

# COMPARISON OF AXIAL LENGTH, KERATOMETRY AND LENS THICKNESS BETWEEN PRETERM AND FULL-TERM BIRTH HISTORIES

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**Background:** The process of eyeball growth in infants occurs from the womb. In some studies, children with a history of prematurity can experience obstacles to eyeball development, causing refractive errors. Eyeball axial length growth, keratometry and lens thickness are very important in emetropization which determines refractive status.

**Objective:** To determine the comparison of eyeball axial length, keratometry and lens thickness in children with a history of preterm birth compared to full-term birth.

**Methods:** This study was an analytic observational study with a cross-sectional design. A total of 140 subjects aged 7-14 years were included in this study. The sample was divided into two groups: 70 subjects with a history of preterm birth and 70 subjects with a history of full-term birth. Measurement of ocular parameters was performed using an IOL master 700.

**Results:** Subjects with a history of preterm birth had similar axial lengths to those with a history of full-term birth,  $23.60 \pm 1.633$  mm and  $23.57 \pm 1.236$  mm, respectively ( $p = 0.895$ ). The keratometry values of the subjects with preterm birth history (K1  $45.20 \pm 0.856$  D, K2  $46.71$  D and Mean K  $-1.62$  D) were steeper than those of the subjects with full-term birth (K1  $42.96 \pm 1.160$  D, K2  $44.11$  D and Mean K  $-1.03$  D) with p values of 0.0001, p 0.0001 and p 0.001, respectively. Lens thickness was found to be thicker in the group of subjects with a history of preterm birth (3.66 mm) compared to term (3.39 mm) with a p value = 0.0001.

**Conclusion:** The morphology of the anterior segment of the eyeball, namely keratometry and lens thickness, was significantly different between preterm and full-term children. In addition, the axial length of the eyeball in children born prematurely was comparable to the axial length of the eyeball in children born at term. The results of this study indicate differences in the development of eyeball morphology in children born preterm.

**Keywords:** preterm, axial length, keratometry, lens thickness, IOL Master 700

## INTRODUCTION

The process of eye development begins while in the womb.<sup>1</sup> Eye development begins at 22 days gestation but progresses rapidly at 32 weeks until birth.<sup>2</sup> Adequate

birth age is needed so that the development of the baby's eye can take place optimally.<sup>1</sup> According to the World Health Organization (WHO), preterm birth is a live birth that occurs before the gestational age reaches 37 weeks.<sup>3</sup> The incidence of

preterm in Indonesia reaches 15.5% of all live births.<sup>4</sup> Preterm birth can have an impact on eye development.<sup>5</sup> Nissenkorn et al said 50% of preterm children with a history of retinopathy of prematurity had myopic refractive errors and 16% of preterm children without a history of retinopathy of prematurity had myopia.<sup>6</sup> Zha et al showed that the group of preterm infants had a shorter axial length of the eyeball compared to the group of full-term infants.<sup>5</sup> Mohd-Ali et al suggested that children with a history of prematurity tend to experience changes in corneal curvature to be steeper and thickening of the lens.<sup>7</sup>

Emetropization is a process of eyeball development in which the axial length of the eyeball will increase while the optical power of the cornea and lens will decrease proportionally.<sup>2</sup> Changes in eyeball growth in preterm children affect the emetropization process.<sup>8</sup> This condition can increase the risk of visual impairments such as refractive errors and amblyopia.<sup>8</sup> Therefore, the researcher wanted to examine the comparison of axial length, keratometry and lens thickness in patients with preterm and full-term birth histories.

## METHODS

This study was an analytical observational study with a cross-sectional design and then performed a comparative analysis to assess the comparison of axial length, keratometry and lens thickness in subjects with a history of preterm and full-term birth. Subjects in this study were patients aged 7 - 14 years by assessing

previous birth history. The research was conducted at Cicendo Eye Hospital Bandung. The sampling technique was done by consecutive sampling.

Inclusion criteria were patients aged 7 to 14 years, willing to participate in the study and able to follow instructions during the biometry examination and the biometry used was reliable. Exclusion criteria were patients with a history of eye surgery, ocular trauma involving the refractive media, intraocular abnormalities such as congenital cataracts, Persistent Fetal Vasculature, congenital glaucoma and patients with retinopathy of prematurity stages 4 and 5.

General data of the subject including name, age, gender, birth history and documentation of the KIA (maternal and child health) book or medical record of the subject's birth were recorded. Sharp vision examination, non-contact tonometer (TOPCON CT80, USA), anterior segment examination using slit lamp biomicroscope, posterior segment examination using aspheric lens (+20 D or +30 D), maximum refractive correction with and without cyclopegics and biometry examination using IOL Master 700 (Carl Zeiss Medical Technology, USA) were performed.

## RESULTS

Primary research data were taken at the Pediatric Ophthalmology and Strabismus Polyclinic and Diagnostic Unit at the National Eye Center of Cicendo Eye

Hospital from July to August 2023 with a total study sample of 140 subjects with a division of the two groups of 70 subjects in the premature history group and 70 subjects in the full-term group. All selected eyes were right eyes. Hypothesis testing was performed to compare numerical variables, namely axial length and K1 with normal distribution using the unpaired t test, while assessing K2, Mean

$\Delta K$  and lens thickness with abnormal distribution using the Mann Whitney test. The results of this study showed that chronological age, gender and refractive error in the subject's parents did not have significant differences in values so that the data obtained were homogeneous and suitable for comparison in further analysis.

**Table 1. Comparison of Characteristic Subject in Premature and Full-term Groups**

Variables	Groups		P-value
	Premature N=70	Full-term N=70	
<b>Chronological Age (years)</b>			<b>0.081</b>
Median	8,50	10,00	
Range (min-max)	7,00 - 14,00	7,00 - 14,00	
<b>Gender</b>			<b>0.734</b>
Male	40 (57,1 %)	38 (54,3%)	
Female	30(42,9%)	32(45,7%)	
<b>Gestational Age (weeks)</b>			<b>0.0001**</b>
Median	35,00	39,00	
Range (min-max)	24,00 - 36,00	37,00 - 41,00	
<b>Refractive Error in Parents of Subject</b>			
Myopia	28 (40 %)	32 (45,7 %)	<b>0.495</b>
Hypermetropia	3 (4,3%)	2 (2,9%)	<b>1.000</b>
Astigmatism	12 (17,1 %)	16 (22,9 %)	<b>0.398</b>
<b>History of Retinopathy of Prematurity</b>		2 (2,88%)	

Characteristics in the premature group had a median patient age of 8.5 years younger while in the full-term group the median age was 10 years. The median gender of the subjects was male, 40 subjects (57.1%) in the preterm group (p 0.734). The mean gestational age of

subjects with a history of preterm birth was 35 weeks while in the full-term group it was 39 weeks, which was statistically significantly different (p 0.0001). The majority of parents in both groups had refractive errors, 61.4% in the preterm group and 71.5% in the full-term group.

The most common refractive error in parents was myopia in both groups with a magnitude of 28 people (40%) in the preterm group but both were not significantly different (p 0.495). In the preterm group, there were 2 subjects who had a history of retinopathy of prematurity

with a diagnosis of regressed retinopathy of prematurity with a history of laser treatment. Comparison of axial length in the group with a history of preterm birth has a mean of  $23.60 \pm 1.633$  mm similar to the axial length in the group with a history of full-term birth with a p value of 0.895.

**Table 2. Comparison of Axial Length, Keratometry and Lens Thickness in Premature and Full-term Groups**

Variables	Groups		P-value
	Premature N=70	Full-term N=70	
<b>Axial length (mm)</b>			<b>0.895</b>
Mean $\pm$ Std	23,60 $\pm$ 1,633	23,57 $\pm$ 1,236	
Range (min-max)	18,48 - 27,49	20,04 - 26,77	
<b>Keratometry</b>			
<b>K1 (D)</b>			<b>0.0001**</b>
Median	45.15	43.07	
Range (min-max)	44.00 - 48.42	39.32 - 44.86	
<b>K2 (D)</b>			<b>0.0001**</b>
Median	46.71	44.11	
Range (min-max)	44.30 - 53.03	40.86 - 47.21	
<b>Mean <math>\Delta</math>K (D)</b>			<b>0.001*</b>
Median	-1.62	-1.03	
Range (min-max)	-8.48 - (-0.30)	-5.01 - 0.00	
<b>Mean K (D)</b>			<b>0.001*</b>
Median	45.85	43.67	
Range (min-max)	44.15 - 46.91	40.09 - 45.78	
<b>Lens Thickness (mm)</b>			<b>0.0001**</b>
Median	3,66	3,39	
Range (min-max)	3,38 - 5,68	3,10 - 3,57	

Keratometry values in the group with a history of preterm birth, K1 had a median of 45.15 D, for K2 had a median of 46.71 D, Mean  $\Delta$  K had a median of -1.62 D and Mean K had a median of 45.85 D. This was significantly different from the full-

term birth history group which had K1 with a median of 43.07 D, K2 with a median of 44.11 D, Mean  $\Delta$  K had a median of -1.03 D and Mean K had a median of 43.67D. Both groups had statistically significant differences in

keratometry values with  $p < 0.05$ . The lens thickness in the group with a history of preterm birth had a median of 3.66 mm which was significantly different from the group with a history of full-term birth which was 3.39 mm with a value of  $p < 0.0001$ .

## DISCUSSION

The characteristics of the subjects of this study based on chronological age in the subject group with a history of premature birth had a median age of 8.5 years and in subjects with a history of full-term birth had a mean age of 10 years ( $p = 0.081$ ). This is different from Fie et al's research which states that the mean age of all subjects is  $7.2 \pm 2$  years.<sup>9</sup> Other studies have a more mature median age, namely research by Sukumaran et al, which has a median chronological age of 12 years.<sup>10</sup> This difference in chronological age is different because of the different age ranges in the three studies. In the study of Fie et al had an age range of 4-10 years so that the median age was younger, in the study of Sukumaran et al had an age range of 5-16 years so that the median age was more mature while in this study had an age range of 7-14 years so that the median age was 8.5 years.<sup>9,10</sup> Gender distribution in both groups was more male both in subjects with a history of preterm birth, namely 40 subjects (57.1%) and in the full-term group, namely 38 subjects (54.3%) but there was no statistical difference ( $p = 0.734$ ). Similar findings were presented by Fie et al who mentioned that the majority of subjects in the study were male, namely

246 subjects out of 485 subjects (50.7%).<sup>9</sup> In contrast to other studies by Cook et al out of 68 babies studied 35 people (51.4%) were female.<sup>11</sup>

The median gestational age in this study was 35 weeks in the group of subjects with a history of preterm birth and 39 weeks in the group of subjects with a history of full-term birth, with a significant difference with a value of ( $p = 0.0001$ ). The same thing was found in a study by Fie et al. where gestational age had a significant difference between the groups of subjects with a history of preterm and full-term birth.<sup>9</sup> Pacella et al. mentioned that having one parent with refractive error increases the likelihood of the subject having refractive error by a factor of one.<sup>12</sup> French et al said that the possibility of increasing the incidence of myopia can occur by 21.4% (one parent who has myopia) and even up to 22% (both parents have myopia).<sup>13</sup> In another study by Saw et al mentioned that myopia refractive error in parents increases the incidence of myopia progression (0.63 diopters/year) compared to those who do not (0.42 diopters/year).<sup>14</sup> In this study, the majority of parents had myopia refractive error at 40% in the group of subjects with preterm history and 45.7% in the group of subjects with full-term history ( $p = 0.495$ ). The main optical components of the eye are the axial length of the eyeball with a normal size of 22 - 23 mm, the cornea which has a refractive index of 43.00 - 44.00 D and the lens which has a refractive index of 19.00 - 20.00 D. Abnormalities in any of these

components can cause refractive errors. In this study, the mean axial length of the two groups was found to be similar,  $23.60 \pm 1.633$  mm in the premature group and  $23.57 \pm 1.236$  mm in the full-term group ( $p=0.895$ ). In contrast to Fie et al's study, subjects with a history of prematurity had a shorter axial length of the eyeball at the age of  $\leq 7$  years.<sup>9</sup> However, in the older age group of 7-14 years, subjects with a history of premature birth can follow the axial length of the eyeball resembling subjects with a history of full-term birth.<sup>9</sup> The results in this study are similar to a study by Wang et al who found no difference in the axial length of the eyeball between infants with laser-treated stage 1 ROP and a group of infants born full term at the age of 9 years.<sup>15</sup> This suggests that the axial length of children born preterm can match the axial length growth of children born full term.

In the study of Donzis et al, the corneal curvature becomes flat and shrinks within three months after birth.<sup>16</sup> In several other studies, it was stated that corneal curvature decreases slowly in infants.<sup>17,18</sup> In the study of Fie et al, there was no difference in corneal curvature using a schiemplug camera between infants born prematurely and full-term.<sup>9</sup> In contrast to this study, the keratometry value in this study was found to be greater in the group of subjects with a history of preterm birth, namely K1 with a mean of  $45.20 \pm 0.856$  D, K2 with a median of 46.71 D and Mean K with a median of -1.62 D compared to the group of subjects with a history of full-term birth,

namely K1 with a mean of  $42.96 \pm 1.160$  D, K2 with a median of 44.11 D and Mean K with a median of -1.03 D. This is in accordance with Wang et al's research which states that corneal refractive power and corneal curvature are greater in the ROP group than without ROP and the control group.<sup>15</sup> Another study by Fledelius et al. monitored refractive conditions in preterm infants for 7-9 years and found corneal curvature in preterm infants was higher than in term infants.<sup>19</sup>

The majority of eye growth occurs in the first year after birth.<sup>20</sup> The process of early emetropization caused by early exposure to environmental factors and a history of ROP in children born prematurely can lead to aberrant eye growth and a more anterior crystalline lens position.<sup>21</sup> The thickness of the lens in this study was found to be thicker in the group of subjects with a history of premature birth, namely 3.66 mm compared to the group of subjects with a history of full-term birth, namely 3.39 mm ( $p=0.0001$ ). Iwase et al. also mentioned that refractive errors are closely related to increased lens thickness and increased refractive index especially in subjects with a history of retinopathy of prematurity.<sup>22</sup> This is similar to the study of Wang et al. who mentioned that the lens thickness was thicker in the ROP group at 4.48 mm followed by the group without ROP at 3.16 mm and the control group at 4.37 mm.<sup>15</sup> The retinopathy of prematurity group had a thicker lens than the premature group without ROP and controls, which may play a role in the

increased incidence of myopia and astigmatism in retinopathy of prematurity infants.<sup>15</sup> Refractive errors such as myopia in children with a history of full-term birth can be caused by the axial length of the eyeball, while children with a history of premature birth have a normal axial length of the eyeball and even tend to be shorter.<sup>23</sup> This is different from the research of Sharanjeet-Kaur et al, who suggested that children with a history of premature birth without ROP at the age of 3-7 years had steeper corneas, thicker lenses and shorter axial lengths of the eyeball.<sup>8</sup> This different eyeball growth occurs to maintain the emetropia refractive status of the eye. Another study by Chang et al also suggested that children with a history of preterm birth have inhibited development of the anterior segment of the eyeball characterized by a smaller corneal diameter, steeper corneal curvature, shallower depth of the front eye chamber and increased lens thickness.<sup>23</sup> In this study, children with a history of preterm birth had steeper corneas, thicker lenses but the axial length of the eyeball was the same length as children with a history of full-term birth. This difference in eyeball growth can cause refractive errors that occur.

The limitation of this study is that it is a cross-sectional study so it cannot determine the causal relationship. Other ocular parameters that affect refractive errors such as depth of the anterior chamber, central lens thickness and vitreous length were not studied.

In conclusion, the axial length of the eyeball of children with a history of preterm birth is similar to that of children with a history of full-term birth. The keratometry of children with a history of preterm birth is steeper than that of children with a history of full-term birth. The lens thickness of children with preterm history is thicker than that of full-term children.

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