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Original article

Accommodation: Its relation to refractive errors, amblyopia and biometric parameters

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Abstract

Aim: To study accommodation in relation to different refractive errors, amblyopia and to measure the anatomical changes in the accommodating eye

Materials and methods: We studied the amplitude of accommodation (AA) in 150 patients in the age group 11 – 30 years which included emmetropes, myopes, hypermetropes and hypermetropic amblyopes using the Royal Air Force (RAF) rule. The anterior chamber depth (ACD), axial length (AxL) and lens thickness (LT) changes during accommodation were measured using an A-scan. Myopes and hypermetropes were further divided based on the amount of refractive error : < 2D, 2 -4D and > 4D.

Results: Corrected low myopes had the highest accommodation amplitude ($p < 0.05$) followed by emmetropes. Corrected hypermetropes were found to have the lowest amplitude of accommodation ($p < 0.05$). The amblyopic eye had a significantly low AA compared to the non-amblyopic eye ($p < 0.05$). ACD decreased ($p < 0.05$) and LT increased ($p < 0.05$) during accommodation. The AxL increase was maximum in myopes ($p < 0.05$) followed by hypermetropes but the change was not significant in hypermetropes ($p > 0.05$).

Conclusion: The amblyopic eye has low amplitudes of accommodation proving the benefit of near adds in amblyopic patients. Prolonged near work might induce myopia in susceptible eyes by increasing the axial length.

Key words: accommodation, refractive error, amblyopia, biometric changes

Accommodation is the ability of the eye to change the refractive power of the lens to automatically focus on objects at various distances. It is a complex constellation of sensory, neuromuscular and biophysical phenomena by which the overall refracting power of the eye changes rapidly to image objects at different viewing distances clearly on to the retina (Kaufman, 1994). The amplitude of accommodation (AA) is the amount of accommodation exerted to move the focus from the far point (furthest distance at which object is seen clearly) to the near point or the difference between the refractivity of the eye in the two conditions - when at rest with minimal refraction and when fully accommodated with maximal refraction (Duke-Elder, Sir Stewart 1970). It decreases from childhood to 65 years (Abrams, 1995). Often neglected, accommodation is an

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important function of the eye. Both insufficiency and excess (spasm) of accommodation can be problematic. It not only affects vision but leads to other problems like strain and headache. The association of accommodation and its changes in different refractive errors need special attention as it might play a causal role in the etio-pathogenesis.

This study was carried out to find out accommodation in relation to different refractive errors and amblyopia. Also, the anatomical changes during accommodation were studied.

Materials and methods

A total of 150 patients in the age group of 11 – 30 years were included in the study after taking informed consent. The assessment of selected patients included a detailed history, general and ocular examination, including biomicroscopy and direct ophthalmoscopy. All patients underwent a wet retinoscopy followed by dry retinoscopy a week later. Emmetropes, ammetropes and amblyopes without any ocular pathology (normal anterior and posterior segments) or systemic illness presenting to us in the OPD were selected.

The AA was measured using the RAF rule. The patient was asked to focus on a target with fine lines of letters sliding on a 50 cm iron rod. The target was brought from far to near gradually till the patient appreciated blurring. The distance at which blurring just started was taken as the near point of accommodation. If the patient's amplitude was so low that the near point was beyond the length of the instrument, suitable covex lenses were added. The dioptric power of those lenses was deducted from the calculated accommodation in diopters from the RAF rule and the reciprocal of this net power was converted to cms and taken as the near point of accommodation.

We used *DGH 5100e A-Scan/ Pachymeter* to measure the ACD, AxL and LT by applanation method (contact technique). The probe was gently placed on the centre of the cornea maintaining perpendicularity, with the patient in the supine position. It was ensured that no ointment or excess fluid was present on the cornea when commencing the applanation, since even a small amount of fluid might lead to an increased Anterior Chamber Depth reading. A drop of paracaine 0.5 % was instilled in the test eye to anaesthetize the cornea, followed by a drop of a lubricating agent. Measurements were taken with both distance and near fixation.

Eyes were divided based on refractive error (emmetropia, myopia < 2D, 2 - 4 D, > 4D, hypermetropia <2D, 2-4D, >4D), presence or absence of amblyopia. Accommodation amplitudes, LT, ACD and AxL changes during accommodation were studied in different groups.

All statistical analysis was done with the help of the software programme SPSS, version 17.0 using independent 't' test and paired 't' test.

Results

The mean ± SD of the age of the patients in our study was 18.25 ± 5.88 years. The minimum age included in the study was 11 years and maximum was 30 years. The maximum percentage of patients i.e. 13.3 % were of 12 years of age and 8 % were of 11 years of age. The total number of males was 85 and females 65. Table 1 shows the AA in relation to refractive errors. Corrected myopes had the highest AA which was significantly more than that of the emmetropes and corrected hypermetropes ($p < 0.05$). The AA of emmetropes was significantly more than that of the corrected hypermetropes ($p < 0.05$).

Table 1

Amplitude of accommodation in relation to refractive errors

Refractive status	Number of patients	Mean ± SD AA (Diopters)
Emmetropes	18	10.11 ± 1.66
Corrected myopes	75	12.30 ± 2.01
Corrected hypermetropes	57	8.21 ± 2.61

Table 2 shows the AA among myopes. The corrected low myopes (< 2D) had the highest AA compared to myopes: 2 - 4D and >4D ($p < 0.05$). The myopes >4D had the lowest AA but the difference between 2-4D and >4D was not significant ($p>0.05$).

Table2

Amplitude of accommodation in myopes

Refractive status	Number of patients	Mean ±SD AA (diopters)
Corrected myopia < 2D	33	13.32 ± 1.95
Corrected myopia 2 - 4D	25	11.57 ± 1.96
Corrected myopia > 4D	17	11.27 ± 1.70

The difference in AA among hypermetropes of < 2D, 2 - 4D and > 4D, was not significant ($p>0.05$).

Table 3 shows the mean AA in amblyopic and non-amblyopic eyes. The amblyopic eye had a significantly lower AA compared to the non-amblyopic eye ($p < 0.05$).

Table 3: Amplitude of accommodation in amblyopic and non-amblyopic eyes

Table 4 shows anatomical changes during accommodation in all patients irrespective of the refractive error. Lens thickness increased and ACD decreased significantly during accommodation ($p < 0.05$). AxL increased during accommodation but the overall increase was not significant ($p > 0.05$).

Table 4

Anatomical changes during accommodation

	Distance (mm) ±SD	Near (mm) ±SD	p-value
Axial length	22.74 ± 1.30	22.76 ± 1.32	0.162
Lens thickness	3.81 ± 0.14	4.01 ± 0.19	0.00
Anterior chamber depth	2.83 ± 0.12	2.66 ± 0.12	0.00

Table 5 compares axial length changes during accommodation in myopes, hypermetropes and emmetropes. Myopes showed greatest increase in AxL during accommodation which was significant ($p < 0.05$). AxL in hypermetropes didn't change significantly but the increase was significant in emmetropes ($p < 0.05$) which was less compared to myopes.

Table 5

Axial length (AxL) changes during accommodation in myopes, hypermetropes and emmetropes

	AxL ± SD distance (mm)	AxL near (mm) ±SD	p-value
Myopes	23.56 ± 0.80	23.60 ± 0.81	0.02
Hypermetropes	21.67 ± 1.21	21.66 ± 1.22	0.09
Emmetropes	22.74 ± 0.51	22.75 ± 0.50	0.03

Discussion

In the present study, corrected low myopes had the highest amplitude of accommodation followed by emmetropes and the weakest accommodation was seen in corrected hypermetropes. With increasing myopia, the amplitude of accommodation decreased. Corrected hypermetropes had a lower effective accommodation compared to emmetropes and will need near addition at a younger age. The converse applies to myopes. This is due to the lower effectiveness of convex lenses for near compared to concave lenses. Hypermetropes are thus more symptomatic earlier than emmetropes or myopes (Lekha Mary Abraham et al 2005)**.** McBrien *et al 1986* found that the amplitude of accommodation was highest in late onset myopes and least in hypermetropes. After the age of 44 years there seems to be no difference in AA between the three refractive groups (Lekha Mary Abraham et al 2005). Maddock et al (1981) in reporting their findings on tonic accommodation and refraction, noted that low myopes had a higher amplitude of accommodation than either high myopes or emmetropes did, but did not comment on the significance of these findings. The underlying basis for these differences among various groups of refractive error poses an interesting question. It has been reported that the normal physiologic tone of the ciliary muscle in hyperopes is greater than in myopes (Duke-Elder S and Abrams D, 1970). Alternatively, might it represent an active functional response to refractive error as part of an attempted physiologic compensation? The questions raised by these findings require further studies of resting point and refractive characteristics. A possible interpretation of these findings has been put forward by Charman (1982), who suggests that myopes have a weak sympathetic or strong parasympathetic innervation, which would tend to reduce the attainable range of response in the sympathetic region of the response curve. This would adversely affect vision of more distant objects, rendering the subject relatively myopic. When this myopic eye is then corrected with a suitable negative lens, its tonic position of accommodation would lie at a dioptrically lower value than that of an emmetropic eye having a normal autonomic balance. Conversely, a relatively strong sympathetic or weak parasympathetic innervation results in hypermetropia and in the corrected eye having a higher dioptric value of tonic accommodation.

The accommodation amplitude in the amblyopic eye was found to be significantly lower than in the non-amblyopic eye. In a study of accommodation in amblyopia (Goel et al 1981) it has been observed that accommodation is considerably less in the amplyopic eye than in the non-amblyopic and control eyes. This justifies the role of compulsory near vision testing in amblyopic patients and prescribing appropriate near adds.

LT significantly increased and the ACD decreased during accommodation. Lens thickness increases and anterior chamber depth decreases during accommodation for near (Matthias et al 2007). These biometric changes are greater in myopes compared to emmetropes (Alpern, 1958). The correlation between refractive and biometric changes is essentially linear in both myopes and emmetropes. Patients with hypermetropia always use the less hypermetropic eye because it requires less accommodative effort and constantly suppresses the more hypermetropic eye (Robinson et al 5th edition). The axial length increased in both emmetropic and myopic subjects during short periods of accommodative stimulation. Greater transient increases in axial length were observed in myopic than in emmetropic subjects. The mean axial elongation with a 6-D stimulus to accommodation was 0.037 mm in emmetropes and 0.058 mm in myopes (Edward et al 2006). So, near work might induce myopia in patients with susceptible eyes.

Conclusion

Corrected hypermetropes have the lowest AA and so might need a near add earlier compared to corrected myopes who have the highest AA. An amblyopic eye has a low AA and so if near vision is found affected, glasses should be prescribed for near. The axial length increase during accommodation especially in myopes suggests the role of prolonged near work in inducing myopia in susceptible eyes.

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