickness with focus at 6 m was compared with that of 33 cm and 12.5 cm. Hence the increase in lens thickness with accommodation was found to be statistically ‘p’ value was found to be > 0.05 [statistically insignificant] when lens thickness at 6 m was compared with that at 33 cm with =3 D correction. The lens thickness increased with accommodation in 20 subjects of group A while it decreased in 5 subjects.

In group B, the mean lens thickness of right eye increased from 3.924 to 4.006 mm when the focus of the left eye wearing full refractive correction for distance was shifted from 6 m to 33 cm. It further increased to 4.043 mm with focus at 12.5 cm. It returned to 3.929 mm when +3 D correction was given to left eye. The mean increase in lens thickness was 0.82 mm when the focus of the left eye was shifted from 6 m to 33 cm. On further increasing the accommodation by shifting the focus of the left eye to 12.5 cm, the lens thickness increased by 0.119 mm. ‘p’ value was found to be less than 0.01[statistically insignificant] when lens thickness with focus at 6 m was compared with that of 33 cm and 12.5 cm. ‘p’ value was ground to be >0.05 [statistically insignificant] when lens thickness at 6 m was compared with that at 33 cm with +3 D correction.

In group C, the mean lens thickness of right eye increased from 4.009 to 4.108 mm when the focus of the left eye wearing full refractive correction for distance was shifted from 6 m to 33 cm. It further increased to 4.135 mm with focus at 12.5 cm. It returned to 4.015 mm when +3 D correction was given to the left eye. Statistical analysis was carried out with paired‘t’ tests. ‘p’ value was found to be less than 0.01 [statistically insignificant] when lens thickness with focus at 6 m was compared with that of 33 cm and 12.5 cm. ‘p’ value was found to be > 0.05 [statistically insignificant] when lens thickness at 6 m was compared with that at 33 cm with +3 D correction. Lens thickness increased with accommodation in 20 subjects while it decreased in 4 subjects and remained unchanged in 1 subject.

Table 6: Biometric measurement of axial length in mm in right eyes

Sr. No.	Focusing Distance of Left Eye	Axial Length of Right Eye (mm)		
		Group A	**Group B**	**Group C**
1	6 m	22.962±0.620	24.142±0.796	22.002±0.943
2	33 cm	23.012±0.639	24.194±0.803	22.049±0.932
3	12.5 cm	23.049±0.647	24.219±0.812	22.079±0.916
4	33 cm with +3 D correction	22.966±0.620	24.148±0.798	22.003±0.942
5	Difference between [2] and [1]	0.051±0.011*	0.052±0.015*	0.047±0.016*
6	Difference between [3]	0.088±0.017*	0.077±0.022*	0.077±0.026*

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	and [1]			
7	Difference between [4] and [1]	0.005±0.004*	0.006±0.004*	0.001±0.005*

In group A, the mean axial length of right eye increased from 22.961 to 23.012 mm when the focus of the left eye was shifted from 6 m to 33 cm. It further increased to 23.049 mm with focus at 12.5 cm. It returns to 22.966 mm when +3 D correction was given to the left eye. The mean increase in axial length was 0.051 mm when the focus of the left eye was shifted from 6m to 33 cm. On further increasing the accommodation by shifting the focus of the left eye to 12.5 cm, the axial length increased by 0.88 mm. Statically analysis was carried out by using paired 't' tests. 'p' value was found to be more than 0.05 statistically significant. 'p' value was found to be more than 0.05 [statistically insignificant] when axial length increased with accommodation in 18 out of 25 subjects of group A, while it decreased in 6 subjects and remained unchanged in one subject.

In group B, the mean axial length of right eye increased from 24.142 to 24.194 mm when the focus of the left eye after addition of refractive correction for distance was shifted from 6 m to 33 cm. It further increased to 24.219 mm with focus at 12.5 cm. It returned to 24.148 mm when +3 D correction was given to the left eye. The mean increase in axial length was 0.052mm when the focus of the left eye was shifted from 6 m to 33 cm. On further increasing the accommodation by shifting the focus of the left eye to 12.5 cm, the axial length increased by 0.077 mm. 'p' value was found to be less than 0.05 when axial length with focus at 6 m was compared with that of 33 cm and 12.5 cm. 'p' value was found to be more than 0.05 when axial length at 6 m was compared with that at 33 cm with +3 D correction. The axial length increased with accommodation in 18 out of 25 subjects of group B while it decreased in 7 subjects. In group C, the mean axial length of right eye increased from 22.002 to 22.049 mm when the focus of the left eye after addition of refractive correction for distance was shifted from 6 m to 33 cm. It further increased to 22.079 mm with focus at 12.5 cm. It returned to 22.003 mm when +3 D correction was given to the left eye. The mean increase in axial length was 0.047 mm when the focus of the left eye to 12.5 cm, the axial length increased by o.77 mm. 'p' value was found to be less than 0.05 [statistically insignificant] when axial length with focus at 6 m was compared with that of 33 cm and 12.5 cm. 'p' vale was found to be more than 0.05 when axial length at 6 m was compared with that at 33 cm with +3 D correction. The axial length increased with accommodation in 18 out of 25 subjects of group C.

Comparison in between group A, B and C:

Difference in between parameters at 6 m and 33 cm: The mean change in axial length on shifting focus of left eye from 6 m to 33 cm was compared in between groups A,B and C. With the help of unpaired 't' test, 'p' value of >0.1 was obtained when group a was compared with group B. 'p' values was > 0.1 on comparing group A with group C and group B with .'p' value was > 0.1 on comparing group A with group C and group B with group C. Thus, the difference of change in axial length on accommodation in between groups A, B and C was statistically insignificant. Similarly, change in anterior chamber depth and lens thickness was compared between group A, B and C with the help of unpaired 't' test and p value of > 0.1 was obtained in all comparisons.

Difference in between parameters at 6 m and 12.5 cm: The mean change in axial length on shifting focus of left eye from 6 m to 12.5 cm was compared in between groups A, B and C. With the help of unpaired 't' test , 'p' value of > 0.1 was obtained when group A was compared with

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group B. 'p' value was > 0.1 on comparing group A with group C and group B with group C. Thus, the difference of change in axial length on accommodation in between groups A, B and C was statistically insignificant. Similarly, change in anterior chamber depth and lens thickness groups A, B and C with the help of unpaired't' test and p value of > 0.1 was obtained in all comparisons. The difference between parameter at 6 m and 33cm with +3 D was found to be insignificant in all three groups. Hence its variation among groups A, B and C was not subjected to statistical analysis.

Discussion

Accommodation is a unique mechanism by which we can focus the diverging rays coming from a near object on the retina in a bid to see clearly.[1]The increased convexity of lens increases its dioptric allowing the near objects to be focused clearly on the retina.[4]

Recently, Schachar et al have challenged the relaxation hypothesis and proposed a contraction of the ciliary muscle increases, rather than releases, equatorial zonules tension because of posterior and centrifugal movement of the anterior aspect of the ciliary muscle. Schachar et al suggest that this process would increases the lens equatorial diameter, flatten the peripheral lens curvatures, and increases the central lens curvatures during acxcommodation[8,9].

A-scan ultra-sonography is widely available and provides the ovular changes during accommodation. Three main parameters namely anterior chamber depth, lens thickness and axial length were studied with A-scan during accommodation.

Anterior chamber depth

In the present study, the anterior chamber depth decreased in 66 out of 75 subjects with accommodation. The mean decrease in anterior chamber depth was 0.87, 0.100 and 0.095 mm on shifting the focus to 33 cm from 6m in groups A, B and C respectively. With further shifting of focus to 1.5 cm, the anterior chamber depth decreased by 0.122, 0.118 and 0.128 mm in groups A, B and C respectively. Anterior Chamber depth has found to be decreased during accommodation in most of the studies performed with A-scan ultra-sonography, Storey et al, Shum et al and Garner et al have reported decreases in anterior chamber depth with accommodation in their studies done with A- scan ultrasonography.[14, 17, 19] Calmettes et al found reduction in AC depth ranging between 0.1 to 0.5 mm with a mean of 0.23 mm with accommodation in their study using optical pachymetry[12]. Rabie et al studies changes during accommodation with optical pachymetry. They reported mean decrease of 0.21 mm in anterior chamber depth with +3 D of accommodation.[13]Thus, the decrease in anterior chamber depth during accommodation as observed in our study is consistent with other studies carried out on this subject so far.

Lens Thickness

In the present study, the lens thickness increased with accommodation in 60 out of 75 subjects and the mean thickness on shifting the focus of the left eye from 6 m to 33 cm was 0.097, 0.082, 0.099 mm in group A, B and C respectively. On further shifting the focus to 12.5 cm, the lens thickness increased by 0.143, 0.119 and 0.126 mm in groups A, B and C respectively. Storey et al, Shum et al and Garner et al have reported increase in lens thickness with accommodation in their studies done with A-scan ultrasonography[14, 17, 19].

Axial Length

In the present study, axial length increased with accommodation in 54 out of 75 subjects; while it decreased in 20 subjects and remained unchanged in 1

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subject. The mean increase in the axial length on shifting the focus of the left eye from 6m to 33 cm was 0.051, 0.052 and 0.047 mm in group A, B and C respectively. On shifting the focus to 12.5 cm, the axial length was increased by 0.088, 0.77 and 0.77 mm in group A, B and C respectively. Storey et al reported mean increase of 0.08 mm with 2 D of accommodative stimulus in their study carried on 14 subjects carried out with A-scan ultra-sonography using immersion probe[14].

Shum et al, reported on 106 young females found that axial length increased with accommodation in most of the subjects. The mean increase in axial length on accommodation was 0.05 mm when the focus was shifted form 6 mm to 33cm.[17]

The increase in axial length during accommodation can be explained by Coleman's unified model of accommodation in which he attributed an active role to vitreous chamber in addition to the relaxation hypothesis of Helmholtz et al. He hypothesized that a pressure gradient between the compressed vitreous and the anterior chamber may occur during accommodation, which may exert stress on the sclera.[7] Young et al in his experiment showed that the vitreous pressure increases during near viewing.[54]

Shum et al proposed that accommodation might induce an increase in vitreous pressure, which may cause the vitreous chamber to expand and the sclera; which is an elastic tissue to stretch. They further proposed that as the posterior pole is the most extensible part of the sclera; accommodation causes it to be stretched thereby increasing the axial length. During accommodation, the changes in the lens may not be sufficient to focus the image exactly on the retina. A small backward movement of the posterior pole may strengthen the accommodative effect. The near object may then form a clear image on the retina.[17]

In support to Shum's hypothesis, Tokor et al found that the sclera distended in a longitudinal direction at the equator and in both latitudinal and longitudinal directions at the posterior pole with increasing vitreous pressure.[55]

Relationship of accommodative changes with refractive error

Relationship of the ocular changes in accommodation with refractive error was also studied in our study. Group A comprised of emmetropes while group B comprised of myopia less than +5 D and group B comprised of subjects with hyper-metropia of less -5 D and group B comprised of subjects with hyper-metropia of less than +5 D. We did not any significant relationship between the accommodative changes in anterior chamber depth, lens thickness and axial length with refractive error of the eye as per unpaired't' test.

Shum et al also found no significant relation between refractive error and ocular biometric changes when they carried out linear regression analysis of their results[17].

Storey et al studied ocular changes with accommodation with A- scan in two groups of patient. Group 1 comprised with refractive error of 0 to -2.5 D; while group 2 comprised of patients with high myopia with refractive error of -4 to -11 D. They found that the changes in anterior chamber, lens thickness and axial length with accommodation were more in 2 [high myopses] as compared with group 1[14].

On the other hand, Drexler et al found that the axial length elongation with accommodation was more in emmetropes as compared with myopses in their study with partial coherence interfero-metry.[21]

Conclusion

In our study there is decrease in anterior chamber depth with increasing levels of accommodation and the lens thickness increases during accommodation. Present study

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shows small but consistent increase in axial length during accommodation as well as ocular changes during accommodation do not vary according to the refractive status of the patient.

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