

# Ultrasonic biometry of myopic eyes in premature children

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**Background.** The aim of our work was to determine changes in optical-anatomical elements of myopic eyes of full-term and premature children during accommodation by means of precise ultrasonic biometry.

**Materials and methods.** The study was made on healthy full-term children's eyes with emmetropic refraction (group, n = 20); full-term 1<sup>st</sup> degree myopic children's eyes with refraction from -1.0 D to -3.0 D (group 2, n = 16), and premature children's myopic eyes with refraction -1.0 D to -3.0 D (group 3, n = 12). The age of children ranged from 6 to 15 years. Gestation age in the pre-term group ranged from 25 to 34 weeks. All were seen in the clinic for the risk of developing retinopathy of prematurity. Precise ultrasonic biometry was done using the ultrasonic measuring system.

**Results.** Ultrasonic biometry evaluates optical-anatomical parameters in premature children's myopic eyes. Axial length was longer than in healthy and full-term myopic children's eyes (mean,  $24.09 \pm 0.69$  mm) and lens thickness was bigger (mean  $3.35 \pm 0.14$  mm). In the healthy children's group: axial length was  $23.49 \pm 0.48$  mm and lens thickness  $3.00 \pm 0.07$  mm, and in the full-term myopic children's group the axial length was  $23.79 \pm 0.59$  mm and lens thickness  $3.24 \pm 0.14$  mm.

**Conclusions.** No changes in the size of the eye optical-anatomical elements were found in the accommodation process for full-term and premature children's slightly myopic eyes.

In the group of premature children, longer axial length and bigger size of lens thickness were found in myopic eyes ( $24.09 \pm 0.69$  mm and  $3.35 \pm 0.14$  mm, respectively).

In the group of premature children changes in the optical-anatomical elements parameters of myopic eyes were more pronounced than in the group of full-term children, and it could lead to higher myopia development.

Ultrasonic biometry is an effective method in evaluating the activity of eye accommodation apparatus and the possibilities of eye accommodation. Precise ultrasonic biometry can reveal early eye accommodation disturbances in pre-mature children and evaluate the level of myopia.

**Key words:** prematurity, myopia, ultrasound biometry, accommodation

## INTRODUCTION

Myopia is a frequent sequela of retinopathy of prematurity (ROP). The mechanism for myopia development in children born preterm is not well understood. The close association between myopia and retinopathy of prematurity suggested a causal relationship, but myopia of prematurity without ROP has yet to be explained (1–3). Progress of myopia is associated with the stage of ROP, and high myopia is strongly associated with prematurity (4–6). Some authors assert that myopia in ROP is not

associated with the axial elongation of the eyeball. Prematurely born infants examined in school age did not show a higher risk of refractive errors, i. e. myopia. However, they were at a higher risk of squint (21, 22).

A lot of scientists investigating the occurrence and mechanism of myopia focus attention on disorders of accommodation. Low accommodation ability of the eye causes accommodation spasms, pseudomyopia, therefore the eye tries to see the object from a near distance, and this is a pathognomic sign of myopia (7, 8). The eye attempts to change its optical system to see the object which is closer without any accommodation strain. When the optical system is in formation, the

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axis of the eye becomes longer and axial myopia develops (8, 9).

Ultrasonic biometry as one of the objective methods for evaluating the refractogenesis process is widely used in children's ophthalmology.

By measuring the thickness of the cornea, the depth of the anterior chamber, the thickness of the lens, the length of eye axis and the interrelation of optico-anatomical elements it is possible to observe the speed of myopia progression and the effectiveness of treatment measures in stopping this process.

In 1970, D. J. Coleman was the first to use the ultrasonic biometry method to investigate eye accommodation and evaluate changes in the size of optico-anatomical elements during accommodation. He didn't notice marked changes in the length of eye axis while investigating this phenomenon. J. K. Storey (10) indicates an increase in the length of eye axis during accommodation to objects at a close distance. L. F. Garner, G. Smith (11) point out that during accommodation the depth of anterior chamber decreases while the lens thickness increases but the length of the eye axis does not undergo any changes. D. O. Mutti, K. Zadink, R. E. Fusaro investigated the parameters of children's eye lens by ultrasonic biometry and determined that in children aged 6–10 years the thickness of lens decreased by 0.2 mm, i. e. the lens became thinner (12, 13). The authors indicate that after such "growth" of the lens of these children, later on the first signs of myopia occur after the age of 10.

H. C. Fledelius demonstrated more of fetal anterior segment proportions, with flatter anterior chambers and thicker, more spheroid lenses in preterm infants. Ocular growth parameters had lower values in the subgroup with ROP. Oculometrically, it was a more curved cornea and a shorter axial length (14, 15).

According to Choi et. al. (16), the degree of myopia in the eyes of preterm infants with and without ROP was related to the depth of the anterior chamber, the thickness of the lens and the change in axial length, but not to the keratometric value. Garcia-Valenzuela and Kaufman showed that the increased lens thickness in ROP eyes was accompanied by a shallow anterior chamber depth and maintenance of the anterior chamber segment depth similar to a normal neonatal's eye, suggesting a mechanism of altered anterior segment development in ROP, leading to high myopia (17).

Different authors point out rather different changes in the size of optical-anatomical elements. They studied different age groups of children whose eyes were of different refraction degree. Therefore, the refraction process and miopization have not been elucidated in myopic premature children's eyes and requires further investigation.

The aim of our work was to determinate changes in the optico-anatomical elements of full-term children's myopic and premature children's myopic eyes by the method of precise ultrasonic biometry.

## MATERIALS AND METHODS

The study was made on healthy full term children's eyes with emmetropic refraction (group 1,  $n = 20$ ); full-times lightly myopic children eyes with refraction from -1.0 D to -3.0 D (group 2,  $n = 16$ ) and premature children's myopic eyes with refraction from -1.0 D to -3.0 D (group 3,  $n = 12$ ). The age of children ranged from 6 to 15 years. Gestational age in the pre-term group ranged from 25 to 34 weeks. All children were seen in the clinic for the risk of developing retinopathy of prematurity.

In our work, we have evaluated the following data: vision acuity to the distance, accommodation reserves to the distance, eye refraction during cycloplegia (using Cycloglyli 0.1%).

Precise ultrasonic biometry was done using an ultrasonic measuring system which included:

- a) a coordinative equipment on which a 15 kHz ultrasonic transformer was fixed;
- b) an ultrasonic biometric apparatus working in the A-regime. This equipment was constructed at the Biomedical Ultrasonic Engineering Laboratory of Kaunas University of Technology. By using an ultrasonic transformer fixing equipment it was possible to carry out precise ultrasonic biometry more accurately, as it enabled to avoid researcher's hand micro-movements.

During the examination the eye was anesthetized with 0.25% tetracain solution. On putting the ultrasonic transformer to the eye, the glance of the other eye was directed to an object located at a distance of 5 m. Both eyes accommodated at the same time because of the effect of accommodation hysteresis.

In the ultrasonic curve on the A-scanner screen the length of the eye axis, the depth of the anterior chamber, the thickness of the lens, the length of the vitreous were measured.

Analogous measurements were carried out for the eye accommodating to the object located at a distance of 33 cm. After examining one eye, examination of the other eye was done after 60 minutes because of a slow accommodation hysteresis.

## RESULTS AND DISCUSSION

Results are presented as a mean and a standard deviation ( $M \pm SD$ );  $p$  values less than 0.05 were considered to be statistically significant.

Precise ultrasonic biometry shows, that accommodation process changes the optical-anatomical parameters of the eye. In the first group (Table 1), the most intensive changes were found in lens thickness.

To the distance, lens thickness was  $3.00 \pm 0.07$  mm and during accommodation to the nearness reached  $3.28 \pm 0.09$  mm; the difference was  $0.28 \pm 0.07$  mm. Anterior chamber depth changed significantly and reached  $0.23 \pm 0.08$  mm. We did not fix significant changes in the axial length or vitreous body length during accommodation. Ultrasonic biometry has confirmed that the most

**Table 1. Comparison of parameters full-term born children with emmetropic refraction and children with myopic refraction**

| Parameters                                | Group 1     | Group 2     | p      |
|---|-------------|-------------|--------|
|   | Average ±SD | Average ±SD |        |
| Visual acuity                             | 1±0         | 0.38 ±0.22  | <0.001 |
| Accommodation reserves D                  | 9.58±1.46   | 0.69±1.16   | <0.001 |
| Axial length to the distance mm           | 23.49±0.48  | 23.79±0.59  | <0.001 |
| Axial length to the nearness mm           | 23.49±0.48  | 23.79±0.59  | <0.001 |
| Anterior chamber depth to the distance mm | 2.93±0.07   | 2.88±0.21   | <0.001 |
| Anterior chamber depth to the nearness mm | 2.69±0.06   | 2.88±0.21   | <0.001 |
| Difference of anterior chamber depth mm   | 0.23±0.08   | 0±0         | <0.001 |
| Lens thickness to the distance mm         | 3.00±0.07   | 3.24±0.14   | <0.001 |
| Lens thickness to the nearness mm         | 3.28±0.09   | 3.24±0.14   | <0.001 |
| Difference of lens thickness mm           | 0.28±0.07   | 0±0         | <0.001 |
| Vitreous length to the distance mm        | 17.57±0.43  | 17.67±0.47  | <0.001 |
| Vitreous length to the nearness mm        | 17.53±0.44  | 17.67±0.47  | <0.001 |
| Difference of vitreous length mm          | 0.05±0.06   | 0±0         | <0.001 |

**Table 2. Comparison of parameters in full-term born children with emmetropic refraction and prematurity children with myopic refraction**

| Parameters                                | Group 1     | Group 3     | p      |
|---|-------------|-------------|--------|
|   | Average ±SD | Average ±SD |        |
| Visual acuity                             | 1±0         | 0.31±0.21   | <0.001 |
| Accommodation reserves D                  | 9.58±1.46   | 0.86±0.92   | <0.001 |
| Axial length to the distance mm           | 23.49±0.48  | 24.09±0.69  | <0.001 |
| Axial length to the nearness mm           | 23.49±0.48  | 24.09±0.69  | <0.001 |
| Anterior chamber depth to the distance mm | 2.93±0.07   | 2.87±0.15   | <0.001 |
| Anterior chamber depth to the nearness mm | 2.69±0.06   | 2.87±0.15   | <0.001 |
| Difference of anterior chamber depth mm   | 0.23±0.08   | 0±0         | <0.001 |
| Lens thickness to the distance mm         | 3.00±0.07   | 3.35±0.14   | <0.001 |
| Lens thickness to the nearness mm         | 3.28±0.09   | 3.35±0.14   | <0.001 |
| Difference of lens thickness mm           | 0.28±0.07   | 0±0         | <0.001 |
| Vitreous length to the distance mm        | 17.57±0.43  | 17.87±0.63  | <0.001 |
| Vitreous length to the nearness mm        | 17.53±0.44  | 17.87±0.63  | <0.001 |
| Difference of vitreous length mm          | 0.05±0.06   | 0±0         | <0.001 |

active part of the accommodation process – the lens and its thickness fluctuations are of great importance for eye refractogenesis. The results which we obtained after performing measurement of 1<sup>st</sup> degree myopia children who made the second group (Table 1) confirmed that as well. In this group, the eye axis was somewhat longer (23.79 ± 0.59 mm). The lens was also thicker, however, during the process of accommodation we did not notice any fluctuations of lens thickness which remained the same (3.24 ± 0.14 mm); this was confirmed by accommodation reserves which in this group were very low

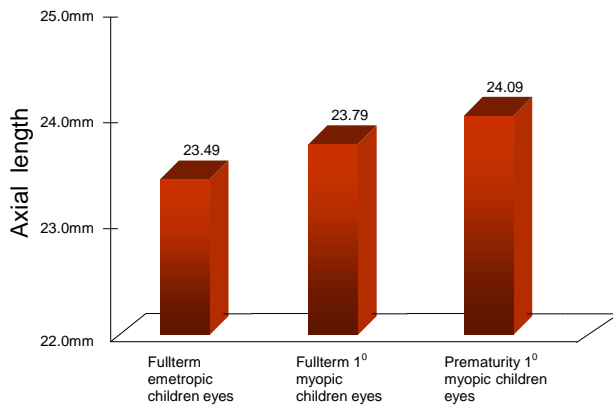
(0.69 ± 1.16 D). This means that the accommodation muscle is completely unable to function, so there are all prerequisites for the progress of myopia. Neither did we notice fluctuations of the length of the anterior chamber or the vitreous body, they were respectively 2.88 ± 0.21 mm and 17.67 ± 0.47 mm (in all cases p < 0.001.).

Similar results have been obtained in the premature children's myopic eye group (Table 2).

Their accommodation reserves were also very low (0.86 ± 0.92 D). During accommodation, we noticed no changes in the size of the optical-anatomical eye elements. However, in contrast to the full-term children's myopic eye group, the length of their eye axis was somewhat bit bigger than in other groups (24.09 ± 0.69 mm), and the length of vitreous body was 17.87 ± 0.63 mm. The thickness of the lens was also bigger (3.35 ± 0.14 mm). These data confirmed that in pre-maturity children's myopic eyes the insufficient ability of the accommodation

muscle to function was even more significant. In this group, the length of children's eye axis was apt to increase quicker than in the case of full-term children's myopic eyes, confirming the author's opinion that prematurity can be a reason for high myopia to develop (7, 17).

In Fig.1 we can see how the data obtained during measurement of eye axis length changed in all three groups, and in Fig. 2 we see the change of lens thickness in these groups. Premature children's eyes have a longer axis and thicker lens in comparison with healthy



**Fig. 1.** Axial length in emmetropic and myopic children eyes

children or with slight myopia children's eyes. Here we have also noticed that the change of eye optical-anatomical elements was most significant in premature children's eyes.

## CONCLUSIONS

No changes in the size of the eye optical-anatomical elements were found in the accommodation process for full-term and premature children's slightly myopic eyes.

In the group of premature children's myopic eyes, longer axes and thicker lens were observed ( $24.09 \pm 0.69$  mm and  $3.35 \pm 0.14$  mm, respectively).

In the group of premature children's myopic eyes, changes in optical-anatomical parameters were more pronounced than in the group of full-term children's myopic eyes and could lead to higher myopia development.

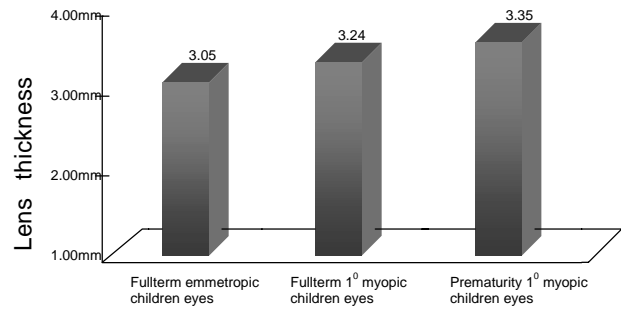
Ultrasonic biometry is an effective method in evaluating activity of the eye accommodation apparatus and the possibilities of eye accommodation. Precise ultrasonic biometry can reveal early accommodation disturbances in premature children's eyes and evaluate the level of myopia.

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**Fig. 2.** Lens thickness in emmetropic and myopic children eyes