ORIGINAL

Observation of Ciliary Body Changes during Accommodation Using Anterior OCT

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Abstract : Aim : To evaluate the anatomical changes in the ciliary body (CB) during naturally stimulated accommodation in children using anterior segment optical coherence tomography (OCT). Methods : This study was a prospective, observational, noncomparative case series included 18 eyes of 9 children (8 males and 1 female) aged from 4 to 10 years. Ciliary body thickness (CBT) was measured temporally by Anterior OCT at 1, 2 and 3 mm posterior to the scleral spur. Measurements were performed in the accommodated state and the unaccommodated state (with cycloplegia). Results : The mean CBT significantly increased by accommodation at 1 mm posterior to the scleral spur from 751±42 to 818±40 μm ($P < 0.001$) and significantly decreased at 2 and 3 mm from 506±66 to 445±59 μm and from 290±54 to 240±50 μm respectively ($P < 0.001$). Conclusion : During accommodation, the anterior portion of the ciliary body thickens, while the posterior portion decreases in thickness. These findings imply that the circular ciliary muscles are mainly involved in accommodation and not the longitudinal muscles. J. Med. Invest. 65 : 60-63, February, 2018

Keywords **:** *Ciliary Body, Accommodation, Anterior OCT*

INTRODUCTION

The mechanism of accommodation was explained by the capsular theory of Helmholtz. The contraction of the ciliary muscles releases the resting tension on the zonules, which in turn releases the outward directed equatorial tension on the lens capsule, allowing the elasticity of the lens to make it more round and increases the refractive power of the eye to bring the retinal image of the near objects on the retina (1).

Several imaging techniques had been used to study accommodation as magnetic resonance imaging (MRI) (2), ultrasound biomicroscopy (UBM) (3) and anterior segment optical coherence tomography (OCT). Among these techniques, OCT is considered a simple, rapid, non-contact method with high image quality and available with software capable of calculating distance and angle (4).

The position of the iris makes imaging of the ciliary muscle difficult. This was the main cause of incomplete available data about the morphological changes of the ciliary muscles during accommodation, especially in children. So, OCT seems to be the most suitable imaging technique for this purpose (5). A study of the accommodation in adults by OCT demonstrated that most of the anatomical changes occur in the anterior part of the ciliary muscles which includes the circular fibers with anterior and inward shift during accommodation (6).

Accommodation in children was studied also by OCT, demonstrating similar results as in adults and proved to be suitable for ciliary muscle as well as to evaluate the changes in the anterior chamber depth and lens thickness during accommodation (7, 8).

The aim of this study was to evaluate the anatomical changes in the ciliary body (CB) during naturally stimulated accommodation in Japanese children using anterior OCT.

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PATIENTS AND METHODS

Study Population

The study population included children from the outpatient ophthalmology clinic at Tokushima University Hospital as well as volunteers who were relatives of hospital staff. A written informed consent was obtained from parents of all participants after being provided with information about the study. The study adhered to the tenets of the Declaration of Helsinki. Ethics Committee approval was obtained.

The inclusion criteria were any Japanese child between the age of 4 to 12 years with spherical equivalent refraction between -3.00 to +1.00 diopter (D). We excluded children with any ocular pathology which might affect accommodation, any previous intraocular surgery, and poor visual acuity or poor cooperation which may interfere with fixation.

Measurements

Manifest refraction and decimal best-corrected visual acuity (BCVA) were measured for all participants. Assessment by anterior segment OCT was done in the accommodated state first, then in the unaccommodated state after the administration of cycloplegic eye drops. All assessments and measurements were carried out by the same examiner (MF) using Casia™ SS-1000 anterior segment OCT (TOMEY Corporation Japan, Nagoya, Japan). The examiner was not masked to the patient accommodative status because the pupil was constricted in the accommodated state and dilated in the unaccommodated (cycloplegic) state. Children with refractive errors were using contact lenses during testing.

Measurements in the accommodated state were obtained by asking the child to look to a near object at a distance of 30 cm. (not to look inside the lens of the instrument) to stimulate accommodation naturally. The object was positioned beside the OCT instrument, to the right side when examining the left eye and to the left side when examining the right eye to capture an image of the temporal ciliary body. We considered pupillary miosis observed during fixation on the object as an indicator that the child is exerting accommodation.

After capturing the image of the ciliary body and taking measurements during accommodation, 1% cyclopentolate eye drops were used for mydriasis and cycloplegia. Two drops were instilled in each eye followed by another two drops after 5 minutes and measurements were taken 25 minutes later. Measurements in the unaccommodated (cycloplegic) state were obtained in the same manner used for the measurements in the accommodated state described above, but without the use of near object.

Measurements of the ciliary body thickness where calculated at 1 mm (CBT1), 2 mm (CBT2) and 3 mm (CBT3) distance from the scleral spur, which were considered as a fixed anatomical landmark. Using the software of the OCT instrument, a line was drown from the scleral spur to the ciliary body apex, three vertical lines were drown vertical on the previously described one at a distance of 1, 2 and 3 mm. Then, the device calculated the length of each line from the supra-ciliary space to the inner surface of the ciliary body to get the thickness at each distance (Figure 1).

The main outcome measures of this study were CBT1, CBT2 and CBT3 temporally in the accommodated and unaccommodated. All measurements were in micrometers (μm).

Statistical analysis

All analyses were performed using SPSS for windows version 9.0 (SPSS, Inc., Chicago, IL). The main outcome measures were expressed as mean (± standard deviation). Comparison of means was performed by the paired Student *t*-test. A *P*-value < 0.05 was considered significant.

RESULTS

This study included 18 eyes of nine children, the demographic characteristics of whom are shown in table 1. Twenty-seven children were examined for participation in this study, and 9 (18 eyes) met the inclusion criteria.

Measurements obtained in the accommodated and unaccommodated stats showed that CBT1 significantly increased by accommodation from 751±42 to 818±40 μm (P < 0.001). The mean increase in thickness was 66±39 μm. On the other hand, CBT2 & CBT3 : significantly decreased by accommodation from 506±66 and 290±54 to 445±59 and 240±50 μm respectively (P < 0.001). The mean decrease in thickness was 61±43 and 59±31μm respectively. These data are summarized in table 2 and figure 2.

DISCUSSION

In this study we observed the ciliary body changes during accommodation in a group of Japanese children. Our results showed that during accommodation the anterior part of the ciliary body increased in thickness while the posterior part decreased. Anatomically, the anterior part is formed mainly by the circular ciliary muscle and the posterior part is formed mainly by the longitudinal ciliary muscles (9). So, our observations support the idea that accommodation is generated by contraction of the circular ciliary muscles and not the longitudinal, resulting in decreasing the tension on the stretched zonules and allowing the elastic lens capsule to make the lens more globular.

Several studies reported the same observations in adults and in children (6, 7, 10, 11). Observations of Kano *et al.* (as well as our study), showed that the circular ciliary muscles are mainly involved in accommodation and not the longitudinal muscles (10).

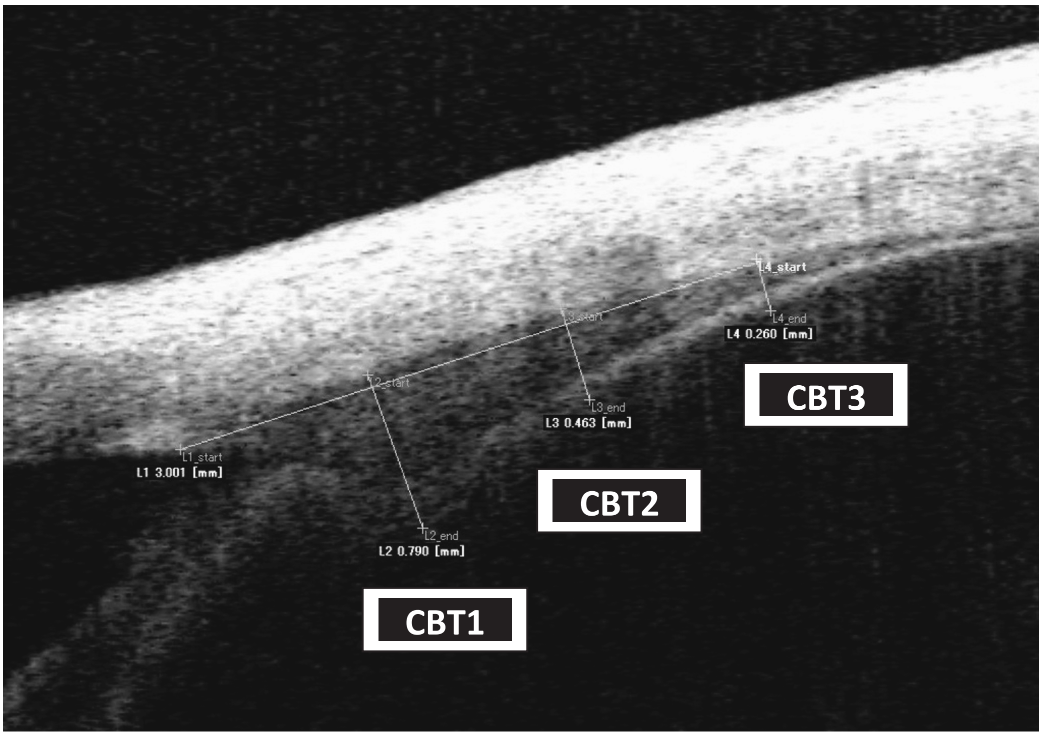

Figure 1 : Anterior segment optical coherence tomography image of the ciliary body. Using the software of the OCT instrument, a line was drown from the scleral spur to the ciliary body apex, three vertical lines were drown vertical on the previously described one at a distance of 1 mm (CBT1), 2 mm (CBT2) and 3 mm (CBT3).

Table 1 : Demographic Characteristics of the Study Sample. D, dioptre ; BCVA, best corrected visual acuity.

Mean age ± SD (rang), y	7.6±2.8 (4-10)
Gender	
Male, Number	8
Female, Number	1
Spherical equivalent refraction, D	-0.72±1.09 (range, -2.75 to +0.75)
Snellen BCVA	1.18±0.26 (range, 0.80 to 1.50)

Table 2 : Changes in the ciliary body thickness during accommodation.

	Accommodated (Non-cycloplegic)	Unaccommodated (Cycloplegic)	*P*-value*	Change in Thickness
CBT1	818±40 μm	751±42 μm	< 0.001	+66±39 μm
CBT2	445±59 μm	506±66 μm	< 0.001	-61±43 μm
CBT3	242±50 μm	295±54 μm	< 0.001	-59±31 μm

CBT1, CBT2 and CBT3 : Measurements of the ciliary body thickness at 1 mm (CBT1), 2 mm (CBT2) and 3 mm (CBT3) distance from the scleral spur.

* P - value < 0.05 was considered significant. Paired sample t-test was used for comparing means

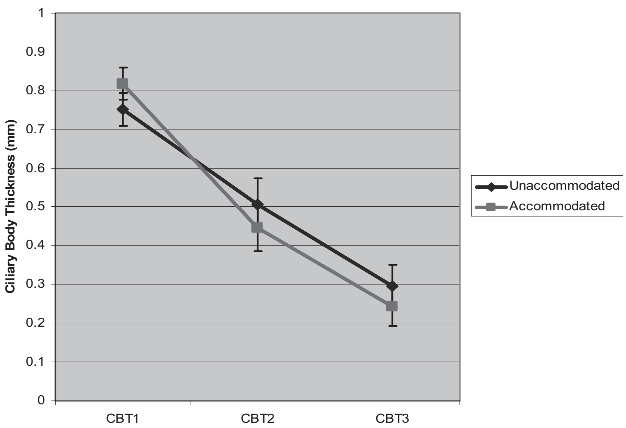

Figure 2 : Changes in the ciliary body thickness during accommodation measured by anterior OCT. Measurements were taken at 1 mm (CBT1), 2 mm (CBT2) and 3 mm (CBT3) distance from the scleral spur.

Lewis *et al*. demonstrated similar results as our study. They reported increase in the ciliary muscle thickness at 1 mm from the scleral spur and thinning at 3 mm during accommodation in children. But, they reported that the point of 2 mm from the scleral spur act as a "fulcrum" along the ciliary muscle where there is no significant change in the thickness (7). We reported different results regarding this point, as we found that the ciliary body thickness decreases during accommodation at the point of CBT2. This difference may be due to racial causes or using different instrument by a different investigator. A large number study with different subjects and races may be needed to solve this question.

Lossing *et al*. studied the ciliary body changes during accommodation in young adults. Using a combination of anterior segment OCT and power refractor they reported the same changes in ciliary body as in our study, i.e. increase thickness in the anterior part and decrease thickness in the posterior part. Moreover, they could measure the amount of change in the ciliary body thickness in relation to the accommodative response in diopters which was not measured in our study (11).

Sheppard and Davies used a different locations to measure the ciliary body thickness during accommodation by anterior segment OCT. They did not use the scleral spur as a fixed anatomical point to localize the point of measurement, but they used the overall ciliary body length. Despite of the different protocol of measurements, they obtained a results comparable to our results (6).

CONCLUSION

The use of anterior segment OCT is very beneficial to study accommodation in children and to evaluate the anatomical changes in the ciliary body. There is a growing consensus that the anterior part of the ciliary body thickens during accommodation and the posterior part became thinner. Further studies on subjects with different ages and using refractors to measure the accommodative response during the test will give use more information about the physiology of accommodation and the exact rule of ciliary body.

CONFLICT OF INTEREST

There is neither a financial relationship nor sponsorship with any organization to be declared.

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