Original Article

Comparing the Use of Smartphone and Vernier Calipers for Corneal Diameter Measurement in Nigerian Term Neonates

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Abstract

Background: Corneal diameter (CD) measurement in newborns is essential for the detection of blinding ocular pathologies. It requires specially trained personnel, contact techniques, and the use of anesthesia. Smartphone use may obviate these challenges. **Aim:** This study compares CD measurement among newborns using a Smartphone and manual calipers. **Subjects and Methods:** This is a cross-sectional comparative study done at Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Nigeria. Consecutively selected stable term neonates whose mothers consented to the study and met the inclusion criteria had their CDs measured with both calipers and smartphones and the values compared. Mean, range, and standard deviation were calculated using Statistical Package for the Social Sciences (SPSS) IBM (version 22), while paired *t*-test calculated the difference in mean CD measurements between both methods. Pearson's correlation and Bland–Altman's analysis determined the correlation and agreement between both methods, respectively. Inter and intraobserver repeatability were assessed. A *P* value less than 0.05 was taken as statistically significant. **Results:** The mean CD measurement using calliper method was 10.01 ± 0.29mm and 10.03 ± 0.24 mm right eye (RE) and left eyes (LE), respectively) for investigator 1 and 10.16 ± 0.25 mm and 10.19 ± 0.21 mm (RE, LE) for investigator 2. Using smartphone measurement, mean CD measurements of 9.98 ± 0.21 mm and 10.00 ± 0.29 mm (RE, LE) were observed for investigator 1 and 10.07 ± 0.19 mm and 10.06 ± 0.21 mm (RE, LE) for investigator 2. The difference in mean CD for both instruments and by both investigators was not statistically significant (P value > 0.05). **Conclusion:** Corneal diameter measurement in neonates using smartphone technology does not deviate significantly from caliper measurement; it is safe, easy to use, and advocated.

Keywords: *Cornea diameter measurements, neonates, Nigeria, smartphone, vernier calipers*

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Introduction

Corneal diameter (CD) measurements have been shown to be a reliable parameter in the diagnosis and monitoring of ocular disorders.[1-15] Contact methods for CD measurement include the use of traditional calipers;[2,16-19] employing the use of local anesthesia, sedation, and occasionally, general anesthesia with their attendant risks by specially trained personnel.[2,11,15]

A simpler, easy-to-use, noninvasive method obviates these risks. Smartphones have incorporated applications that are noncontact, relatively inexpensive, available, easy to maintain, portable, user-friendly,[1] and useful in telemedicine.[11]

This study compares the corneal diameter values in neonates obtained using Smartphone technology compared to measurements obtained with calipers.

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Subjects and Methods

This was a hospital-based cross-sectional comparative study of neonates within the first week of life that was delivered at a tertiary hospital from November 2019 to February 2020. Stable term neonates within 1 week of birth, as assessed by the obstetrician, without ocular or non-ocular conditions, were included in the study. Sampling was by consecutive sampling method of eligible consenting participants.

The horizontal white-to-white CD was measured using vertically held manual callipers from the 3 o'clock to 9 o'clock position on the limbus.

The Samsung J3 phone was used for the anterior segment photograph. The ImageMeter app downloaded free from the phone's Play Store, was used as the digital measurement software application.

The following steps were taken to perform the Smartphone measurement:

1. Photographs of the eyes were taken in primary gaze with the eyelid speculum in place in a supine position.
2. The photograph was opened in the ImageMeter application, and the known length of the interlacing blade of the eyelid speculum was measured with a standard calibrating ruler, and 5 mm was computed as the reference scale.
3. The horizontal CD was automatically measured using the ImageMeter app by drawing a horizontal line with the finger from 3 o'clock to 9 o'clock positions at the limbus bisecting the pupil.
4. The ImageMeter app gives a magnified image of the ongoing measurement as the horizontal lines are drawn both for the interlacing blade and the white-to-white CD on a corner of the phone screen to enhance accuracy.

   There were two investigators: The primary researcher (investigator 1) and a cornea specialist (investigator 2)

Three anterior segment pictures of both eyes in primary gaze were taken by the investigator with the smartphone camera without the camera flash, and the CD measurement was determined as earlier highlighted. The average CD by investigator 1 using the smartphone was documented in proforma A as DS1. All proforma A were kept by investigator 1. Investigator 2 then applied the calipers and measured the white-to-white CD from the 3 o'clock to 9 o'clock limbus for each eye. Three readings were taken, and the average was documented as DC2 in proforma B, which was kept by investigator 2. Subsequently, investigator 1 took measurements with calipers and documented them as DC1 in proforma A, while investigator 2 used the smartphone application to document them as DS2 in proforma B.

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS IBM) software (version 22, Chicago, USA).

Descriptive statistics was used to determine the mean, range, and standard deviation. A paired *t*-test and the Bland–Altman analysis were used to determine the difference in mean CD measurements between both methods, and Pearson's correlation was used to determine the correlation between both methods. A *P* value less than 0.05 was taken as statistically significant.

White-to-white horizontal CD: This is the horizontal distance between the borders of the corneal limbus from 3 o'clock to 9 o'clock positions.

Term neonates: babies born between 37 weeks and 41 weeks + 6 day

Results

A total of 1213 neonates were delivered within the study period, out of which 180 were recruited for the study.

A total of 91 males (50.6%) and 89 females (49.4%) participated in the study. The mean age of the neonates was 0.51 ± 0.50 days with a range of 0–1 day. The mean weight of the neonates was 3.1 ± 0.34 kg with a range of 2.4–4.1 kg.

Table 1: Mean corneal diameter using both methods

Mean±SD	Right Eye	Left Eye	*P*
Mean±SD DC1	10.01±0.29	10.03±0.24	0.643
Mean±SD DC2	10.16±0.25	10.19±0.21	0.364
Mean±SD DSI	9.98±0.21	10.00±0.29	0.196
Mean±SD DS2	10.07±0.19	10.06±0.21	0.774

DC1=Mean corneal diameter measurement using calipers by observer 1, DC2=Mean corneal diameter measurement using calipers by observer 2, DS1=Mean corneal diameter measurement using a Smartphone by observer 1, DS2=Mean corneal diameter measurement using a Smartphone by observer 2 , SD=Standard deviation

Table 2: Range of corneal diameter measurement using both methods

Method	Right eye (mm)	Left eye (mm)
DC1	9.70–10.80	9.70–10.80
DC2	9.70–10.80	9.70–10.80
DS1	9.53–10.53	9.58–10.49
DS2	9.69–10.49	9.60–10.57

DC1=Mean corneal diameter measurement using calipers by investigator 1, DC2=Mean corneal diameter measurement using calipers by investigator 2, DS1=Mean corneal diameter measurement using a smartphone by investigator 1, DS2=Mean corneal diameter measurement using a smartphone by investigator 2

Table 1 shows the mean CD using calipers and Smartphone methods for the right and left eyes for both investigators. The study found a mean CD using the caliper method of 10.01 ± 0.29 mm and 10.03 ± 0.24 mm (right and left eyes, respectively) for investigator 1(DC1). The difference between the right and left eye was not statistically significant ($P = 0.643$). For investigator 2 (DC2), the mean CD by calliper method was 10.16 ± 0.25 mm and 10.19 ± 0.21 mm (right and left eyes, respectively). The difference between the right and left eyes was also not statistically significant ($P = 0.364$). Using Smartphone measurement, mean CD measurements of 9.98 ± 0.21 mm and 10.00 ± 0.29 mm (right and left eyes, respectively) were observed for investigator 1 (DS1) and 10.07 ± 0.19 mm and 10.06 ± 0.21 mm (right and left eyes, respectively) for investigator 2 (DS2). The difference in mean CD between the right and left eyes for both investigators was not statistically significant (P = 0.196 and 0.774, respectively).

Table 2 shows the range of CD using both methods. The range was 9.70–10.80 mm and for investigator 1 (DC1) using caliper for both right and left eyes. Investigator 2 also had a caliper method measurement (DS1), with a range of 9.53–10.53 mm and 9.58–10.49 mm for right and left eyes, respectively, while investigator 2 (DS2) had a range of 9.69–10.49 mm and 9.60–10.57 mm for right and left eyes, respectively.

Table 3 shows the comparison of mean values of CD measurement by both methods for both investigators. The mean difference between DC1 (10.01 ± 0.29 mm) and DS1 (9.98 ± 0.21 mm) was not statistically significant with a P value of 0.344. The table also shows that the mean difference between DC2 (10.16 ± 0.25 mm) and DS2 (10.07 ± 0.19 mm) was not statistically significant, with a P value of 0.074.

Table 4 shows the Pearson's correlation of DC1 with SP1 and DC2 with DS2 (Right eye).

Table 4 shows the comparison of mean values of CD measurement by various methods for both investigators. The mean difference between DC1 (10.01 ± 0.29 mm) and DS1 (9.98 ± 0.21 mm) was not statistically significant with a P value of 0.344. The table also shows that the mean difference between DC2 (10.16 ± 0.25 mm) and DS2 (10.07 ± 0.19 mm) was not statistically significant, with a P value of 0.074.

Figure 1 shows the Bland–Altman graphical analysis of the agreement between calipers and smartphone measurement for investigator 1. MC1 + MSP1: Mean CD measurement using calipers and smartphone by observer 1, respectively. Figure 1 shows the Bland–Altman graphical analysis of the agreement between calipers and smartphone measurement for investigator 1. This shows most of the plots being within the lines of agreement and thus having a significant agreement with a P value of 0.001

Figure 2 shows the Bland–Altman graphical analysis of the agreement between calipers and smartphone measurement for investigator 2. Figure 2 shows the Bland–Altman graphical analysis of the agreement between calipers and smartphone measurement for investigator 2. This shows most of the plots being within the lines of agreement and thus having a significant agreement with a P value of 0.001.

Table 3: Comparison of mean values of CD measurement by both methods in the right eye

Parameter	No of participants	Mean±SD	*t*-test	*P*
DC1	180	10.01±0.29		
DS1	180	9.98±0.21	0.949	0.344
DC2	180	10.16±0.25		
DS2	180	10.07±0.19	0.996	0.074

DC1=Mean corneal diameter measurement using calipers by investigator 1, DC2=Mean corneal diameter measurement using calipers by investigator 2, DS1=Mean corneal diameter measurement using a smartphone by investigator 1, DS2=Mean corneal diameter measurement using a smartphone by investigator 2, SD=standard deviation

Table 4: Comparison of mean values of CD measurement by both methods in the right eye

Parameter	No of participants	Mean±SD	*t*-test	*P*
DC1	180	10.01±0.29	0.949	0.344
DS1	180	9.98±0.21		
DC2	180	10.16±0.25	0.996	0.074
DS2	180	10.07±0.19		

DC1=Mean corneal diameter measurement using calipers by investigator 1, DC2=Mean corneal diameter measurement using calipers by investigator 2, DS1=Mean corneal diameter measurement using a smartphone by investigator 1, DS2=Mean corneal diameter measurement using a smartphone by investigator 2, SD=Standard deviation

Table 5: Intraobserver variability

	A	B	C	*P*
Mean DC1 values	10.03	9.99	10.02	0.797
Mean DC2 values	9.890	10.18	10.17	0.809
Mean DS1 values	10.01	9.99	9.95	0.899
Mean DS2 values	10.06	10.08	10.06	0.926

A, B, C: Mean corneal diameter for the three measurements made using calipers and smartphone by investigator 1 (DC1, DS1) and investigator 2(DC2, DS2), respectively. DC1=Mean corneal diameter measurement using calipers by investigator 1, DC2=Mean corneal diameter measurement using calipers by investigator 2, DS1=Mean corneal diameter measurement using a Smartphone by investigator 1, DS2=Mean corneal diameter measurement using a Smartphone by investigator 2

Figure 1: Bland-Altman Analysis for DC_1 and DS_1

Variables	Coefficients	*t*-test	*P*
Constant	−7.149	−4.432	0.001
(MC1 + MSP1)/2	0.718	4.449	0.001

Dependent variable: Difference (MC1−MSP1)

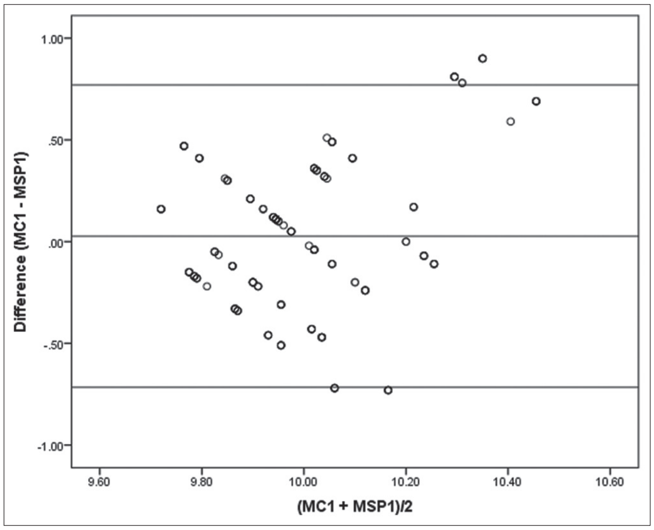

Figure 1: Bland–Altman analysis for DC1 and DS1. MC1 + MSP1: Mean corneal diameter measurement using calipers and Smartphone by investigator 1, respectively

Table 6: Interobserver variability

Calipers	DC1	DC2	*P*
	10.01	10.16	0.904
Smartphone	DS1	DS2	
	9.98	10.07	0.879

DC1=Mean corneal diameter measurement using calipers by investigator 1, DC2=Mean corneal diameter measurement using calipers by investigator 2, DS1=Mean corneal diameter measurement using a smartphone by investigator 1, DS2=Mean corneal diameter measurement using a smartphone by investigator 2

Table 5 shows intraobserver variability using repeated analysis of variance (ANOVA). Table 5 shows intraobserver variability using repeated ANOVA, which showed non-statistically significant variability for caliper measurements of investigators 1 and 2 (P = 0.797 and 0.809 respectively) as well as smartphone measurements for investigators 1 and 2 (P = 0.899 and 0.926 respectively).

Table 6 shows interobserver variability using a paired *t*-test. Table 6 shows interobserver variability using a paired *t*-test. The interobserver variability did not meet statistical significance for caliper measured CD between both investigators (P = 0.904). It also did not meet statistical significance between smartphone measurements of both investigators (P = 0.879).

Discussion

In this study, the mean birth weight of the neonates was 3.1 ± 0.34 kg, which was similar to that of Olatunji *et al.*[11] carried out in southwest Nigeria, which reported a mean weight of 3.06 ± 0.4 kg but differed from that of Sehrawat *et al.*[20] in India, who reported an average weight of 2.880 ± 0.5 kg for term neonates. This dissimilarity may be related to the general anthropometric difference associated with race and ethnicity. This study, however, noted a birth weight range of 2.4 to 4.1 kg against 2.2 to 4.5 kg reported by Olatunji *et al.*,[11] whose study was carried out in the southwestern part of Nigeria. This may not be unrelated to ethnic differences in birth weight.

Figure 2: Bland-Altman Analysis for DC_2 and DS_2

Variables	Coefficients	*t*-test	*P*
Constant	–4.756	–3.587	0.001
(MC2 + MSP2)/2	0.480	3.660	0.001

Dependent variable: Difference (MC2−MSP2)

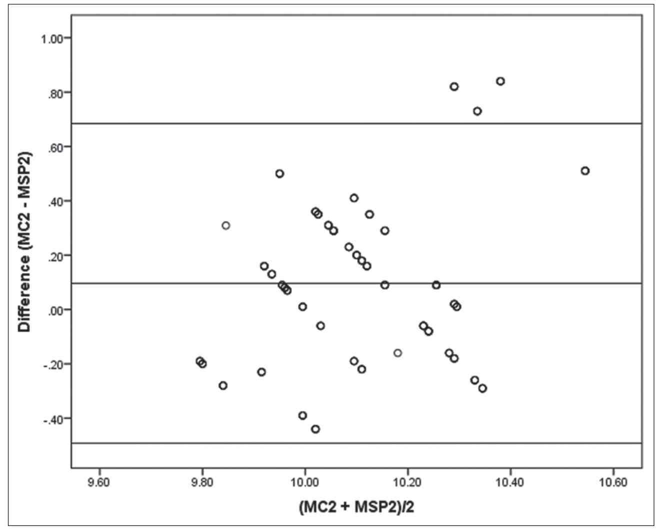

Figure 2: The Bland–Altman graphical analysis of the agreement between calipers and smartphone measurement for investigator 2. MC2 +MSP2: Mean corneal diameter measurement using callipers and smartphone by investigator 2 respectively

The mean postnatal age for this study participants was 0.51 ± 0.5 days with a range of 0–1 day. This was similar to the report of Ghansemi *et al*.[17] who measured CD in 1-day-old neonates only, but contrasted with that of Olatunji *et al*.[11] who had a mean postnatal age of 47.1 ± 4.9 h.[11] This difference might be attributed to the sampling method. While Olatunji *et al*. examined all eligible neonates within 1 week of birth, this study selected the first three neonates delivered each day that met the eligibility criteria.

Furthermore, in this study, the mean CD measurement for investigator 1 using calipers was 10.01 ± 0.29 mm (right eye) and 10.03 ± 0.24 mm (left eye), and for investigator 2, 10.16 ± 0.25 mm (right eye), and 10.19 ± 0.21 mm (left eye). These measurements are similar to the mean caliper measurements of 9.87 ± 0.40 mm by Olatunji *et al*.,[11] 10.26 ± 0.59 mm, Ashaye *et al*.[10] and 10.0 ± 0.4 mm in Korean newborns by Kim *et al*.[21] This similarity may be related to the similarity in mean birth weight. This, however, contrasts with the findings by Kirwan *et al*.[22] who reported an average measurement of 9.6 ± 0.5 mm. However, their findings were obtained at a gestational age of 39–42. Sehrawat *et al*.[20] in New Delhi, India, reported a mean CD of 9.5 ± 0.6 mm. Differences in anthropometric characteristics are likely implicated as the mean birth weight of their study participants was 2.88 ± 500 kg compared to that in this study.; birth weight has previously been shown to correlate positively with CD.[21]

In addition, the mean CD using smartphone technology for investigator 1 were 9.98 ± 0.21 mm and 10.00 ± 0.29 mm (right and left eyes, respectively), and for investigator 2, 10.07 ± 0.19 mm and 10.06 ± 0.21 mm (right and left eyes respectively) This is similar to that of Lagreze *et al*.[23] who reported a mean CD of 9.98 mm and 9.79 ± 0.44 mm by Ghansemi *et al*.[17] using photographic methods. In addition, this study showed no statistically significant difference in CD measurement for the right and left eyes for both investigators using these two methods. Similar findings have been documented by Olatunji *et al*.[11] and Ghansemi *et al*.[17] as found in most normal paired organs of the body. As a result, further statistical analysis was done using CD measurement of the right eye only in order to make the work less cumbersome.

Importantly, this study demonstrated no statistically significant difference in the measurement of CD using callipers and smartphones by both investigators. This is similar to the study by Harby *et al*. in Saudi Arabia,[1] who also compared smartphone technology to the caliper method, and Robinson *et al*.[24] who also used a Medical-Nikkor f200 mm lens camera versus the caliper method.[1] Chen *et al*.[12] however, found a statistically significant difference in the measurement of CD using intraocular lens (IOL) master and calipers; the difference in the mean CD using both methods was 0.1 mm. This difference of 0.1 mm is unlikely to be of significant clinical importance, considering that many surgeons add 0.5 to 1 mm to the external corneal white-to-white measurement to determine the overall diameter for an anterior chamber phakic lens.[25,26] Salouti *et al*.[18] in their study, comparing CD measurement using Orbscan IIz and Pentacam also suggested that a difference of 0.1 mm, though statistically significant, was not clinically relevant.

This study showed a significant correlation between both methods by both investigators following Pearson's correlation analysis. This is further established by Bland–Altman's plot, which demonstrated that over 95% of measurements are within the limit of agreement with a P value of 0.001. This further emphasizes the significant correlation between both methods earlier observed following Pearson's correlation analysis.

Conclusion

This study has demonstrated that in the measurement of CD in neonates, smartphone measurements do not deviate significantly from measurements using calipers. This suggests that smartphone measurement is an acceptable alternative to the traditional caliper method. Moreover, smartphone technology can measure to the nearest 0.1 mm, unlike calipers that are calibrated in 1 mm increments and may be able to measure only to the nearest 0.5 mm, making smartphone measurement potentially more accurate. Furthermore, the repeatability of smartphone measurement compared to caliper measurement suggests a reliable method of measurement.

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Conflicts of interest

There are no conflicts of interest.

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