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Assessing agreement of inter-pupillary distance measurements between contact and non-contact digital pupillometers during COVID-19

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Abstract
Purpose: Interpupillary distance (IPD) measurement is important in various sub-fields in ophthalmology and vision sciences. Social distancing is one of the protocols which is being followed since COVID -19 pandemic across the globe. This protocol was a major limitation while measuring the IPD during spectacle dispensing. Hence, we need an alternate method which allows to measure IPD at 1-meter distance. This study aims to report the agreement between contact and non-contact IPD measurements.
Methods: Monocular and binocular distance and near IPD were measured using contact (Essilor pupillometer; Pupillon, Essilor, France) and non-contact (OptikamPad; Optikam Tech Inc., Canada) measuring device. Gender effects were assessed using Wilcoxon and Mann-Whitney tests respectively. Agreement was assessed using Spearman correlation and Bland-Altman plots.
Results: A total of fifty subjects IPD data were analysed (male 62.0%). The mean age ± standard deviation (SD) for the study subjects were 53.35 ± 11.91 (range 32 - 81) years. The IPD measurements by Contact digital pupillometer and Non-Contact digital IPD measuring devices showed an insignificant difference both for monocular and binocular IPDs and also had a good agreement between the methods.
Conclusions: The IPD measurements by the Non-Contact digital IPD measuring device was comparable with the Contact digital pupillometer. In order to maintain social distance during COVID 19, the non-contact digital measuring device can be considered as an alternate tool for IPD measurement.

Keywords: Inter-pupillary distance, COVID-19, social distance, pupillometer

Introduction
The anatomic Inter-Pupillary Distance (IPD) is the distance measured from the center of one eye pupil to the center of another eye pupil measured in millimeters (mm) [1, 2]. The IPD would vary from person to person and between the eyes [3]. An average adult IPD ranges from about 54 mm to 72 mm [2, 4]. Generally, the IPD is smaller in children than the adults and will not be more than 48 mm in very young children [5]. As IPD would vary with age, gender or ethnicities, it is imperative to measure IPD every time before dispensing a spectacle [1]. The commonest method of measuring IPD is by using a PD Ruler or a mm scale [6]. However, they do suffer parallax error which is expected to cause inaccurate IPD up to 7mm [7]. So contact digital pupillometers (Fig.1A) have become a standard method of measuring IPD measurements across the globe [8]. Contact digital pupillometers allows us to take IPD measurements in close proximities (Fig.1A). One of the biggest challenges during COVID 19 is to maintain social distance while handling with patients [9]. This warrants an alternative and accurate method to measure IPD with social distancing. A commercially available non-contact digital IPD measuring device (Fig.1B: OptikamPad: Optikam Tech Inc., Canada) allows us to measure IPD measurements at a distance (approximately 1 meter) [10]. However, to the best of our knowledge this is not a validated tool for measuring IPD. This study aims to validate and compare the agreements between contact and non-contact digital methods.

Methods
Subjects
Subjects (n=50) who reported to the Optical Service center, located at a tertiary eye care center, in Southern India between August 2021 and November 2021 for ordering their new pair of lenses were enrolled for the study.

The study was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Vision Research Foundation, Chennai, India. The exclusion criteria included best-corrected visual acuity worse than 6/9, squinting, and any condition which affects IPD measurements. The statement of written informed consent was obtained prior to the enrolment from all the subjects.

IPD measurement

The IPD measurements were performed using a Contact digital pupillometer (Figure 1A) and a Non-contact digital IPD measuring device (Figure 1B: Optikam Pad: Optikam Tech Inc., Canada). Two experienced examiners performed the measurements, where one examiner (MS) performed non-contact digital measurement and the other examiner (SP) performed contact digital pupillometer to avoid examiner bias. The order of IPD measurements were randomised.

Fig 1A: IPD measurement using the commercially available Contact digital pupilometer

Fig 1B: IPD measurement using the commercially Non-Contact Digital IPD measuring Device

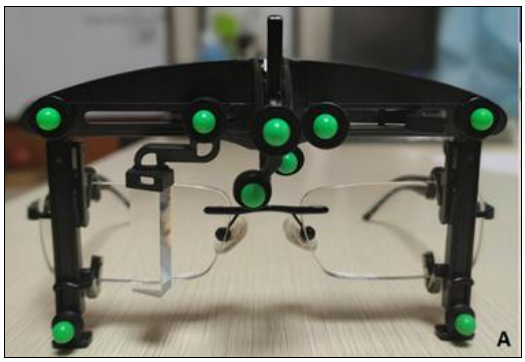

Fig 2A: EY-Stick Version 2

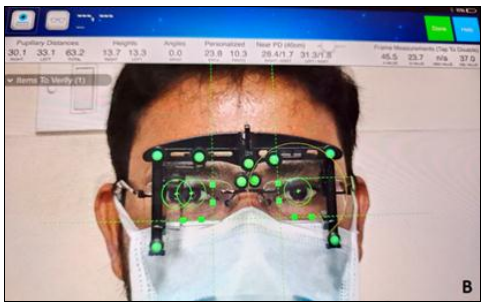

Fig 2B: EY-Stick Version 2 on subject face with measurements

The EY-Stick (Figure 2 A & B) consists of 4 main elements: Frame Hooks, Wrap Arm, Posture Swing assembly, Vertex Distance Prism. The EY-Stick has a few green-coloured knobs which are reference points that sensors and capture measurements via OptikamPad [10]. Every time, after inserting the frame to the EY-stick, it was made sure that the frame was aligned properly. The subject had to be seated in their natural posture and were asked to look straight at a far object. The swing assembly should be locked only when the subject is in the natural posture till then it should be let free. Before taking the measurement, the Optikam Pad allows us to select the frame and lens type. The OptikamPad were held such that all the green-coloured knobs were inside the focusing square box. By clicking on the capture option, a photo was captured with the help of a flashlight [10, 11].

The subject's demographic details along with their measurements were saved in the Optikam App. For the same subject, the other examiner measured the monocular IPD for distance and near using Contact digital pupillometer. For that, the subject was made to sit at the eye level of the examiner and the subject was asked to hold the pupillometer with both hands. It was made sure that the instrument was placed properly in the face on the nose bearer and their forehead touching the forehead bearer. For measuring distance IPD, the pupillometer was set to infinity (∞) and for measuring near IPD, the pupillometer were set to 35 cm. A cursor on top allows us to move right or left to measure monocular pupillary distances (PD). To measure the binocular PD, the cursor is moved to the centre. Left and Right measuring keys are just below the display window which are adjustable keys in which the black line was made to coincide with the centre of the corneal reflection visible from the measuring window. Now the subject was asked to look at the light inside the pupillometer and the examiner made sure that the black line coincided with the centre of corneal reflection. The measurements were taken from the display window and documented appropriately for distance and near.

Results

The IPD for distance and near measurements of fifty subjects (mean age ± SD; 53.35 ± 11.91 (range 32-81) years were analysed. This includes 31 males and 19 females. Results were expressed as the mean ± standard deviation (SD) and median (Inter quartile range: IQR) since some data were non-normally distributed and tabulated in Table 1. A statistically insignificant difference was observed between the male and female participants for age, mean spherical equivalent, near addition, and left eye best-corrected visual acuity (BCVA). However, the right eye BCVA showed a statistically significant difference ($p < 0.05$).

Table 1: Demographic, refractive error status, and visual acuity details

	Male (n=31)		Female (n=19)		
	Mean ± SD	**Median (IQR)**	**Mean ± SD**	**Median (IQR)**	**p-Value**
Age (Year)	51.57 ± 12.43	49.50 (41.0 – 59.50)	56.67 ± 10.48	55.00 (47.0 – 66.0)	0.164
SE RE (D)	0.29 ± 1.55	0.00 (-0.38 – 1.25)	0.40 ± 1.23	0.25 (-0.50 – 1.25)	0.806
SE LE (D)	-0.11 ± 1.40	0.00 (-0.25 – 0.00)	-0.03 ± 0.80	-0.25 (-0.50 – 0.75)	0.540*
Addition RE (D)	2.10 ± 0.76	2.25 (1.50 – 2.75)	2.16 ± 0.65	2.25 (1.50 – 2.50)	0.781
Addition LE (D)	2.00 ± 0.71	2.00 (1.50 – 2.50)	2.22 ± 0.64	2.50 (1.50 – 2.50)	0.324
BCVA RE (LogMAR)	0.15 ± 0.32	0.00 (0.00 – 0.20)	0.00 ± 0.08	0.00 (-0.08 – 0.00)	0.010*
BCVA LE (LogMAR)	0.15 ± 0.58	0.00 (0.00 – 0.10)	0.11 ± 0.52	0.00 (-0.08 – 0.00)	0.099*

*Mann-Whitney U-test, SE: Spherical equivalent, RE: Right eye, LE: Left eye, D: Dioptre, Addition: Near addition, BCVA: Best-corrected visual acuity

Table 2 shows the mean monocular pupillary values for distance (DPD) and near (NPD) measured using the contact digital Pupillometer and non-contact digital device. On comparison, pupillary distances for both distance and near didn't show any significant difference between methods.

Table 2: Mean and standard deviations of monocular pupillary distance of study participants

	Optikam	**Digital PD meter**	**p-Value***
RE DPD (mm)	31.76 ± 2.26	31.44 ± 1.98	0.456
LE DPD (mm)	31.43 ± 1.73	31.10 ± 1.60	0.331
RE NPD (mm)	29.77 ± 2.07	29.05 ± 1.92	0.082
LE NPD (mm)	28.92 ± 4.16	28.85 ± 1.42	0.912

*Student t-Test, mm: Millimetre, RE: Right eye, LE: Left eye, DPD: Distance pupillary distance, NPD: Near Pupillary distance

Bland-Altman analysis was performed for both non-contact digital IPD measuring device and contact digital methods for the distance (Figure 3 A & B) and near IPD measurements for the right and left eyes respectively (Figure 3 C & D). The non-contact digital pupillometer showed an overall good agreement with the contact digital pupillometer. However, the lowest bias was for distance IPD in the right and left eyes (Figure 3 A & B). A low to poor agreement was shown for the near IPD in the right and left eyes (Figure 3 C & D).

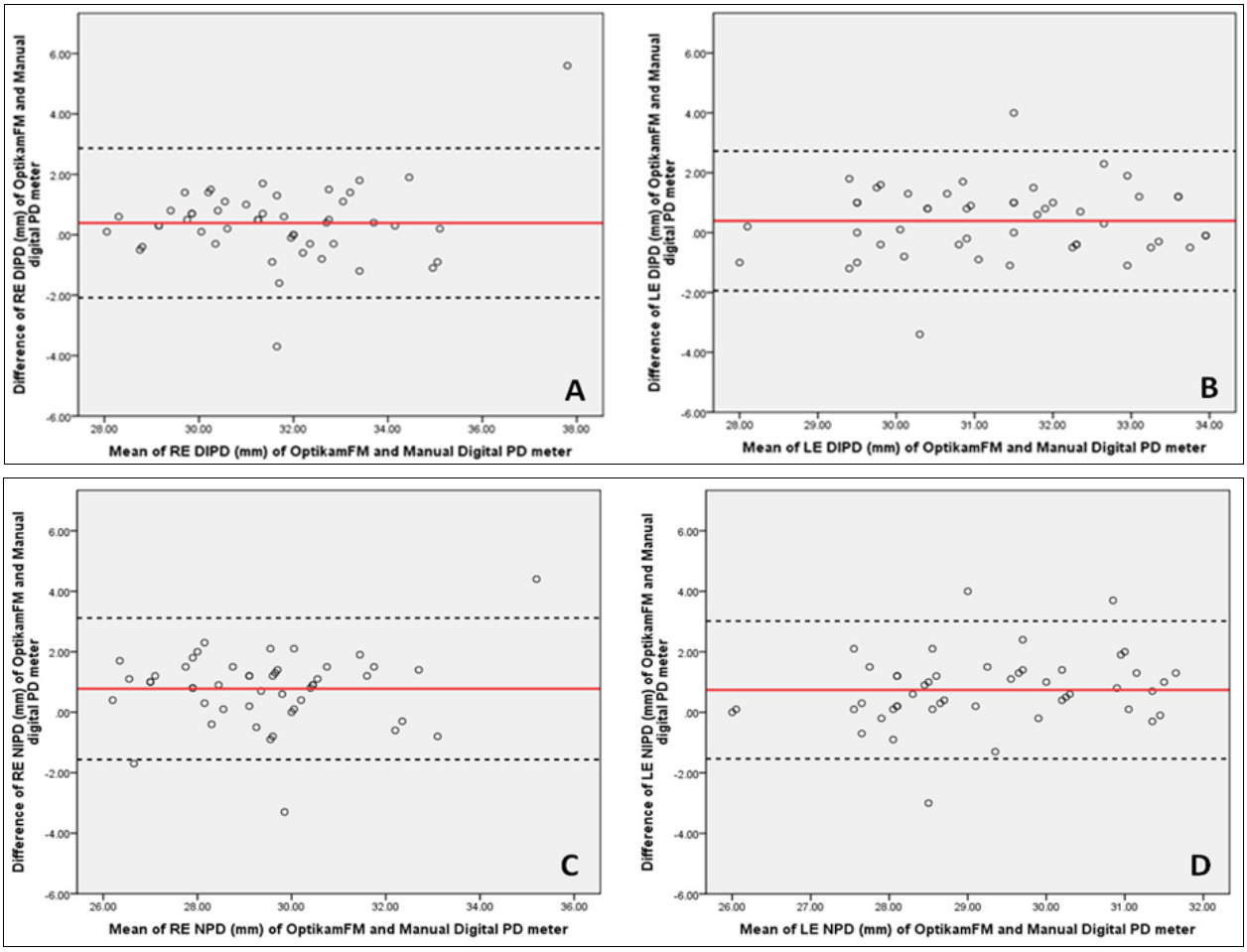

Fig 3: Bland-Altman plots show an agreement between Contact digital pupilometer and Non-Contact digital IPD measuring device for both distance and near PDs. A: Agreement for the distance for right eye, B: Agreement for the distance for left eye, C: Agreement for the near for right eye, D: Agreement for the near for left eye

Table 3: Correlation, agreement, and mean difference between Contact and Non-Contact methods of distance and near monocular PD

	Correlation		Bland and Altman Agreement				
	r_s	P	MD (mean ± SD)	MD + 1.96 SD	MD - 1.96 SD	% observations within clinical range	
						± 1.0 mm	± 1.5 mm
RE Distance PD (mm)	0.825	<0.00	0.39 ± 1.26	2.87	-2.08	67.3	87.8
LE Distance PD (mm)	0.740	<0.00	0.39 ± 1.19	2.73	-1.94	65.3	85.7
RE Near PD (mm)	0.821	<0.00	0.78 ± 1.19	3.12	-1.57	51.0	79.6
LE Near PD (mm)	0.728	<0.00	0.74 ± 1.16	3.02	-1.54	57.1	81.6

MD: Mean difference, RE: Right eye, LE: Left eye

Discussion

A good agreement was found for distance IPD between contact and non-contact digital methods. A low to moderate agreement was observed for near IPD between the methods. IPD measurements are an essential part of any spectacle dispensing process [1]. An incorrect IPD measurement will lead to unwanted prismatic effect, which may lead to visual discomfort to the wearers [1, 12]. Also, it may impact the binocular vision and stereopsis which are an important facet of the visual functioning [8]. Measuring IPD using contact digital pupillometer during the pandemic is quite challenging since it requires the examiner to go closer to the subjects. As Non-Contact digital IPD measuring device had a good agreement with contact digital pupillometer, this could be used as an alternate tool for measuring IPD especially in these challenging times. There is an increasing trend in spectacle purchase through online mode especially during these times [13]. The IPD measurements becomes a challenging task for online dispensers. Application like these can be incorporated along with frame selection module so that the spectacle dispensing based on their individual IPD values could be made possible.

Generally, it takes about approximately 2 minutes to complete the IPD measurements using contact digital pupillometer. However, it gives only the IPD measurement, whereas a non-contact digital pupillometer with one click, we are able to get the following measurements: Distance & Near Monocular IPD, Binocular PD for distance, Fitting Height, Frame Measurements (A Size, B Size and Distance between lenses: Distance between lenses), Pantoscopic Tilt, Wrap Angle, Eye Rotation Centre distance [10, 11]. However, the non-contact digital device does not allow us to change fixation from distance to near like a contact digital pupillometer. Another limitation of this study is small sample size in a hospital based population. Also, this study tested for only progressive addition lens wearers. This needs to be tested for other spectacle designs including distance single vision and bifocal.

Conclusion

The IPD measurements by the non-contact digital measuring device was comparable with the contact digital pupillometer. Non-contact digital IPD measuring device can be used as an alternate tool for measuring IPD especially in these challenging times.

List of abbreviations

IPD: Inter pupillary distance, PD: Pupillary distance, RE: Right eye, LE: Left eye, DPD: Distance pupillary distance, NPD: Near pupillary distance, SD: Standard deviation, IQR: Inter quartile range, BCVA: Best corrected visual acuity, D: Dioptre, mm: Millimetre, SE: Spherical equivalent, cm: Centimetre

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None

Ethics approval and consent to participate

The study was approved by the Institutional Review Board of Vision Research Foundation, Chennai, India. The study conformed to the tenets of the Declaration of Helsinki, and signed informed consent was obtained from all subjects.

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