Original article

White-to-white corneal diameter of full-term Nigerian newborns

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ABSTRACT

Background: Measurement of corneal diameter (CD) in children is pertinent in the diagnosis and monitoring of some ocular diseases, especially anterior segment anomalies and congenital glaucoma. Data on normal values of CD in African children are scarce, and Caucasian values are mostly referred to. The aim of this study was to determine the normative values of CD in full-term newborns and to assess its relationship with some birth parameters.

Methods: Horizontal and vertical CDs were measured in 1000 eyes of 500 consecutive normal full-term babies within their 1st week of life using calipers in a cross-sectional study. The relationship between CD and different variables was assessed using multiple linear regression.

Results: A total of 254 (50.8%) male and 246 (49.2%) female babies were involved in the study. The values (mean ± standard deviation) of horizontal and vertical CD were 9.87 ± 0.04 mm (range 9.00–10.75 mm) and 9.62 ± 0.41 mm (range 8.75–10.75 mm), respectively. There was no statistically significant difference between the mean horizontal CD for the right and left eyes (p = 0.39). The mean horizontal CD in males were not significantly different from that in females (p = 0.21). The 95% range for horizontal CD (mean ± 2 standard deviations) was 9.06–10.66 mm. Birth weight showed a positive correlation with CD (r = 0.59, p < 0.001).

Conclusion: From the results of this study, normative values of CD in full-term Nigerian newborns have been established. This will enhance the ophthalmic care of newborns in Nigeria and Africa as a whole.

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1. Introduction

Corneal diameter (CD) is an essential clinical diagnostic and monitoring tool in the practice of ophthalmology and more importantly in its pediatric subspecialty. Its measurement has also been found useful in cataract, with refractive surgery being particularly important when implanting intraocular lens and estimating anterior chamber width and ciliary sulcus size. Measurement of CD is particularly relevant in pediatric ophthalmology because deviations from normal values play an important role in the diagnosis of ophthalmic conditions such as relative anterior microphthalmos, corneal dystrophies, microcornea, and congenital glaucoma.

Early diagnosis and appropriate intervention may be sight saving in some cases of childhood blindness, one of which is congenital glaucoma. CD value is usually greater than normal in eyes with congenital glaucoma, and it is a sensitive parameter in diagnosis and monitoring of such patients who sometimes present with haziness of the cornea. However, neonates may sometimes be born with a cloudy cornea in the absence of glaucoma, and determining the diameter of the cornea in such cases may be crucial to diagnosis because a corneal haze is present in other diseases such as sclerocornea and congenital hereditary endothelial dystrophy.

At present, the frequently used reference values for Nigerian and African children as a whole are often those obtained from studies of Caucasian children even when racial variation has been reported in general and ocular biometric parameters. The present study was therefore designed to determine the normal values of CDs in...
Nigerian newborns and possible relationship with some birth parameters.

2. Methods

2.1. Patients

This was a cross-sectional study. We included healthy full-term newborns (37–42 weeks of gestation) delivered between August 2011 and October 2011 in a teaching hospital in the north central geopolitical zone of Nigeria. The University of Ilorin Teaching Hospital is a tertiary health center that also offers secondary health care to all socioeconomic classes in its catchment areas. All full-term babies born in the hospital within the study period constituted the study population. A total of 500 consecutive babies of consenting mothers were recruited into the study. Babies with any congenital anomalies (ocular or nonocular) or uncertain gestational age were excluded, as were babies of mothers with antenatal conditions likely to cause intrauterine growth retardation, products of multiple pregnancy, and those with stillbirth. General examination was conducted by a pediatrician who certified them healthy and excluded any congenital abnormalities prior to enrollment into the study.

Ethical approval was obtained from the Ethical Review Committee of the hospital, and informed oral consent was taken from all mothers. Anthropometric measurements (birth weight, head circumference, baby length) were taken by trained staff within the 1st hour of life. Postnatal age and sex were also recorded. Gestational age was estimated from the last menstrual period and recorded in days.

2.2. Methods

CDs were measured by one of the authors (VAO, an opthalmologist) within the 1st week of life while the infants were still on the postnatal wards. Babies were placed in the supine position on the examination couch, and the anterior segments of both eyes were examined with a pen torch. A local anesthetic drop was applied to expose the limbus for proper measurement of the white-to-white CD. A caliper was then used to measure the white-to-white vertical and horizontal CDs with the examiner standing at the head end of the couch. Vertical diameter was measured from 12 o’clock limbus, whereas horizontal diameter was measured from 3 o’clock to 9 o’clock limbus. Three readings were taken of each eye, and an average of the readings was taken as the CD.

2.3. Statistical analysis

Analysis of data was performed with SPSS version 16 (SPSS Inc., Chicago, IL, USA). Mean, standard deviation (SD), median, and range were calculated. Differences between data sample means were determined using Student t test. To analyze the association between birth parameters and CD, Pearson’s correlation coefficients were calculated. For simple and multiple linear regression analyses, \( p < 0.05 \) was considered statistically significant.

3. Results

3.1. Neonatal characteristics

Out of the 500 babies examined, there were 254 (50.8%) males and 246 (49.2%) females, with a male/female ratio of 1:1. As shown in Table 1, the gestational ages ranged from 259 days to 294 days with a mean of 271.3 ± 10.8 days, and birth weight ranged from 2.2 kg to 4.5 kg with a mean of 3.06 ± 0.4 kg. Other birth parameters are summarized in Table 1. There was no significant sex difference in these parameters.

3.2. CD

Modal and median values for both vertical and horizontal CD in both eyes were similar (Table 2). In males, the right mean vertical diameter was 9.59 ± 0.40 mm and 9.60 ± 0.43 mm in the left, and the right mean horizontal diameter was 9.84 ± 0.42 mm and 9.79 ± 0.44 mm in the left. Female newborns had a mean vertical diameter of 9.60 ± 0.35 mm in the right and 9.62 ± 0.43 mm in the left, whereas the right horizontal diameter was 9.89 ± 0.38 mm and the left horizontal diameter was 9.88 ± 0.39 mm (Table 3). There was no significant sex difference in the mean values of vertical or horizontal CD as shown in Table 3. Differences in laterality of the horizontal diameter also proved nonsignificant (\( p = 0.39 \)). Figs. 1 and 2 depict the distribution of horizontal CD in both eyes. The 95% range (mean ± 2SD) for horizontal CD using the mean value of the left eyes was 9.06–10.66 mm. Based on this, 0.8% of the sample had macrocornea and 9.6% had microcornea.

3.3. Birth parameters and CD

Table 4 shows the relationship between birth weight and CD. CD was positively correlated with birth weight (\( r = 0.59, p < 0.001 \)). By contrast, there were no significant associations with birth length, sex, postnatal age, and head circumference. A multiple regression model was generated, including birth weight, sex, postnatal age, gestational age, length, and head circumference. In this model, it was exhibited that birth weight was the strongest independent predictor of CD (Table 5). The model showed that a 1-kg increase in birth weight is associated with at least a 0.36- and 0.41-mm increase in vertical and horizontal CD, respectively (Table 5).

4. Discussion

Our study aims at providing normative data on the CD among newborn Nigerian children. To the best of our knowledge, this
study provides the largest sample size of published data on CD in newborn Nigerians/Africans.

The horizontal CDs in Caucasians at birth are approximately 10 mm, with the fastest growth rate occurring in the first few months of life and attaining adult size at ages 1–3 years.7,8 The mean horizontal CD in the present study is 9.87 ± 0.40 mm. This is comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparable to the value of 9.98 mm reported by Lagreze and Zobor9 using the photography method. There are previous reports comparing with the value of the study.

In the present study, the mean birth weight of female infants was greater than that of males. Accordingly, the mean horizontal CD was found to be slightly higher in female infants, although the mean values in both sexes showed no significant difference. This insignificant sex difference in CD observed in the current study is consistent with previous reports.13,14 However, a study in Middle East Asia indicated significantly larger CDs in the male sex.15 The mean horizontal CD of the right eyes was similar to that of the left eyes with no significant difference.

Micro- and macrocornea in the newborn in this study can be defined as horizontal CD less than 9.06 mm and greater than 10.66 mm, respectively, based on the 95% range obtained in our study. Using this definition, less than 1% (0.8%) had macrocornea and 9.6% had microcornea in this study. Furthermore, birth weight was found to be positively correlated with CD in the 1st week of life. This is in consonance with a previous study.16

Different methods have been described in the literature as regards the measurement of CD. These include the use of manual calipers, millimeter rule, slit lamp attachment, photographic measurement, orbscan II, IOL Master, EyeSys corneal analysis, and the

### Table 2
Vertical and horizontal corneal diameter (CD) in newborns.

<table>
<thead>
<tr>
<th></th>
<th>Right eye (n = 500)</th>
<th>Left eye (n = 500)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical CD</td>
<td>Horizontal CD</td>
</tr>
<tr>
<td>Mode</td>
<td>9.50</td>
<td>10.00</td>
</tr>
<tr>
<td>Median</td>
<td>9.50</td>
<td>10.00</td>
</tr>
<tr>
<td>Mean</td>
<td>9.59</td>
<td>9.87</td>
</tr>
<tr>
<td>SD</td>
<td>0.38</td>
<td>0.40</td>
</tr>
<tr>
<td>Range</td>
<td>8.75–10.50</td>
<td>9.00–10.50</td>
</tr>
</tbody>
</table>

SD = standard deviation.

### Table 3
Vertical and horizontal corneal diameter (CD) by sex.

<table>
<thead>
<tr>
<th></th>
<th>Male (n = 254)</th>
<th>Female (n = 246)</th>
<th>p</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical CD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.59</td>
<td>9.60</td>
<td>0.89</td>
<td>0.60</td>
</tr>
<tr>
<td>SD</td>
<td>0.40</td>
<td>0.35</td>
<td>0.43</td>
<td>0.43</td>
</tr>
<tr>
<td>Range</td>
<td>9.00–10.50</td>
<td>8.75–10.50</td>
<td>8.75–10.50</td>
<td>9.00–10.50</td>
</tr>
<tr>
<td>Horizontal CD</td>
<td>9.84</td>
<td>9.89</td>
<td>0.37</td>
<td>0.79</td>
</tr>
<tr>
<td>SD</td>
<td>0.42</td>
<td>0.38</td>
<td>0.44</td>
<td>0.39</td>
</tr>
<tr>
<td>Range</td>
<td>9.00–10.50</td>
<td>9.00–10.50</td>
<td>8.75–10.75</td>
<td>9.00–10.75</td>
</tr>
</tbody>
</table>

SD = standard deviation.

### Table 4
Corneal diameter (CD) stratified by birth weight.

<table>
<thead>
<tr>
<th>Birth weight</th>
<th>Right eye (n = 500)</th>
<th>Left eye (n = 500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Vertical CD</td>
<td>Horizontal CD</td>
</tr>
<tr>
<td>&lt;2.5 kg</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Mean</td>
<td>9.00</td>
<td>9.08</td>
</tr>
<tr>
<td>SD</td>
<td>0.26</td>
<td>0.19</td>
</tr>
<tr>
<td>Range</td>
<td>8.75–9.50</td>
<td>9.00–9.50</td>
</tr>
<tr>
<td>2.5–3.5 kg</td>
<td>416</td>
<td>416</td>
</tr>
<tr>
<td>Mean</td>
<td>9.60**</td>
<td>9.87*</td>
</tr>
<tr>
<td>SD</td>
<td>0.36</td>
<td>0.37</td>
</tr>
<tr>
<td>Range</td>
<td>9.00–10.50</td>
<td>9.00–10.50</td>
</tr>
<tr>
<td>&gt;3.5 kg</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Mean</td>
<td>9.80**</td>
<td>10.15**</td>
</tr>
<tr>
<td>SD</td>
<td>0.29</td>
<td>0.20</td>
</tr>
<tr>
<td>Range</td>
<td>9.50–10.50</td>
<td>10.00–10.50</td>
</tr>
</tbody>
</table>

N = sample size; SD = standard deviation.

*p < 0.05 compared with <2.5 kg group.

**p < 0.05 compared with <2.5 kg and 2.5–3.5 kg groups.
Galilei.\textsuperscript{10,17–19} CD was measured with the use of calipers in the current study because it is readily available, easy to use, less technically challenging, and one of the most commonly used tools in everyday practice. It is also more affordable in a developing economy such as Nigeria.

The strength of this study lies in the large sample size. However, this study has several limitations. First, recall bias might have been produced from the method of determining the gestational age by confirming the last menstrual period from the mothers and introduced error in calculating the gestational age. Second, because the majority (84%) of the babies belonged to one particular ethnicity, which is composed of diverse ethnicities. Racial variation has been reported in general and ocular biometric parameters.\textsuperscript{5,6}

In conclusion, the mean horizontal CD in the 1st week of life as found among Nigerian newborns was 9.87 ± 0.40 mm, whereas the vertical CD was 9.62 ± 0.41 mm. There was no statistically significant difference in sex or laterality. There was no correlation between CD and sex, birth length, and head circumference. The results also indicate that birth weight is a strong correlate of CD.

Acknowledgments

The authors are grateful to Dr L.A. Olatunji for statistical assistance as well as reviewing the manuscript and Mr Amos Salami for assistance in data collection.

Table 5

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Vertical corneal diameter</th>
<th>Horizontal corneal diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>0.36 (0.04)</td>
<td>0.41 (0.05)</td>
</tr>
<tr>
<td>p &lt; 0.0001</td>
<td>0.001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Model summary

\( R^2 = 0.33 \) adjusted; \( R^2 = 0.37 \) unadjusted.

\( B \) = unstandardized regression coefficient; \( \beta \) = standardized regression coefficient; SE = standard error.

References