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Original Article

Reliability and Validity of Video Centration Devices While Comparing with Clinical Interpapillary Distance Measurement

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Purpose: The purpose of this study was to investigate the reliability and validity of video centration devices when comparing with clinical interpapillary distance instruments.
Methods: There were sixty-three university students aged from 20 to 22 with no eye diseases, no strabismus or anisometropia, and also otherwise healthy conditions were recruited in the study. For the purpose of the present study, PD rule, pupilometer (Essilor), and video centration device (Rodenstock ImpressionIST) were operated by a licensed and experienced optometrist. Pearson correlation, ANOVA analysis, t-test, and linear regression were analyzed for explanations.
Results: PD ruler, Essilor pupilometer, and Rodenstock ImpressionIST all capture validity and reliability. The accuracy and validity of near PD measurement between PD rule and pupilometer were confirmed; but still existed minor difference between both instruments. Monocular PD measurements showed high correlations but no significant different between pupilometer and video centration devices. Results suggested that it would be concern with the settings of video centration devices system while examination. Linear regression analysis suggested that near and distance pupilometer values might effectively predict the data of video centration devices, cross comparison can avoid the human errors and instrument setting.
Conclusion: Clinical instruments are treasure for practical measurement by trained examiners, video centration devices apply another quality and repeatable option for comparing and systematical lens design. Since human errors in the study were still retaining less than 0.5mm, corresponding to the standard prescription, it needed to mention that the probability of human errors might be avoided as much as possible.

Keywords: interpupillary distance, pupilometer, video centration devices

1. Introduction

Inter-pupillary distance (IPD) is the distance between the centers of the pupils of two eyes. Besides binocular viewing system development, IPD is also critical for prescribing a pair of spectacles, lens power calculation and centration of focus are very important, especially for progressive additional lens prescription. Centration errors may result in visual asthenopic problems, stereoscopic quality vision decrease and usable zones of presbyopic reading lenses reduction (1-4). In addition, IPD value also play a key role in prescribing lens prescription and treating abnormal binocular vision, AC/A ratio (accommodative convergence/accommodation), and the amount of

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binocular convergence, or prism prescription (5, 9, 21, 22, 23) are the good examples.

Binocular IPD includes distance and near values, monocular PD indicates right eye and left eye PD. Clinical techniques contains PD-ruler, pupilometer and video centration device (10-14). Two main methods of video centration device are measuring clip and two-camera 3D video centration system (17-20). Although video centration device required more funding and more time than other centration techniques, it could match all the relevant centration parameters, such as frame to cornea distance, pantoscopic tilt of frame, back vertex distance, fitting height, Frame wrap angle, and etc. By auto-photo via high-technique computerize and commercial consulting system, the accurate of video centration device might up to 0.1mm (15-16, 21, 22).

Overall, the purpose of this study was to investigate the validity and reliability of video centration devices when comparing with clinical inter-pupillary distance instruments. In other words, the correlation and difference between PD ruler, pupilometer, and video centration devices were then analyzed.

2. Methodology

There were Sixty-three university students aged from 20 to 22 with no eye diseases, no strabismus or anisometropia, and also otherwise healthy conditions were recruited in the study. For the purpose of the present study, PD rule, pupilometer (Essilor), and video centration device (Rodenstock ImpressionIST) were operated by a licensed and experienced optometrist. Near (40 cm) and distance Interpupillary Distance (IPD), right eye and left eye monocular pupillary Distance(PD) were measured in a random order, and repeated the same measurements and the same sequences one week later from the first visit. This study complied with the Declaration of Helsinki as a statement of ethical principles to provide guidance to physicians and other participants in medical research involving human subjects and had reviewed by CSMUH IRB(CS19110). Data were then analyzed for Pearson correlation, ANOVA analysis, t-test, and linear regression by using the SPSS 24 package (IBM, USA)

2-1. PD Rule

A licensed and Experienced optometrist sat opposite to the participants, and had the participant fixate his or her right eye on the examiner's left eye. Using a penlight to have the pupil light-spot, and using a millimeter PD rule placed parallel to the floor on the bridge of the participant's nose, the top edge of the rule was located midway along the vertical meridian of the pupil and the location on the rule associated with the nasal limbus was identified. The subject was then asked to fixate the left eye on the examiner's right eye. The position of pupil light reflecting points on PD scale was recorded. Near PD were then examined when the gazing target turned to 40 cm.

2-2. Pupilometer

Pupilometer was used by one trained examiner only and served as the gold standard or referent for these experiments. The instrument was place down the bridge of the nose of the participant and following the manufacturer's instructions, the examiner located the first Purkinje corneal reflex to assess binocular distance PD, near PD were then examined, too.

2-3. Rodenstock ImpressionIST

The video centration devices (Rodenstock ImpressionIST) captured two images with two cameras, one camera looked at the face from the front and the other from the below and the side, patients just need to be properly positioned only once. The camera was set to a fixed distance, and the direction of gaze was also pre-adjusted. After setting up the device, (1) ask patients stand in front and keep 75 cm away from the device without any prescription, (2) adjust the height of ImpressionIST to form patients' image on the center of the screen. (3) Touch the panel to be autofocus and photo, then check the light and pupil if matched. (4) Take the values of distance PD, right and left eye PD.

3. Results

3-1. Instruments Reliability

The repeatability of PD rule, pupilometer, and video centration devices were shown in Table 1. Statistical results presented that all three instruments

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Table 1. Repeatability --1st and 2nd comparison about three PD Instruments

Measurement	Means difference	Standard Deviation	t	Sig	Correlation
PD rule (distance)	0.43	1.27	2.78*	0.007	0.94**
Pupilometer (distance)	0.06	0.87	-0.43	0.667	0.97**
Pupilometer (distance) -- right eye	0.01	1.05	-0.06	0.952	0.87**
Pupilometer (distance) -- left eye	0.01	0.88	-0.71	0.943	0.88**
video centration devices (distance)	0.08	0.53	-1.19	0.237	0.99**
video centration devices (distance) -- right eye	0.02	0.97	0.181	0.857	0.91**
video centration devices (distance) -- left eye	-0.10	0.88	-0.904	0.370	0.91**
PD rule (near)	0.14	1.08	1.05	0.297	0.95**
Pupilometer (near)	0.16	0.97	-1.29	0.207	0.96**
Pupilometer (near) -- right eye	0.09	0.84	-0.825	0.413	0.90**
Pupilometer (near) -- left eye	0.06	0.75	-0.664	0.509	0.91**

* $p<0.05$ **$p<0.01$

had highly reliability between test 1st and re-test 2nd at distance (PD rule: $r=0.94$, $p<0.001$, pupilometer: $r=0.97$, $p<0.001$, and video centration devices: $r=0.99$, $p<0.001$) and at near (PD rule: $r=0.95$, $p<0.001$, pupilometer: $r=0.96$, $p<0.001$), so as to monocular PD measurements. However, PD rule was relatively subjective that might have more obvious disparities ($t=2.77$, $p=0.007$) between test 1st and re-test 2nd which might result from participants' fixation point or personal reasons. The test and re-test repeatability analysis was not shown significant difference in right eye and left eye, and either at distance or at near PD measurements.

3-2. Instruments Validity

The validity of distance PD measurements between PD rule, Pupilometer, and video centration devices were shown in Table 2. Results showed the means and standard deviation of three instruments were: PD rule (63.09±3.24), Essilor Pupilometer (63.21±3.59), and Rodenstock ImpressionIST (63.40±3.78), although Pearson correlation indicated high correlation between three measurements, t-test analysis showed that the values of video centration devices was significant higher than PD ruler and Pupilometer (Table 2), The research inference is due to the use of mirror photography for video centration

Table 2. Correlation and t-test analysis between three PD Instruments

	r	Sig	t	Sig
PD ruler - Pupilometer (distance)	.963**	.000	-.950	.346
PD ruler - video centration devices(distance)	.964**	.000	-2.316*	.024
Pupilometer - video centration devices(distance)	.983**	.000	-2.181*	.033
PD ruler – Pupilometer (near)	.963**	.000	5.005**	.000
Pupilometer - video centration devices (right eye)	.728**	.000	-.008	.994
Pupilometer - video centration devices (left eye)	.755**	.000	-.837	.406

* $p<.05$ **$p<.001$

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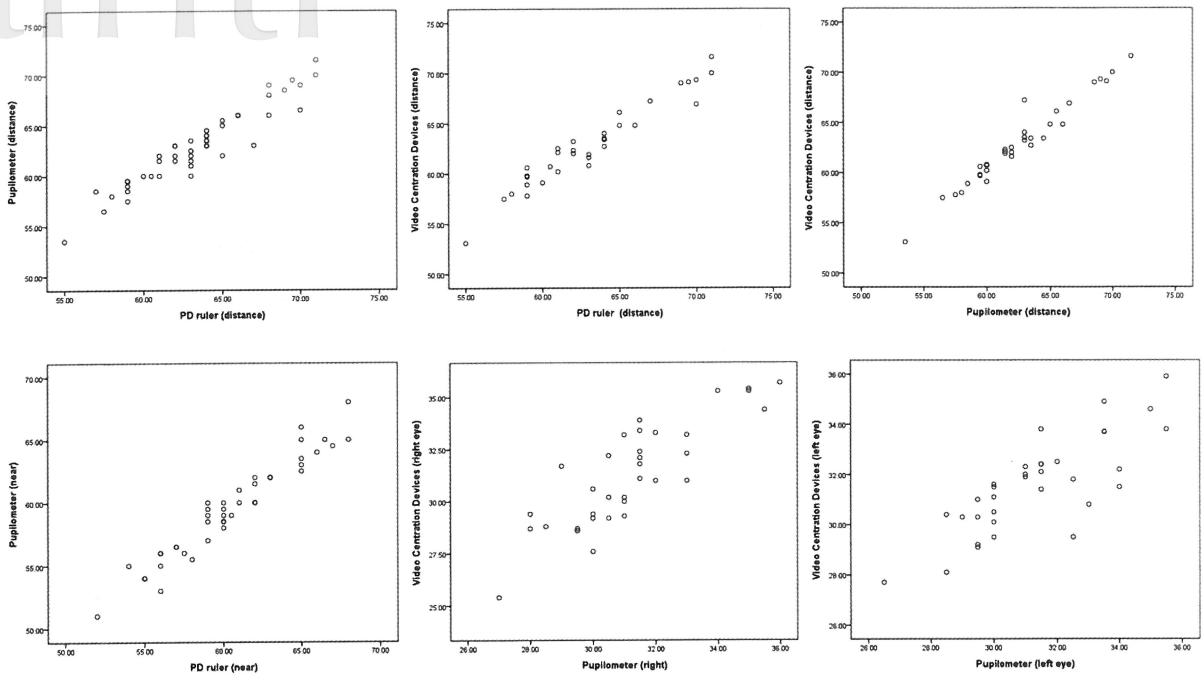


Figure 1. Correlation between three PD Instruments

devices, which has better control of parallelism of the long-distance visual axis and finer calculation units.

The validity of near PD measurements, because video centration devices takes distance PD only, the means and standard deviation of near PD measurement were: PD rule (60.39±3.40) and pupilometer (59.62±3.40), highly correlation (r=0.963, p=0.000) and significant difference (t=5.005, p=0.000) also shown in the study; that meant the accuracy and validity of near PD measurement between PD rule and pupilometer were confirmed; however, difference still existed between both instruments. Optometrists or opticians need to proceed functional assessment while prescribing. The result also mentioned the probability of human errors might be avoided as much as possible.

In addition, monocular PD measurements were only useful with pupilometer and video centration devices. High correlations (right PD: r=0.728, p=0.000; left PD: r=0.755, p=0.000) but no significant different between both instruments (right PD: t=-0.008, p=0.994; left PD: t=-0.837, p=0.406). A novel finding was that the correlation between pupilometer right eye and video centration devices right eye showed lower correlated coefficient than pupilometer right eye and video centration devices left eye (r=0.882, p=0.000) or pupilometer left eye and video centration devices right eye (r=0.897, p=0.000). It would be concern with the settings of video centration devices system.

Moreover, it was important to mention that the difference between distance and near PD measurement. Results showed significant difference between PD ruler (distance PD - near PD= 3.00±0.79) and pupilometer (distance PD - near PD= 3.70±1.08). Clinically, the PD difference between near and distance is often calculated according to the triangle formula, according to which the difference between PD58-68mm is about 4mm, the experience is derived from the distance PD to infer the near PD value. The study found that the value of distance and near PD difference between PD rule and pupilometer showed significantly difference (t=-2.342, p=0.024). There were 91.5% of PD ruler and 81% of pupilometer, distance and near PD difference were within 4mm corresponding to the calculation formula estimate (Table 3). Linear regression analysis suggested that near and distance pupilometer values might effectively predict the data of video centration devices, The VIF

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Table 3. distance and near PD difference between PD rule and pupilometer

	PD rule	Distance-Near	Pupilometer	Distance-Near
	N	%	N	%
Within 4mm	43	91.5	34	81.0
Over 4mm	4	8.5	8	19.0

Table 4. Linear regression analysis with video centration devices as dependent parameter

Model		B	SE	β	T	Sig	VIF
1	content	2.651	2.601		1.019	0.317	
	Pupilometer(Near)	1.019	0.044	0.976	23.307	0.000	1.000
2	Content	0.402	1.809		0.222	0.826	
	Pupilometer(Near)	0.532	0.090	0.510	5.893	0.000	9.255
	Pupilometer(Distance)	0.495	0.087	0.494	5.705	0.000	9.255

value between the independent variables were also acceptable (Table 4).

4. Conclusion

PD ruler, Essilor pupilometer, and Rodenstock ImpressionIST are all capture validity and reliability, clinical instruments are treasure for practical measurement by trained examiners, video centration devices apply another quality and repeatable option for comparing and systematical lens design. Video centration devices are more accurate (up to 0.1mm), and have higher repeatability. In addition to the application of measuring interpupillary distance, there are also eye height, tilt angle, vertex distance, surface shape factor, frame factor, and high-level that are all important parameters for the visual efficiency when the lens are fitted. Cross comparison can avoid the human errors and instrument setting.

5. Discussion

With the development of higher-order lenses, the parameters precision for prescribing lenses are getting more and more effective, by the way, PD measurement tools are also changing with each passing day. The principle of PD measurement is often applied to the pupil reflection, which is related to the cornea light reflection point crossing the optic axis and the corneal pupil axis, that is about 3-5 degrees to the nasal. In the science of measurement, there are many clinical concerns, such as tool accuracy, repeatability and reproducibility. Clinical consideration, PD measurement is correlated with many variances, such as age, gender, race, eye anatomy and physiology (pupil size, heterophoria, esophoria, exophoria, and eye movement (23)). Even if the results of this study showed the difference between distant and near PD which was more than 4 mm predicted by the formula, the study showed 8.5% and 19.0% statistical distribution in PD rule and pupilometer, respectively. Moreover, lens decentration might create a prism effect according to Prentice's rule, and even lead to many visual symptoms (24, 25). As we know the interaction between prism diopter, accommodation, phoria, and myopia progression, will lens decentration induce longer axial length and worse myopia, that need more and further evidence to confirm.

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