Ocular Growth and Refractive Error Development in Premature Infants without Retinopathy of Prematurity

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Purpose. This investigation studied the factors involved in the development of refractive error (RE) in premature infants unaffected by retinopathy of prematurity (ROP).

Methods. Premature infants enrolled in the national ROP screening program were recruited and examined at 32, 36, 40, 44, and 52 weeks' postmenstrual age. At each examination, axial length (AXL), anterior chamber depth (ACD), and lens thickness (LT) were measured on the A-scan biometer. Corneal curvature (CC) was recorded with a video-ophthalmophakometer, and refractive state was determined with routine cycloplegic refraction. Multilevel modeling techniques were used to determine the relationships between all the variables throughout the study period, as well as individual growth rates.

Results. Sixty-eight premature infants were included. AXL and ACD showed linear patterns of growth, whereas LT changed little over the study period. CC showed a quadratic growth pattern, and unlike the previous variables, correlated well with refractive state. Premature infants were myopes at the start of the study, with refraction becoming emmetropic as they neared full term and then hypermetropic toward the end of the study.

Conclusions. Most of the components of refractive status showed linear patterns of growth during this early phase of ocular development. CC displayed a more complex pattern of growth, which correlated well with refractive state. Compared with full-term infants examined around term, this group has shorter AXLs, shallower anterior chambers, and more highly curved corneas. In addition, less of the expected hypermetropia developed in the premature group, which seems mainly due to the differences in ACD and corneal curvature. (*Invest Ophthalmol Vis Sci.* 2003;44:953–960) DOI:10.1167/iovs.02-0124

The World Health Organization has classified myopia as among the leading causes of blindness and vision impairment in the world today.[1] The prevalence of myopia varies enormously, depending on country of origin, ethnicity, age at examination, family history,[2] and occupation.[3] The prevalence in school-age children ranges from less than 2% in 5-year-olds in the united states,[4] up to 20% in 12-year-olds in Hong Kong.[5] These prevalences tend to increase in most populations during the teenaged years, from 37% in Greek students[6] to 65% in Singaporean graduates.[7] In addition, the incidence in this population is increasing, having doubled in a decade.[7]

In comparison, in some Inuit populations, the prevalence has remained low, and largely unchanged.[8] Some investigators have attributed this difference to changes in environmental factors, such as near work, that affect the former populations.

As well as environmental factors, it has been noted that children of parents with myopia have a predisposition to myopia later in life,[9] and several genetic loci associated with pathologic myopia and increased ocular size have been isolated.[10] Premature infants with or without retinopathy of prematurity (ROP) are also at increased risk of myopia, as well as anisometropia, astigmatism, and strabismus.

Studies of refractive state among premature infants are difficult to compare, because of methodological variations, including differences in age at examination, classification of ROP, and cohort size. However, cross-sectional studies report rates of myopia ranging from 5%,[11] through 22.4%,[12] to more than 80%,[12,13] depending on the presence and severity of ROP and the ages at the time of examination. This form of myopia is attributed to shorter axial length (AXLs) and shallower anterior chambers, with more highly curved corneas and more spherical lenses.[12,14]

More information can be gained from longitudinal studies. The CRYO-ROP group reported findings at 3 months and 5.5 years in untreated infants.[13,15] At 3 months of age, those without ROP had a 10% prevalence of myopia; those with moderate ROP, 35%; and those with residua such as macular heterotopia, 72%. By 5.5 years, these percentages had changed only slightly, to 10%, 35%, and 82%, respectively, with most changes observed during the first year. Another other research group has found higher incidences of myopia at similar ages: 30% in those without ROP, 70% in resolved ROP, and 90% in cicatricial ROP, although this particular sample showed a higher prevalence of severe ROP than most.[16]

The most extensive work has been performed by Fledelius,[14,17–19] with two decade's worth of oculometric and refractive data on premature infants. His 7- to 10-year follow-up of children screened for ROP showed an incidence of myopia of 25% in those with regressed ROP, compared with 5% in those without the disease.[18]

Most of these studies began measurements after 3 months of age. Consequently, information about concurrent early longitudinal changes in refractive state and of the structural components of the eye of premature infants is sparse.

The purpose of this study was to look prospectively at premature infants unaffected by ROP during the early phases of ocular growth, and to identify factors contributing to refractive status at this time. It was hoped that this might add to existing knowledge of factors affecting emmetropization after premature birth.

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TABLE 1. Table of Biometric Variables

Variable	T	Mean ± SD	Minimum	Maximum	*n*
CC	1	6.10 ± 0.41	4.88	7.06	33
	2	6.43 ± 0.24	5.63	6.92	44
	3	6.94 ± 0.24	6.06	7.40	50
	4	7.21 ± 0.28	6.32	7.81	47
	5	7.55 ± 0.31	7.02	8.25	27
ACD	1	1.98 ± 0.19	1.20	2.26	54
	2	2.11 ± 0.32	1.46	3.95	53
	3	2.25 ± 0.19	2.00	2.73	55
	4	2.43 ± 0.23	1.93	3.06	53
	5	2.80 ± 0.25	2.26	3.22	38
LT	1	3.84 ± 0.22	3.07	4.51	54
	2	3.93 ± 0.18	3.57	4.64	52
	3	3.98 ± 0.19	3.35	4.71	55
	4	3.98 ± 0.22	3.21	4.42	53
	5	3.96 ± 0.21	3.64	4.62	38
PSL	1	9.62 ± 0.43	8.66	10.79	54
	2	10.12 ± 0.46	8.66	11.83	53
	3	10.60 ± 0.45	9.60	11.66	55
	4	11.02 ± 0.45	9.80	11.73	53
	5	11.81 ± 0.54	10.53	12.92	38
AXL	1	15.44 ± 0.42	14.20	16.58	54
	2	16.09 ± 0.45	15.03	17.06	53
	3	16.84 ± 0.46	15.86	18.00	55
	4	17.43 ± 0.48	16.26	18.46	53
	5	18.58 ± 0.54	17.40	19.90	38
RE	1	−2.06 ± 2.27	−7.00	4.75	58
	2	−1.23 ± 2.17	−5.75	5.00	53
	3	+0.74 ± 1.83	−3.75	4.50	54
	4	+1.89 ± 1.76	−3.50	5.00	54
	5	+2.12 ± 1.25	−0.90	5.00	38

All data are expressed in millimeters except RE, which is in diopters. T, time point.

METHODS

This cohort of infants was recruited from the neonatal intensive care unit of Liverpool Women's Hospital (Liverpool, UK). Regional ethics committee approval and informed parental consent were obtained. Infants examined included those falling within the screening criteria for the ROP screening program: infants born before 32 weeks' gestational age and/or infants with birth weight below 1500 g.

Any infant too unfit for the longer examination necessary for the study was excluded. Infants were examined at 32 (T1), 36 (T2), 40 (T3), 44 (T4), and 52 (T5) weeks' postmenstrual age. These time points were deliberately chosen to be adequately spaced, without interfering with or delaying the usual ROP examinations.

Measurements at each examination included AXL, ACD, and LT. These were measured using an A-scan biometer (Humphrey Systems, Dublin, CA), using the technique described by Butcher and O'Brien.[20] This involves applanation of the cornea with the A-scan probe after the instillation of the topical anesthetic benoxinate hydrochloride 0.4%. The probe is placed lightly on the center of the cornea, perpendicular to its axis. The probe is maintained in this position until three clear traces are obtained on the screen. The average value from the three best images is recorded for all axial dimensions. (Posterior segment length [PSL] was calculated by subtracting the sum of ACD and LT from AXL, and this result was checked with the printed scan.)

Corneal Curvature

Corneal curvature (CC) was measured with a video-based keratophakometer, previously described by Wood et al.[21] The unit consists of a camera coupled to a video recorder. The camera has a plastic faceplate, which has illuminating infrared LEDs distributed around its perimeter. The mires are focused around the infant's cornea and the image captured on the video recorder for later analysis of corneal curvature (CC). The camera is calibrated using a series of stainless-steel ball bearings of known radius of curvature.

Refractive State

Full cycloplegic refraction was performed by streak retinoscopy, 30 minutes after the administration of 0.5% cyclopentolate and 2.5% phenylephrine. All refraction was performed by the same examiner (AC), with intermittent verification by the departmental optometrist to ensure accuracy. Handheld lenses were used to enable the examiner to ensure the streak was kept on axis. This was relatively simple, because at this age, ocular movements were minimal during the refraction. An allowance of 1.5 D was allowed for a working distance of two thirds of a meter. Refractive error (RE) was recorded in the form of spherical equivalent = sphere + cylinder/2.

Retinopathy of Prematurity

All infants were screened by the same examiner (DC) who has 13 years' experience in screening premature infants. After instillation of an additional drop of benoxinate hydrochloride 0.4%, a lid speculum was placed gently between the lids. Scleral indentation was then performed to allow examination of the far periphery. All methodology adhered to the tenets of the Declaration of Helsinki.

Statistical Analysis

Data were examined by multilevel modeling for repeated measures. This method was chosen, because different observations of the same child may be dependent, and simple regression analysis would not correct for the lack of independence between observations. Many methods for analyzing longitudinal data require the same number of measurements to be collected from every subject (e.g., repeated measures analysis of variance), and for each subject to attend at every period. In a clinical setting, this would have been unrealistic. Therefore, this more appropriate analytical technique was used.

All statistical analysis was performed on computer (SAS, ver. 8; SAS, Cary, NC, for SunOS using the Proc Mixed procedure). Multilevel regression models were used to look at the relationships between AXL, ACD, LT, CC, and RE and age. In addition, the relationship between AXL and RE, ACD and RE, LT and RE, and CC and RE, controlling for age, was analyzed. The multilevel regression methodology allowed for

TABLE 2. Estimates of Each Biometric Variable at Term and Growth Rates Over the Whole Study Period from Multilevel Analysis

Variable	Intercept*	Growth Rate	Quadratic†
CC	6.87 ± 0.027 (<0.0001)	0.0947 ± 0.0039 (<0.0001)	−0.0034 ± 0.0005 (<0.0001)
ACD	2.26 ± 0.02 (<0.0001)	0.04 ± 0.002 (<0.0001)	
LT	3.93 ± 0.018 (<0.0001)	0.0056 ± 0.0018 (<0.0039)	
AXL	16.66 ± 0.04 (<0.0001)	0.16 ± 0.004 (<0.0001)	
RE	+0.87 ± 0.20 (0.9562)	0.24 ± 0.0016 (<0.0001)	0.089 ± 0.034 (0.0133)

Data are expressed as millimeters (mean ± SE), except for RE, which is expressed in diopters. The probability appears in parentheses.

* Mean fitted value of the variable of interest at term, 40 weeks postmenstrual age.

† Rate of change.

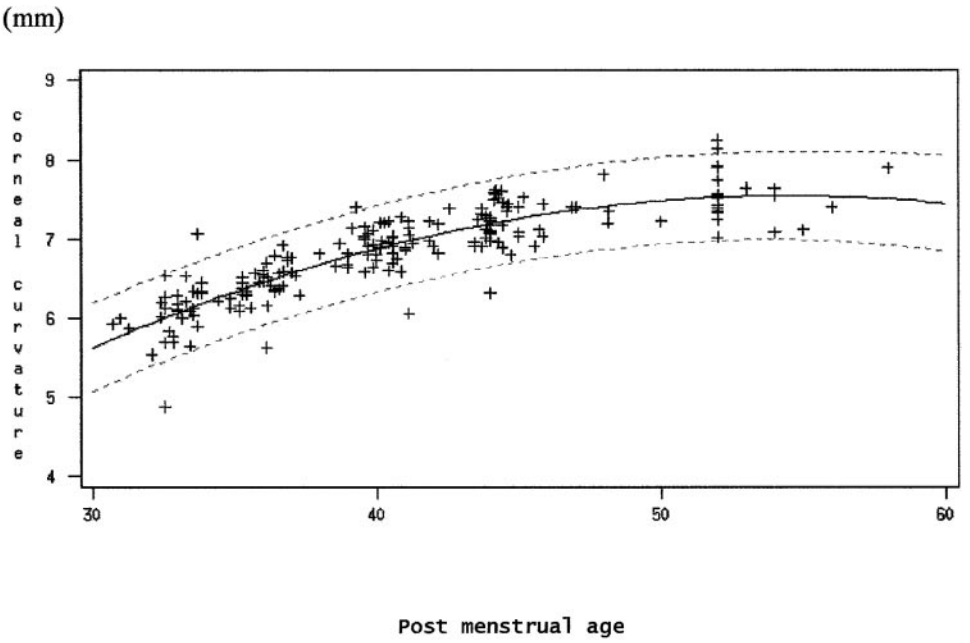

FIGURE 1. Changes in radius of CC (in millimeters) with time. *Solid line*: line of best fit; *dashed lines*: 95% confidence intervals.

fitting of a linear relationship or a quadratic relationship, as appropriate. Once an appropriate model had been found for the biometric parameters and refractive state, each model was refitted including gender, to identify if at this early stage of ocular development, there was any effect due to gender difference.

Estimates of the intercept (value at term) and slope coefficients (rate of growth) of the fitted relationship are presented with their standard errors. Only the results for the final model for each variable have been presented. The data have been centered so that the intercept parameter always indicates the mean value of the variable of interest at term, namely 40 weeks postmenstrual age. The slope parameter in a linear model indicates the rate of change of the variable, the number of millimeters of change occurring per week. When a quadratic term is included in the model, the coefficient is indicated by how much the rate of change is changing. To find the predicted value of a parameter y at a given postmenstrual age x, given the intercept a the slope coefficient b and quadratic term c:

$$y = a + b(x - 40) + c(x - 40)^2$$

For a linear relationship, the last part of the equation is excluded.

RESULTS

In 68 infants examined during the study period, no ROP developed (35 boys and 33 girls). These 68 infants had an average birth weight of 1256.9 ± 334.6 g (SD) and an average gestational age of 29.4 ± 1.87 weeks (SD).

At T1 (average, 32.9 weeks), 54 infants were examined; T2 (average, 36.1 weeks), 53; at T3 (average, 40 weeks), 55; at T4 (average, 44.7 weeks), 53; and at T5 (average, 52.9 weeks), 38. There was no statistically significant difference between boys and girls in any of the variables measured at any time point.

Table 1 shows results for each of the biometric parameters at each time point. Table 2 shows estimates of means for each of the biometric variables at 40 weeks postmenstrual age, using multivariate analysis. Included are growth rates for each parameter. In addition, for CC and RE, which both showed quadratic growth patterns, the quadratic component (the rate at which the growth rate is changing) was documented. This component was negative for CC, which suggests that the growth rate was slowing down. The opposite effect was re-

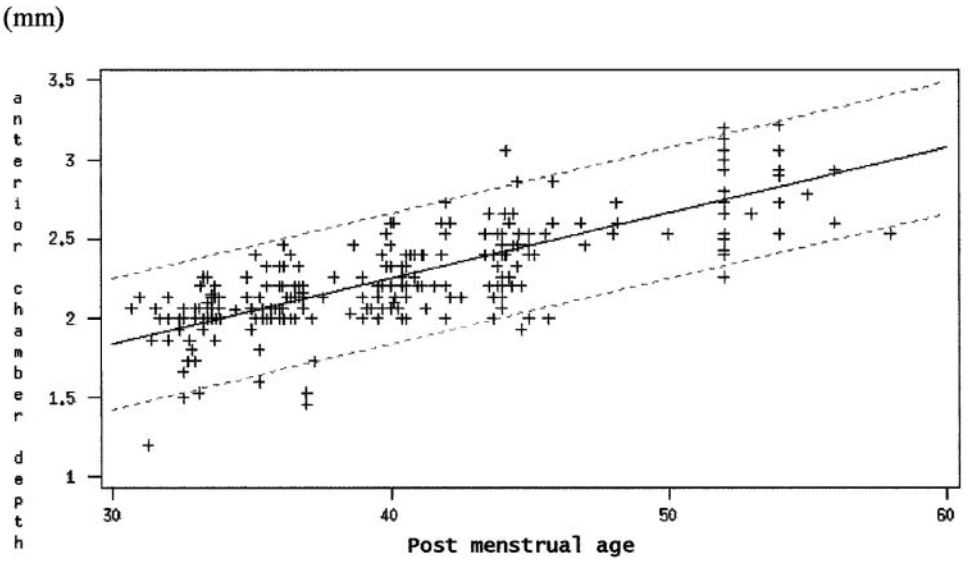

FIGURE 2. Changes in ACD (in millimeters) with time. *Solid line*: line of best fit; *dashed lines*: 95% confidence intervals.

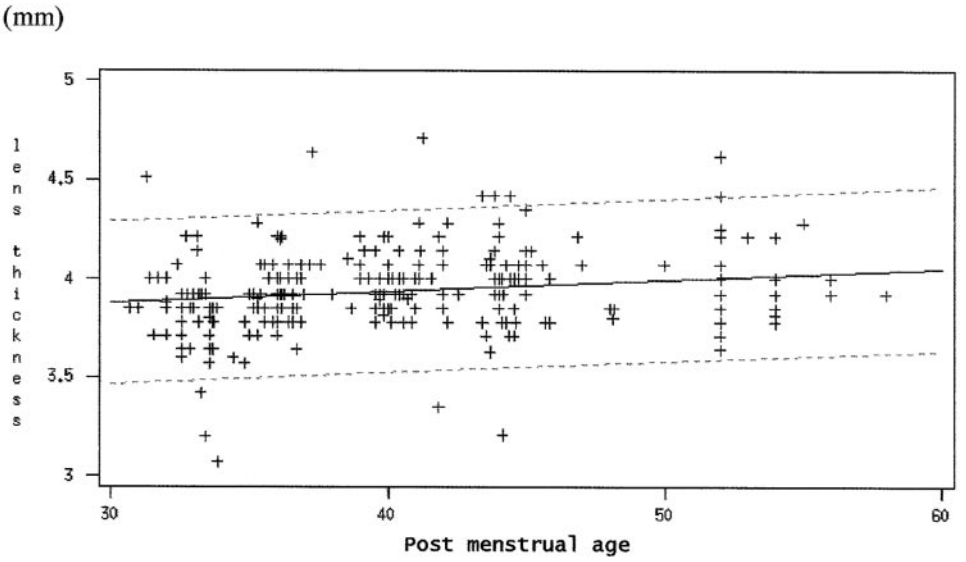

FIGURE 3. Changes in LT (in millimeters) with time. *Solid line*: line of best fit; *dashed lines*: 95% confidence intervals.

corded for rate of change of refractive state, although both values were extremely small.

When the data for the 40-week (T3) time point taken from Table 1 are compared with those parameter estimates from Table 2 at term, the values are very similar. This indicates the accuracy of the regression formula generated for each variable.

Corneal Curvature

Corneal radius of curvature followed a quadratic pattern of growth (Fig. 1). The rate of growth slowed down after 40 weeks postmenstrual age. Corneal radius of curvature increased at an average rate of 0.0947 mm per week. Thus, during a period of 4 weeks the radius could be expected to increase by 0.379 mm. The fitted value of CC in an infant of 36 weeks was $6.87 + 0.0947(36 - 40) + -0.0034(36 - 40)^2 = 6.436$ mm, and at 48 weeks, 7.41 mm.

Anterior Chamber Depth

The ACD followed a linear growth pattern during this 5-month period (Fig. 2). It increases at a rate of just 0.04 mm per week, so that during a period of 4 weeks, it deepened by 0.16 mm. The fitted value of ACD in an infant of 36 weeks was $2.26 + 0.04(36 - 40) = 2.1$ mm, and at 48 weeks = 2.58 mm.

Lens Thickness

LT changed very little during this early period (Fig. 3). Measurement error may partially explain the lack of a clear pattern of growth. In addition, cycloplegia may have resulted in incomplete relaxation of the ciliary muscle in some eyes, thus affecting measurable LT. However, the results suggest that LT increased in the period from 32 weeks to term, from 3.84 to 3.98 mm, and then stabilized. It was not possible to model this nonlinear relationship effectively because the changes were too slight.

Axial Length

AXL was found to increase rapidly during this period (Fig. 4). Growth followed a linear model. However, there was more variation in AXL in the latter part of the study. AXL was found to increase at a rate of 0.16 mm per week, so that during a period of 4 weeks, an infant's eye would be expected to grow on average by 0.64 mm. The fitted value of AXL for an infant of

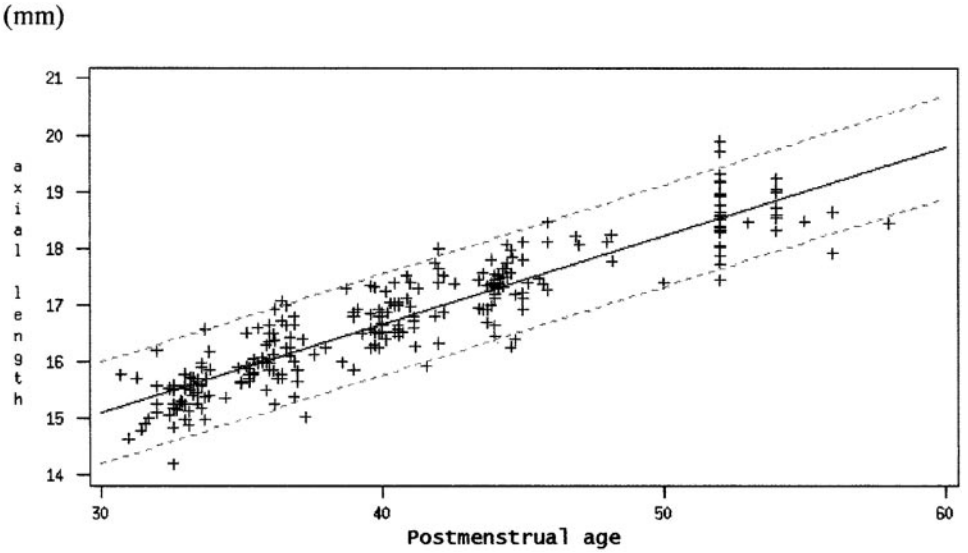

FIGURE 4. Changes in AXL (in millimeters) with time. *Solid line*: line of best fit; *dashed lines*: 95% confidence intervals.

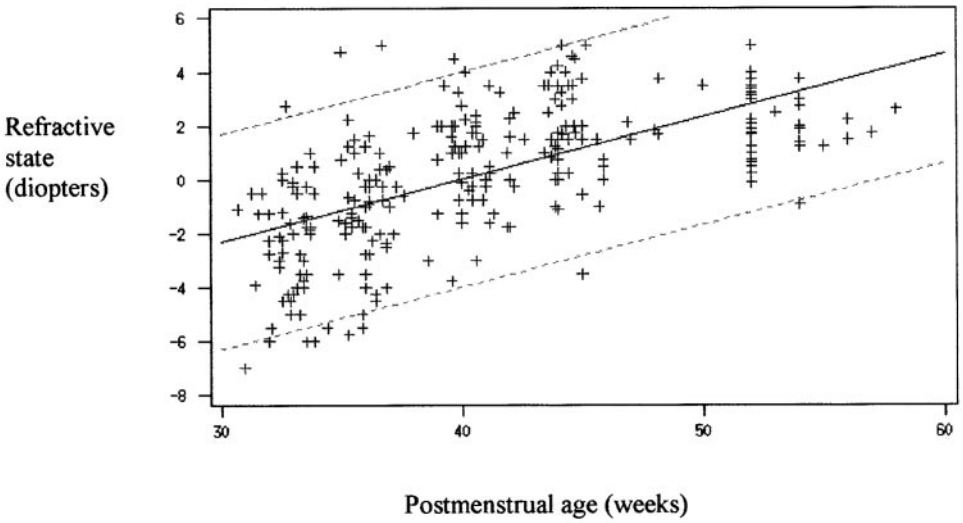

FIGURE 5. Changes in RE (in diopters) with time. *Solid line*: line of best fit; *dashed lines*: 95% confidence intervals.

36 weeks was 16.66 + 0.16(36 - 40) = 16.02, and at 48 weeks = 17.94 mm.

Refractive Status

Refractive state showed an average myopia of -2.00 D at the beginning of the study, followed by a trend toward hypermetropia, resulting in an average final spherical equivalent of +2.12 D (Fig. 5). The spread of RE was wider at the start of the study. Most infants showed little RE just before term. The relationship between the biometric variables and RE, while controlling for age, was explored. CC appeared to show the best fit with changes in RE. For each millimeter increase in radius of curvature, there was a 2.17 ± 0.41-D (±SE) increase in spherical equivalent ($P < 0.0001$). This model is centered so that the intercept value is equal to the mean refraction for an infant with average CC (6.85 mm) at 40 weeks. The fitted value of RE for an infant with a CC of 7 mm at 44 weeks is 0.38 + [(7 - 6.85) × 2.17] + [(44 - 40) × 0.089] = +1.06 D.

Table 3 shows that during the 5-month study period, the eye underwent a relatively large proportion of its growth. AXL increased by 20% during this time. However, it is clear from these data that the anterior chamber undergoes the largest percentage change during this early period of ocular growth (41%), and that by 54 weeks postmenstrual age it has almost approached the adult proportion in relation to AXL. In contrast, LT still accounts for a relatively large proportion of the total AXL, compared with an adult. These data are also represented in the bar chart (Fig. 1).

DISCUSSION

The components of refractive state show linear patterns of growth up until 44 weeks postmenstrual age, with the exception of CC (Figs. 2 to 6). AXL as a whole continued to follow this trend, as did ACD. In contrast, changes in LT were negligible after term. The linear patterns of growth of AXL and ACD were similar to those previously reported.[22–25] However, small ACDs and LTs measurements coupled with measurement error may obscure more subtle underlying patterns of growth.

TABLE 3. Relative Growth of Each Component from 32 to 54 Weeks and as a Proportion of Total AXL at Different Ages

	Increase from 32 to 54 wk	32 wk	36 wk	40 wk	44 wk	52 wk	Adult
ACD	41	12.7	13.1	13.4	13.9	15.1	16.0
LT	3.0	24.8	24.0	24.0	24.0	21.3	16.1
PSL	22.7	62.5	62.9	62.9	63.2	63.6	67.9
AXL	20.1	—	—	—	—	—	—

Data are expressed as percentages of total AXL.

Each of the biometric variables in turn were fitted against refractive state. During this early growth phase, we found a relatively weak relationship between AXL, ACD, and refractive state. This supports the findings of one previously published study,[25] but contrasts with the results of others.[26,27] CC provided the best explanation for the significant variation in RE. For each 1-mm increase in radius of CC, RE increased by approximately +2 D.

There are few directly comparable early longitudinal studies that record all the components of RE. However, it is interesting to compare these data with previous studies of infants at around term. This is summarized in Table 4.

Corneal Curvature

Comparative data for CC are most abundant in the report by Inagaki,[28] who studied both premature (average gestational age was 36.4 weeks) and full-term infants at varying ages. His CC of 6.80 mm (49.50 D) for premature eyes at 2 weeks is comparable to the finding in this study (6.73 mm, according to the quadratic modeling for the same age). The longitudinal data supplied by Inagaki mixes full-term with preterm CCs from 2 to 12 weeks. Data are therefore not directly comparable, although, as might be expected, our data for premature infants revealed consistently smaller radii of CC.

ACD and LT

The current ACD and LT results at term (2.25 and 3.98 mm, respectively) are comparable to those of O'Brien and Clark[23] (2.36 and 3.99 mm), Yamamoto et al.[24] (2.14 and 3.99 mm), and Fledelius[25](2.37 and 3.99 mm) at the same age.

O'Brien and Clark[23] performed the only previous work in which all biometry measurements were recorded. The current data were very similar throughout the study period, which is not surprising, given that the studies were performed within the same region and shared one author (DC). (There was no overlap with this set of infants.)

Axial Length

In this group of infants, AXL at term (16.84 mm) is comparable to that of Tucker et al.[22] at 16.6 mm, of O'Brien and Clark[23] at

TABLE 4. Published Studies of Ocular Growth at or Near Full Term

Study	Gestational Age (wk)	Age at Examination (Postmenstrual Age, wk)	RE (D)	AXL (mm)	ACD (mm)	LT (mm)	PSL (mm)	CC (mm)
Current	29.4	40	0.74	16.84	2.25	3.98	10.6	6.94
Tucker et al.[22]	30.5	31		16.6				
O'Brien and Clark[23]	29.9	40		16.73	2.36	3.99		
Yamamoto et al.[24]				16.81	2.14	3.99		
Fledelius[25]	31.1	40.1	−1.54	17.02	2.37	3.99	10.69	
Harayama et al.[26]	(fixed fetuses)	40		16.52				
Gordon and Donzis[27]			−1.00	15.10				
Inagaki[28]	36.4	38.4	1.96					
Preterms at 38.4 weeks								6.8
Mixed preterm & full-term at 2 weeks								7.2
Mixed at 4 weeks								7.35
Mixed at 8 weeks								7.5
Mixed at 12 weeks								7.65
Graham and Gray[29]			0.5					

16.73 mm, and Yamamoto et al.[24] at 16.81 mm. The slightly smaller AXL of 16.52 mm found by Harayama et al.[26] may be explained by the measurements' being taken from fetuses fixed in formalin. The small AXL from Gordon and Donzis[27] of 15.1 mm[27] was taken from a cross-sectional study of 79 premature infants without ROP. They were grouped together at the time of their examinations into 35 to 40 weeks postmenstrual age, and a figure biased toward shorter AXLs resulted. Conversely, the larger AXL from Fledelius[25] of 17.02 mm is from a cross-sectional study of 101 premature infants of gestational ages ranging from 25 to 34 weeks (average, 31). Some of these infants had regressed stage 1 or 2 ROP. These infants were examined between 36 and 54 weeks postmenstrual age. The values were then adjusted mathematically to create an AXL at 40 weeks. These factors, in addition to differences in ethnicity and social class, may have contributed to the discrepancy with other series.

Refractive State

Comparative values for refractive state are mostly quoted at or around term. Our RE of +0.74 D is greater than that of Graham and Gray,[29] who measured refraction in their infants at 2 weeks of age and found an RE of +0.50 D. They do not state the average gestational age, postmenstrual age, or birth weight, and direct comparison is therefore impossible. Gordon and Donzis[27] quote an RE of −1.00 D at between 35 and 40 weeks postmenstrual age. Again, the preponderance of younger infants may explain the bias toward myopia. Fledelius[25] quoted an even more myopic RE of −1.54 D at term. This amount was adjusted mathematically from a wider range of postmenstrual ages. The longer AXL described earlier may explain some of this myopia, but not all.

It is also interesting to compare this study's refractive data with those of full-term infants at similar ages. Most investigators report moderate hypermetropia at term: Luyckz[30] found +2.40 D (using 1% cyclopentolate), Gernet[31] +2.75 at 1 week of age (using atropine), and Blomdahl[32] +3.60 D at 2 to 4 days (using 1% cyclopentolate). In contrast, Wood et al.[33] found less hypermetropia at 2 weeks of age (+0.50 D using 0.5% cyclopentolate), as did Grignolo and Rivara[34] (+0.52 D). The latter used 0.5% tropicamide, which may not provide as much cycloplegia, thus resulting in a myopic error.

Table 5 summarizes the associated biometry results for these studies. In general, when compared with premature infants at 40 weeks postmenstrual age, full-term infants had longer AXLs. Fledelius[19] also reported that AXL in premature eyes does not catch up with that in full-term eyes, even by 18 years of age. Of noticeable exception are the data from Larsen[35] and Blomdahl,[32] who reported lower AXLs. It should be noted that in both these studies, the immersion technique was used to measure AXL. In addition, Isenberg et al.[36] report an AXL of 16.2 mm. This group consisted of both premature and full-term infants, and no separate data are available for the subgroups. This may explain the smaller AXLs.

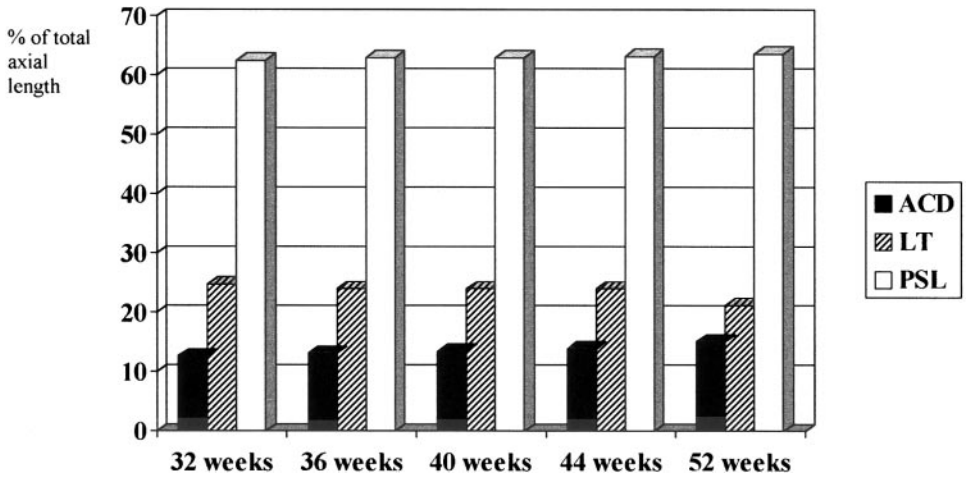

FIGURE 6. Relative composition of AXL.

TABLE 5. Published Data of Ocular Growth at Term in Full-Term Infants

Study	Age	RE (D)	AXL (mm)	ACD (mm)	LT (mm)	PSL (mm)	CC (mm)
Current	40 weeks*	0.74	16.84	2.25	3.98	10.6	6.94
Yamamoto et al.[24]	Full term		17.8	2.35	3.82		
Luyckz[30]	1 week	2.4	17.6	2.55	3.65	10.8	
Gernet[31]	1 week	2.75	17.15	2.9	3.4		
Blomdahl[32]	2–4 days	3.6	16.6	2.6	3.6		7.0
Wood et al.[33]	2 weeks	0.5					
Grignolo and Rivar[34]		0.52					
Larsen[35]			16.78m 16.40f	2.38	3.95	10.33	
Isenberg et al.[36]	Full term		16.2	2.0	3.8	10.5	

m, male; f, female.
* Postmenstrual age.

Blomdahl[32] measured an average radius of CC of 7.0 mm at term (using the Javal-Schiotz keratometer), which is larger than our CCs at term (6.94 mm). Full-term ACDs are also greater, with Isenberg et al.[36] reporting a noticeable exception again. There are no obvious differences between premature and full-term LTs, however.

The current group of premature infants had shorter AXLs than would be expected for their refractive states. The more highly curved cornea and shallower anterior chamber with an anteriorly displaced lens all contribute to myopia and in this situation clearly helped to offset the hypermetropia that would be expected with shorter AXLs. This may also account for why less hypermetropia was found in these infants than in the full-term infants at similar ages, in whom longer AXLs were found in association with deeper anterior chambers and less CCs.

The presence of a shallower anterior chamber and more highly curved cornea may suggest some degree of inhibition of the growth of the front of the eye. This theory is supported by the finding that in eyes affected with ROP, the amount of astigmatism is greater in eyes with more severe disease and that the axis of astigmatism rotates according to the location of the disease within the retina.[37] These findings are similar to those found in anterior segment growth arrest. In anterior segment growth arrest, it is postulated that the area of the globe undergoing maximal growth is mechanically restricted by the biological stress of the retinopathy.[37,38] Because of this, a shallower anterior chamber forms, as well as a more highly curved cornea and a more anteriorly situated lens. All these factors induce a myopic shift in RE. Although they were unaffected by ROP, the group of infants in the current study were already showing such signs at this early stage of ocular development. This may explain why premature infants without ROP also show a tendency toward myopia later on in childhood.

This study reports the rapid growth of the eye in the first few months of life after premature birth. It outlines the biometric, keratometric, and refractive changes that occur concurrently in those infants at risk for ROP but who do not have the condition develop.

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E R R A T U M

Erratum in: "Corneal Neovascularization after Excimer Keratectomy Wounds in Matrilysin-Deficient Mice" by Kure et al. (*Invest Ophthalmol Vis Sci.* 2003;44:137–144).

One of the authors' names was incorrectly spelled. Faris Gosheh should have been Faris Ghosheh.