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Ultrasonic biometry of fullterm and prematurity children eyes accommodation

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Abstract

The aim of our work has been to determinate changes in optical-anatomical elements of full-term and pre-maturity children myopic eyes during accommodation using precise ultrasonic biometry.

Research has been done on healthy full-term children eyes with emmetropic refraction (*n*=20);pre-term emmetropic children (*n*=8);full-term 1st degree myopic children eyes with refraction from -1.0D to -3.0D (second group, *n*=16), and pre-maturity children myopic eyes with refraction -1.0D to -3.0D (third group, *n*=12). The age of children ranged from 6 to 15 years old. Gestagetion ages in the pre-term group ranged from 28 to 34 weeks.

Ultrasonic biometry evaluates optical-anatomical parameters changes in pre-maturity children myopic eyes. The axial length was longer than in healthy and full-term myopic children eyes, average 24.09±0.69 mm), and the lens thickness was bigger (average 3.35±0.14 mm). In the healthy children group respectively the axial length was 23.49±0.48 mm, and lens thickness was 3.00±0.07 mm and in the full-term myopic children group the axial length was 23.79±0.59 mm, the lens thickness was 3.24±0.14 mm.

In the group of pre-maturity children myopic eyes changes in optical-anatomical elements parameters were more active than in the group of full-term children myopic eyes and it can lead to a higher myopia development.

Keywords:

Introduction

A lot of scientists investigating the occurrence and mechanism of myopia pay the greatest attention to disorders of accommodation. Low ability of accommodation of the eye causes accommodation spasms, pseudomyopia, for that reason eyes tries to see the object from near distance and this is pathognomic sign of myopia [1, 2]. The eye attempts to change its optical system to see the object which is closer without any accommodation strain. When optical system is in formation the axis of the eye becomes longer and axial myopia develops [2, 3].

Myopia is a frequent sequelae retinopathy of prematurity. The mechanism for myopia development in children born preterm is not well understood. The close association between myopia and retinopathy of prematurity (ROP) suggested a causal relationship, but myopia of prematurity without ROP has yet to be explained [4,5,6]. Progress of myopia is associated with the stage of ROP, and high myopia is strongly associated with prematurity [7,8,9]. Some authors assert that myopia in ROP is not associated with axial elongation of the eyeball. Prematurely born infants examined in a school age did not show a higher risk of refractive errors, i c. myopia. However, they were at a higher risk having squint [16,17].

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

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

In 1970 D.J. Coleman was the first to use the ultrasonic biometry method to investigate the eye accommodation and evaluate the changes in the size of optico-anatomical elements during accommodation. He did not 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 near 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 eye axis does not undergo any changes. D.O.Mutti, K.Zadink, R.E.Fusaro investigated parameters of children eye lens by the ultrasonic biometry method and determined that in children of 6-10 years old the thickness of lens decreased by 0.2mm, i.e. the lens became thinner [12,13]. The authors indicate that after such "growth" of lens of these children later on the first signs of myopia occur after the age of 10.

Fledelius H.C. study demonstrated more foetal anterior segment proportions, with flatter anterior chambers and thicker, more spheroid lenses in the preterm infants. Ocular growth parameters had lower values in the subgroup with ROP. Oculomentrically it was a more curved cornea and a shorter axial length [14,15].

According to Choi M.Y, Park I.K, Yu Y.S (Korea), the degree of myopia in eyes of preterm infants with and without ROP was found to be related to the depth of the anterior chamber, the thickness of the lens and the change in axial length but not to keratometric value [16].Garcia-Valenzuela E., Kaufman L.M. discussed that the increased lens thickness seen in ROP eyes was accompanied by a shallow anterior chamber depth and maintenance of the anterior chamber segment depth, similar to the normal neonatal eye, suggesting a mechanism of altered anterior segment development in ROP lending to high myopia [17].

According to the literally data different authors paint out rather different changes in a size of optical-anatomical elements. Different authors studied different age groups of children whose eyes were of a different refraction size. That's why we see that refraction process and miopization has not been fully studied in myopic prematurity children eyes and requires a further investigation.

The aim of our work has been to determinate changes in optico-anatomical elements of full-term myopic and prematurity children myopic eyes using the precise ultrasonic biometry.

Methods and materials

Research has been done on healthy full term children eyes with emetropic refraction (first group *n*=20); preterm emmetropic group (second group *n*=8); fulltime light myopic children eyes with refraction from -1.0D to -3.0D (third group, *n*=16) and prematurity children myopic eyes with refraction from -1.0D to -3.0D (fourth group *n*=12). The age of children ranged from 6 to 15 years old. Gestational ages in the pre-term group ranged from 28 to 34 weeks. All were seen in the clinic due to the risk of developing retinopathy of prematurity.

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

The precise ultrasonic biometry was done by an ultrasonic measuring system which included:

a) coordinative equipement on which ultrasonic transducer of 15 MHz was fixed.

b) ultrasonic biometric apparatus working on A-regime.

This equipment was constructed in Biomedical Ultrasonic Engineering Laboratory of Kaunas University of Technology. By using ultrasonic transducer fixing equipment it was possible to carry out the precise ultrasonic biometry more exactly as this enabled to avoid researcher's hand micro-movements.

During the examination the eye was anesthezed by 0.25% of tetracain solution. Having put ultrasonic transducer to the eye the glance of another eye was directed to the object located at 5m distance. Both eyes accommodate equally at the same time because of the effect of accommodation hysteresis.

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

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

Results and discussion

Results are presented in the text as the mean and standard deviation (M±SD), *p* values less than 0.05 were considered to be statistically significant.

The precise ultrasonic biometry manifests that accommodation process changes the optical-anatomical parameters of the eye. In the first group (Table 1), the most intensive changes were in the lens thickness. To the distance the lens thickness was 3.00±0.07 mm and during accommodation to the nearness reached 3.28±0.09 mm. The difference was 0.28±0.07 mm and during accommodation to the nearness reached 3.28±0.09 mm. The difference was 0.28±0.07 mm. The anterior chamber depth changed significantly and reached 0.23±0.08 mm. We have not fixed significant changes of the axial length or the vitreous body length during accommodation. Ultrasonic biometry has confirmed that the most active part of the accommodation process - the lens and fluctuations of its thickness are of great importance for eye refractogenesis. The results of the ultrasound biometry of preterm emmetropic children eyes (Table 1) confirmed that in this group the length of the eye axis was a bit shorter 23.18+-0.04 mm, the anterior chamber depth is smaller (2.92+-0.05 mm), the lens thickness 2.97+-0.07 mm, and the difference during accommodation 0.25+-0.05 mm. The results which we obtained after performing measurement of myopic children of 1st degree who made the third group (Table 2) confirmed that as well. In this group the length of the eye axis was a bit larger 23.79±0.59 mm. The lens was also thicker, however, during accommodation process we have not noticed fluctuation of lens thickness and its thickness remained the same 3.24±0.14 mm, that was confirmed by accommodation reserves which in this group were very low 0.69±1.16D. That means that the accommodation muscle is completely unable to function, so there are all prerequisites for progress of myopia. We have also not noticed fluctuation of the length of either anterior chamber or vitreous body and they were respectively of 2.88±0.21 mm and 17.67±0.47 mm values (in all cases $p<0.001$.).

Similar results have been obtained in pre-maturity children myopic eye group (Table 3). Their accommodation reserves have also been very low 0.86±0.92D. During accommodation process we have not noticed size changes of optical-anatomical eye elements. However, to the contrary of the full-term children myopic eye group, the lengths of their eye axis were a bit bigger than in other groups, i.e. 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. That has confirmed that in pre-maturity children myopic eyes the insufficient ability to function of the accommodation muscle was even more significant. In this group the length of children eye axis is apt to increase quicker than in the case of full term children myopic eyes. That confirms the author opinion that pre-maturity can be a reason of a high myopia development [1, 17].

In Fig.1 we can see how the data obtained during measurement of eye axis length changed in all groups, and in Fig.2 we see the change of lens thickness in all three groups. Pre-maturity children myopic eyes have a bigger axial length and thicker lens in comparison with healthy children or with light myopia children eyes. Here we have also noticed that the most significant change of eye optical-anatomical elements was in pre-maturity children myopic eyes.

Table 1.**Comparison of parameters fullterm born children and pre-term born children with emmetropic refraction.**

Parameters	1 group	2 group	*p*
	Average ±SD	Average ±SD	
Visual acuity	1±0	1±0	*p*<0,001
Accommodation reserves, D	9,58±1,46	9,06±1,32	*p*<0,001
Axial length to the distance, mm	23,49±0,48	23,18±0,44	*p*<0,001
Axial length to the nearness, mm	23,49±0,48	23,18±0,04	*p*<0,001
Anterior chamber depth to the distance, mm	2,93±0,07	2,92±0,05	*p*<0,001
Anterior chamber depth to the nearness, mm	2,69±0,06	2,69±0,03	*p*<0,001
Difference of the anterior chamber depth, mm	0,23±0,08	0,23±0,07	*p*<0,001
Lens thickness to the distance, mm	3,00±0,07	2,97±0,07	*p*<0,001
Lens thickness to the nearness, mm	3,28±0,09	3,22±0,09	*p*<0,001
Difference of the lens thickness, mm	0,28±0,07	0,25±0,05	*p*<0,001
Vitreous length to the distance, mm	17,57±0,43	17,29±0,39	*p*<0,001
Vitreous length to the nearness, mm	17,53±0,44	17,27±0,42	*p*<0,001
Difference of vitreous length, mm	0,05±0,06	0,04±0,05	*p*<0,001

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

Parameters	1 group	3 group	*p*
	Average ±SD	Average ±SD	
Visual acuity	1±0	0,38±0,22	*p*<0,001
Accommodation reserves, D	9,58±1,46	0,69±1,16	*p*<0,001
Axial length to the distance, mm	23,49±0,48	23,79±0,59	*p*<0,001
Axial length to the nearness, mm	23,49±0,48	23,79±0,59	*p*<0,001
Anterior chamber depth to the distance, mm	2,93±0,07	2,88±0,21	p<0,001
Anterior chamber depth to the nearness, mm	2,69±0,06	2,88±0,21	*p*<0,001
Difference of the anterior chamber depth, mm	0,23±0,08	0±0	*p*<0,001
Lens thickness to the distance, mm	3,00±0,07	3,24±0,14	*p*<0,001
Lens thickness to the nearness, mm	3,28±0,09	3,24±0,14	*p*<0,001
Difference of the lens thickness, mm	0,28±0,07	0±0	*p*<0,001
Vitreous length to the distance, mm	17,57±0,43	17,67±0,47	p<0,001
Vitreous length to the nearness, mm	17,53±0,44	17,67±0,47	*p*<0,001
Difference of vitreous length, mm	0,05±0,06	0±0	*p*<0,001

Table 3. **Comparison of parameters full-term born children with emmetropic refraction and prematurity children with myopic refraction.**

Parameters	1 group	4 group	*p*
	Average ±SD	Average ±SD	
Visual acuity	1±0	0,31±0,21	*p*<0,001
Accommodation reserves, D	9,58±1,46	0,86±0,92	*p*<0,001
Axial length to the distance, mm	23,49±0,48	24,09±0,69	*p*<0,001
Axial length to the nearness, mm	23,49±0,48	24,09±0,69	*p*<0,001
Anterior chamber depth to the distance, mm	2,93±0,07	2,87±0,15	*p*<0,001
Anterior chamber depth to the nearness, mm	2,69±0,06	2,87±0,15	*p*<0,001
Difference of the anterior chamber depth, mm	0,23±0,08	0±0	*p*<0,001
Lens thickness to the distance, mm	3,00±0,07	3,35±0,14	*p*<0,001
Lens thickness to the nearness, mm	3,28±0,09	3,35±0,14	*p*<0,001
Difference of the lens thickness, mm	0,28±0,07	0±0	*p*<0,001
Vitreous length to the distance, mm	17,57±0,43	17,87±0,63	*p*<0,001
Vitreous length to the nearness, mm	17,53±0,44	17,67±0,63	*p*<0,001
Difference of vitreous length, mm	0,05±0,06	0±0	*p*<0,001

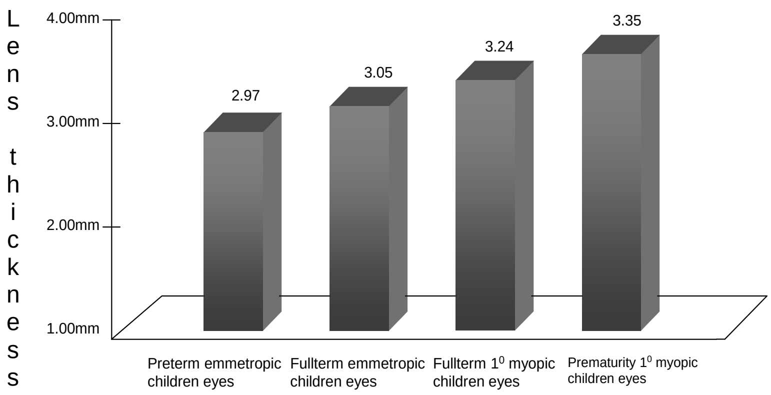

Fig.1. **Lens thickness in emmetropic and myopic children eyes**

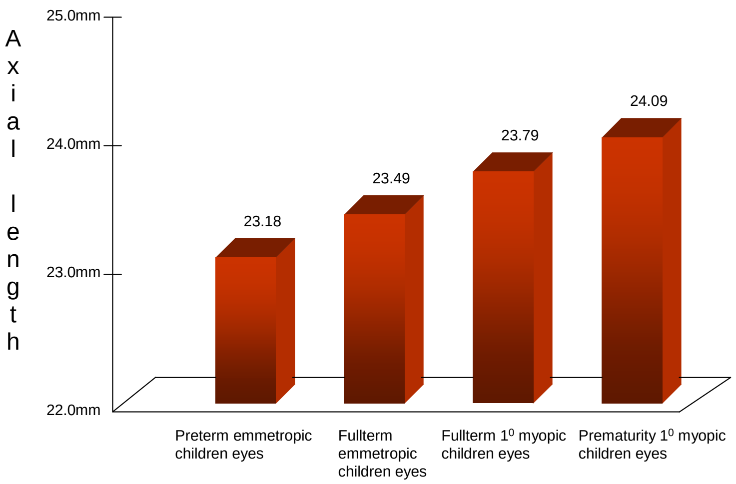

Fig.2. **Axial length in emmetropic and myopic children eyes**

Conclusions

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

2. The size of optico-anatomical parameters in preterm emmetropia children eyes are smaller than in full-time emmetropic children eyes.

3. No changes in the size of the eye optical-anatomical elements were found in the accommodation process for full-term and pre-maturity children slight myopic eyes.

4. In the group of pre-maturity children myopic eyes longer axial length and bigger size of lens thickness were observed. It was 24.09±0.69 mm and 3.35±0.14 mm respectively.

5. In the group of pre-maturity children myopic eyes changes in optical-anatomical elements parameters were more active than in group of full-term children myopic eyes and it can lead to higher myopia development.

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Laiku gimusių ir prieš laiką gimusių vaikų akių akomodacijos ultragarsine biometrija

Reziumė

Remiantis ultragarsinės biometrijos duomenimis aptariami 6-15 m. amžiaus laiku gimusių ir prieš laiką gimusių (neišnešiotų) vaikų akių optinių-anatominių elementų pokyčiai akomodacijos metu. Buvo tirtos 4 asmenų grupės: pirmoje grupėje (n=20) - laiku gimusių emetropinės refrakcijos vaikų akys; antroje grupėje (n=8) - prieš laiką gimusių vaikų emetropinės refrakcijos akys; trečioje grupėje (n=16) - laiku gimusių 1^0 trumparegių vaikų akys; ketvirtoje grupėje (n=12) - prieš laiką gimusių 1^0 trumparegių vaikų akys. Nustatyti ryškesni optinių-anatominių elementų parametrų pokyčiai 1^0 miopinėse prieš laiką gimusių vaikų akyse (vidutinis akies ašies ilgis 24,09±0,69 mm, lęšiuko storis 3,35±0,14 mm). Be to, miopizacijos procesas aktyviau ir greičiau vyksta prieš laiką gimusių vaikų grupėje, o tai gali nulemti aukšto laipsnio trumparegystę.

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