Keratometry measurements in preterm and full term newborn infants

R Friling, D Weinberger, I Kremer, R Avisar, L Sirota, M Snir

AIM: To evaluate the relation between postconceptual age and birth weight with keratometric values in preterm and full term infants.

METHODS: A prospective cross sectional study was performed. The cohort included 99 infants (198 eyes) admitted to the Neonatal and Neonatal Intensive Care Units at Schneider Children’s Medical Center of Israel from February to September 2000. Keratometry in the horizontal and vertical meridians was performed in both eyes of each infant by two ophthalmologists using an autokeratometer. The results were evaluated according to: postconceptual age (<32 weeks, 32–36 weeks, >36 weeks) and birth weight (<1500 g, 1501–2500 g, >2501 g).

RESULTS: Corneal curvature measurements decreased progressively with both postconceptual age and birth weight. At <32 weeks, mean (standard deviation) readings were 63.3 (3.2) dioptric (D) for the horizontal meridian and 57.3 (2.6) D for the vertical meridian; corresponding values at >36 weeks were 54.0 (3.0) D and 50.7 (2.4) D. In the <1500 g group, mean (SD) readings were 61.3 (3.9) D for the horizontal meridian and 56.0 (2.9) D for the vertical meridian; corresponding values in the >2501 g group were 51.3 (2.1) D and 48.6 (1.8) D.

CONCLUSIONS: There is an inverse relation of horizontal and vertical keratometric values with both postconceptual age and birth weight. Highest readings were noted in the babies with the lowest birth weight and youngest postconceptual age. The decrease in corneal dioptric power to normal values is linear and is apparently part of the normal ocular maturation.

RESULTS
There were 52 males and 47 females. Mean gestational age, BW, and PCA are presented in table 1 Mean horizontal and vertical corneal meridians for the right and left eyes are presented in table 2. As no significant differences were detected between the right and left eyes, we used the mean values of both eyes for the analyses. There was a highly significant correlation between the vertical and horizontal meridians (r = 0.92, p<0.001).

Table 3 presents the keratometry readings of the horizontal and vertical corneal meridians and the calculated difference between them (Δ HV) by BW and PCA.

Mean (SD) horizontal meridian in the lowest BW group was 61.3 (3.9) dioptric (D), and mean vertical meridian, 56.0 (2.9) D. Values were lower in the 1501–2500 g group (horizontal meridian 56.8 (2.3) D, vertical meridian 52.7...
Keratometry in newborns

A significant decline in the horizontal meridian in the 32–36 week group were 58.3 (3.0) D and 53.9 (2.5) D, and in the vertical meridian, 57.3 (2.6) D. Corresponding values in the preterm and term babies were very similar to those of Ehlers et al.13 However, in our study we recorded a higher mercury status in prematurely born infants changed to myopia between the ages of 3 months and 1 year, but not thereafter. Therefore, they assumed that in preterm infants, myopia could be predicted by the refractive findings at 3 months of age. In our study, only babies with ROP stage 1–II without plus disease were included. Therefore, we did not find an association between ROP stage and keratometric values.

Astigmatism occurs more frequently in the neonatal period than in later life and has a different axis. Fulton et al examined 75 infants under 1 year of age and noted astigmatism greater than 1 D in 19%.14 In a related study,24 they noted a relationship between astigmatism and higher degrees of myopia, and suggested that the more severe larger astigmatism may contribute to the development of myopia by the visual blurring mechanism found in animals. Rutstein et al noted that extremely premature infants tended to have more myopia and greater astigmatism than infants born closer to term.3

Fielder et al postulated that lower extraterrestrial temperatures may impede corneal flattening in preterm infants.25 However, other studies have found that normal ocular development and emmetropisation are apparently dependent on regulatory mechanisms in the retina and central nervous importance of high corneal refractive power in the development of myopia in preterm children. However, the relative weight of each of the refractive elements—namely, corneal curvature, depth of the anterior chamber, lens thickness, and axial length—remains controversial.

There is a general consensus that the degree and frequency of myopia are proportional to changes in the cicatricial retinopathy,14 17 but there still remains disagreement regarding the refractive abnormalities in eyes in which the ROP disappears spontaneously. Some authors have found that the degree and frequency of myopia in these cases were similar to those in eyes without ROP.14 15 Others have claimed that the frequency of myopia was high in preterm infants regardless of ROP.20 21 Quinn et al found that refractive status in prematurely born infants changed to myopia between the ages of 3 months and 1 year, but not thereafter. Therefore, they assumed that in preterm infants, myopia could be predicted by the refractive findings at 3 months of age. In our study, only babies with ROP stage 1–II without plus disease were included. Therefore, we did not find an association between ROP stage and keratometric values.

### DISCUSSION

At birth, the globe is larger in its transverse diameter than in its sagittal diameter (mean 18.3 mm); the vertical diameter measures 17.3 mm. In preterm infants, the sagittal and transverse diameters are nearly identical, and the vertical diameters are smaller.

The horizontal and vertical corneal diameters at birth are high (approximately 10 mm) relative to the adult eye, attaining adult size at ages 1–3 years.2 The period of most rapid corneal growth is the first six months of life. The newborn cornea is also steeper than the adult cornea, and is usually more curved in its periphery than centrally.3 The mean radii of the curvature of the anterior and posterior surfaces of the human cornea are 7.8 and 6.5 mm, respectively, compared with the radius of the external surface of the scleral globe, which measures 11.5 mm. The radii of the corneal curvature translate into a vergence of power of approximately 48.8 D, which accounts for three quarters of the total refractive power of the eye.10

Many studies on the radius of the corneal curvature in newborns and infants have been published, but the results vary owing to the technical difficulties of using a keratometer while the babies are moving. Ehlers et al reported a mean value of 53.13 D for preterm infants, 47.50 D for full term infants, and 43.69 D for children aged 2–4 years.11 Donzis et al found the corneal curvature to be about 60 D at 28 weeks gestational age; at term, the mean curvature was about 51 D.12 In preterm infants, there was reduction of about 8 D in the corneal curvature in the last three months of gestation. The authors concluded that the radius of corneal curvature reaches adult range at about 3 years of age. Yamamoto et al, in a trial to fit a contact lens to newborns, found that the mean corneal curvature of the preterm baby was 50.75 D, and of the full term baby, 48.06 D.13 In a study of preterm babies aged 2–12 weeks, Yuji reported a rapid corneal curvature change (from 49.01 to 45.98 D) during the first two to four weeks of life, followed by a deceleration after eight weeks (44.60 D).14 Regardless of gestational age at birth, the power of the corneal curvature rapidly decreased and reached normal childhood range within 12 weeks.14 Our results in preterm and term babies are very similar to those of Ehlers et al12 and Yamamoto et al.13 However, in our study we recorded both horizontal and vertical keratometry powers and noted that both BW and PCA played an important role. The lower the BW and PCA, the higher the horizontal, vertical, and Δ HV values.

Hittner et al3 and Gallo and Fagerholm1 found an association between high keratometric values and retinopathy of prematurity (ROP). They emphasised the pathogenic

<table>
<thead>
<tr>
<th>Study population</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age (weeks)</td>
<td>31.6 (4.4)</td>
<td>24–40</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>1600 (750)</td>
<td>570–4400</td>
</tr>
<tr>
<td>Postconceptional age (weeks)</td>
<td>34.2 (3.9)</td>
<td>24.4–42.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizontal and vertical meridians of the right and left eyes</th>
<th>Right eye</th>
<th>Left eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal meridian (D)</td>
<td>58.6 (5.0)</td>
<td>58.6 (5.0)</td>
</tr>
<tr>
<td>Vertical meridian (D)</td>
<td>53.8 (3.9)</td>
<td>54.2 (3.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizontal and vertical corneal meridians by various parameters</th>
<th>Horizontal meridian (H)</th>
<th>Vertical meridian (V)</th>
<th>Δ HV (mean (SD))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (g)</td>
<td>&lt;1,500 (n=56)</td>
<td>61.3 (3.9)</td>
<td>56.0 (2.9)</td>
</tr>
<tr>
<td>1,500–2,500 (n=30)</td>
<td>56.8 (2.3)</td>
<td>52.7 (1.7)</td>
<td>4.1 (1.5)</td>
</tr>
<tr>
<td>≥2,500 (n=13)</td>
<td>51.3 (2.1)</td>
<td>48.6 (1.8)</td>
<td>2.7 (1.2)</td>
</tr>
<tr>
<td>Significance of difference</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Postconceptional age (weeks)</td>
<td>&lt;32 (n=32)</td>
<td>63.3 (3.2)</td>
<td>57.3 (2.6)</td>
</tr>
<tr>
<td>32–36 (n=57)</td>
<td>58.3 (3.0)</td>
<td>53.9 (2.5)</td>
<td>4.4 (1.9)</td>
</tr>
<tr>
<td>≥36 (n=30)</td>
<td>54.0 (3.0)</td>
<td>50.7 (2.4)</td>
<td>3.3 (1.2)</td>
</tr>
<tr>
<td>Significance of difference</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>
system.\textsuperscript{23} Wildsoet and Pettigrew gave chickens intravitreal injections of kainic acid and found that higher doses induced corneal flattening which stopped the myopic shift associated with the expansion of the vitreal chamber.\textsuperscript{24} Nevertheless, in some of the eyes given a low dose, the corneal steepening caused a myopic shift, which was opposed by the effects on eye growth and refractive changes. Chemical elements may affect corneal steepening, expansion of the vitreous chamber, and cornea-lens separation.

In conclusion, our study revealed an inverse relationship of horizontal and vertical keratometric readings, and the difference between them, with PCA and BW. Babies with the lowest BW and PCA had the highest keratometric readings. The decrease in corneal diopteric power toward normal values with the increase in BW and PCA is linear, in accordance with other maturation parameters, and it is probably part of the normal ocular maturation process, along with the increase in eyeball dimensions.

ACKNOWLEDGEMENTS

We would like to thank Gloria Ginzach and Hanni Penn for their editorial and secretarial assistance, and Pnina Balitus for the statistical calculations.

Authors’ affiliations

R Friling, M Snir, Schneider Children’s Medical Center, Department of Ophthalmology, Petah Tiqva, Israel
L Sirota, Department of Neonatology, Schneider Children’s Medical Center of Israel
D Weinberger, J Kremer, R Avisar, Department of Ophthalmology, Rabin Medical Center, Beilinson Campus, Petah Tiqva and Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel
Correspondence to: R Friling, Department of Ophthalmology, Schneider Children’s Medical Center of Israel, 14 Kaplan Street, Petah Tiqva 49202, Israel; friling@netvision.net.il

REFERENCES