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Comparison of the VISX wavescan and OPD-scan III with the subjective refraction

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Abstract. – OBJECTIVE: To compare the refractive errors measured by the VISX WaveScan, OPD-Scan III and the subjective refraction. The optometry accuracy of computer operated aberrometer used before refractive surgery has been debatable. Hence, a clear study on the role of such automated equipment in optometry is the need of the hour as compared to subjective refraction.

PATIENTS AND METHODS: Seventy-six patients (152 eyes) were recruited from January 2013 to December 2013. All patients were measured with subjective refraction by the phoropter (NIDEK, RT-5100), objective refraction by the WaveScan (AMO Company, USA), OPD-Scan III (Nidek Technologies, Japan). The sphere, cylinder, axis of the three methods were compared and analyzed.

RESULTS: The diopter of sphere power measured by WaveScan was lower than that of the subjective refraction and the difference was 0.13 ± 0. 30D (t = 3. 753, *p* <0. 001). While the diopter of cylinder power was higher and the difference was 0.13 ±0.43D (t = 3. 664, *p* <0. 001). There was no significance for sphere, cylinder and spherical equivalent between OPD-Scan III and subjective refraction (*p* >0. 05). The value of the difference between WaveScan and subjective refraction was 5.87°±6.19°on average, while the difference between OPD-Scan III and subjective refraction was 3.82°±3.95°on average. The differences between the two were statistically significant (t =2. 817, *p* =0. 006).

CONCLUSIONS: The results of sphere and cylinder measured by WaveScan and subjective refraction were different. As the latest integrated equipment, the Nidek OPD-Scan III gives a more accurate measurement of objective refraction when compared with subjective refraction. The latest Nidek OPD-Scan III may prove to be an useful tool for preoperative optometry deviation based on objective refraction.

Key Words:
WaveScan, OPD-Scan III, Subjective refraction, Optometry.

Introduction

After the clinical practice and continuous technological innovation over the years, refractive surgery has been proven to be a safe and effective method to correct refractive errors. However, there are still some patients with residual diopters of refractive errors[1-3], as for the reason; the preoperative optometry deviation is one of the factors that cannot be ignored. Currently, the optometry methods before refractive surgery contain subjective refraction and objective refraction. Subjective refraction includes integrated refractor (or manifest refraction) and trial lenses for refraction; while objective refraction includes computer automated optometry and retinoscopy[4-6].

In recent years, the WaveScan widely used in a clinical setting can not only measure higher-order aberrations, but also measure the diopters of refractive error, which also belongs to the objective optometry. The WaveScan and OPD-Scan are the aberrometer frequently used in clinical setting. The optometry accuracy of WaveScan has been analyzed by several studies in China and other parts of the world, but the results are inconsistent[7,8].

OPD-Scan III is the latest device of the OPD-Scan system, which has integrated[9] multiple functions of aberration, curvature of the cornea, corneal topography, optometry, pupil analysis, etc. As a new device, the accuracy of its multiple measurement functions has not been fully clinically proven. This paper, thus, presents a comparative study on the measurement accuracy of refractive errors by OPD-Scan III, WaveScan and the subjective refraction.

Patients and Methods

Patients

Seventy-six patients (152 eyes), who were admitted in laser treatment center for myoporthosis from January 2013 to December 2013 were selected randomly. There were 32 males and 44 females aged from 18-42 years (24.7±4.5). All the patients had myopia or myopic astigmatism complex, excluding other eye diseases or systemic di-

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sease and the best corrected visual acuity (BCVA) of all the patients was ≥5.0.

Subjective Refraction

Integrated refractometer (NIDEK, Gamagori, Aichi, Japan; RT-5100) was used for refraction. The main steps include scieropia, red and green test, cross-cylinder, binocular balance, etc.

WaveScan check

WaveScan aberrometer (AMO Company, Tampa, FL, USA) was used to check for objective refraction. The check was performed in a darkroom. The head position of the patient was placed properly so that they looked straight ahead and it was ensured that no eyelashes or eyelid occlusions were present and there was an intact tear film. The inspection process was performed in accordance with operational processes. Every eye was checked several times. After three measurements, values with high repeatability were saved and selected, the measurement result with the best image quality was selected as the WaveScan aberrometer refraction result based on image quality.

OPD-Scan III check

OPD-Scan III (Nidek Technologies, Japan) was used to perform the check in the darkroom. Patients were asked to widen the eyelids as much as possible so as to expose the cornea and the whole pupils. Also, it was ensured that tear films were intact at the same time and the checks performed several times. Placido image with one of the best qualities was selected as the refraction results. All of the above refraction methods were performed by the same experienced staff.

Statistical Analysis

All the statistical analyses were carried out using the SPSS version 19. 0 The paired sample t-test was applied for the comparison of the measurement data and the χ^2 test was applied for the comparisons of enumeration data. If p <0.05, the differences were considered as statistically significant.

Results

Comparisons of the results measured by WaveScan, OPD-Scan III and subjective refraction

The data of sphere, cylinder and spherical equivalent measured by WaveScan, OPD-Scan III and subjective refraction are as shown in Table I. Statistical analysis showed that the diopters of spherical power measured by WaveScan optometry were lower than the subjective refraction. The differences were 0.130 ±0.30D, which was statistically significant (t = 3. 753, p <0.001). The cylinder diopters were relatively high. The differences were 0.130±0.43D, which was statistically significant (t = 3.664, p <0.001). The differences of spherical equivalent were not statistically signficant (t = 1.881, p =0.082). The differences on sphere, cylinder and spherical equivalent measured by OPD-Scan III and subjective refraction were not statistically significant (p >0.05).

Comparisons on the differences of cylinder diopters measured by WaveScan, OPD-Scan III and subjective refraction

The ratios of eyes number, whose differences of spherical diopters measured by WaveScan, OPD-Scan III and subjective refraction were within ±0.25D, accounted for 57.9%, 75.0% respectively and the differences between the two were statistically significant (χ^2 = 4.987, p =0.026). The ratios of eyes number, whose differences were within ±0.50D and ± 1.00D between the two were not statistically significant (χ^2 =0.315, p =0.575; χ^2 = 2.027, p =0.155). As for cylinder diopters, the ratio of eyes number, whose differences were within ±0.25D accounted for 69.7%, 90.8% respectively and the differences between the two were statistically insignificant (χ^2 = 10.632, p =0.001). The

Table I. Comparison of cylinder diopters between WaveScan and OPD-Scan III[1].

Measurement indicators	WaveScan	OPD-Scan III	Subjective refraction	t_1	p_1	t_2	p_2
Sphere	-3. 28±1. 31	-3. 46±1. 22	-3. 41±1. 27	3. 753	0. 000	1. 288	0. 202
Cylinder	-0. 99±0. 82	-0. 88±0. 83	-0. 86±0. 86	3. 664	0. 000	0. 081	0. 935
Spherical equivalent	-3. 78±1. 18	-3. 90±1. 13	-3. 84±1. 19	1. 881	0. 082	1. 167	0. 247

t_1, p_1 represent the test value when WaveScan is compared with subjective refraction; t_2, p_2 represent the test value when OPD-scan III compared.

Table II. Comparison of difference between cylinder diopters of WaveScan and OPD Scan III.

Optometry method	Sphere			Cylinder		
	±0.25D	±0.50D	±1.00D	±0.25D	±0.50D	±1.00D
WaveScan	88 (57.9)	140 (92.1)	152 (100)	106 (69.7)	142 (93.4)	152 (100)
OPD-Scan III	114 (75.0)	136 (89.5)	148 (97.4)	138 (90.8)	150 (98.7)	152 (100)
$\chi 2$	4.987	0.315	2.027	10.632	2.776	-
p	0.026	0.575	0.155	0.001	0.096	-

t_1, p_1 represent the test value when WaveScan is compared with subjective refraction; t_2, p_2 represent the test value when OPD-scan III compared.

ratios of eyes number, whose differences were within ± 0.50D and ± 1.00D between the two were not statistically significant (χ^2 = 2.776, p =0.096) (Table II).

Comparisons on concave-cylinder axial degree measured by WaveScan, OPD-Scan III and subjective refraction

The mean differences of axial degree measured by WaveScan and subjective refraction were 5.87°±6.19°, while the mean difference between OPD-Scan III and subjective refraction was 3.82°±3.95°. Compared to WaveScan, the axial degree measured by OPD-Scan III was closer to the result of subjective refraction and the difference between the two were statistically significant (t = 2.817, p =0.006). The ratios of eyes number, whose differences of axial diopters measured by WaveScan, OPD-Scan III and subjective refraction were within 5°, accounted for 61, 8%, 69.7%, respectively. The difference between the two ratios was statistically significant (χ^2 = 8.423, p = 0.004). The ratios of eyes number, whose differences were within 10°, accounted for 78.9%, 97.4% respectively and the differences between the two ratios were also statistically significant (χ^2 = 12. 352, p <0. 001) (Table III).

Discussion

Currently, objective refraction method (computer or retinoscopy method) is being usually applied to identify the diopters of patients initially in the optometric process before the refractive surgery, whereas integrated refractometer is applied in subjective refraction to adjust the results of objective refraction precisely. Objective optometry has the advantages of quick speed, high repeatability, but is prone to be influenced by the performance of the equipment and the operation of the examiner. As the "gold standard" of the optometry, subjective refraction result is the closest to the visual requirements of the patients, but it is easily influenced by the psychological state of the patient and the experience level of the examiner. Thus, different examiners may yield different refraction results[10].

The emergence of WaveScan is a great advancement in the field of refractive surgery in recent years, which can not only measure higher-order aberrations but also measure the patient's refractive diopters. As for some complex refractive errors (irregular astigmatism), WaveScan examination has certain advantages. The refractive diopter of WaveScan is the vital reference to determine the pre-distortion degree of refractive surgeries for customized ablation. The treatment parameters, such as a cylinder, an axial degree, etc., cannot be revised manually[11,12] in the customized ablation guided by some devices like Zywave, WaveScan aberrometer, which can only be determined by aberration measurement results. Therefore, the accuracy of optometry degree directly determines the surgical effect of individual treatment. There have been numerous reports[13-15] about the accu-

Table III. Comparison on concave-cylinder axial degree measured by WaveScan and OPD-Scan III.

Concave-Cylinder axial	WaveScan	OPD-Scan III	X^2	p
±5°	94 (61.8)	106 (69.7)	8.423	0.004
±10°	120 (78.9)	148 (97.4)	12.352	0.000
±15°	138 (90.8)	152 (100)	7.338	0.007

racy degree of refractive errors measured by different types of wave-front aberrometer, but some reports have had inconsistent results. WaveScan and OPD-Scan are the two kinds of frequently used aberrometer. Kim et al[8] found that the spherical and cylinder degrees measured by WaveScan were highly consistent with the results of subjective refraction[8]. Perez-Straziota et al[16] also found that the measurement results of WaveScan had no significant difference from subjective refraction. Feng et al[7] revealed that the spherical diopters of WaveScan optometry were lower than subject refraction and the cylinder diopter was also lower. It was also found in this study that the spherical diopters of WaveScan optometry were lower than subject refraction with 0.13D on average and the cylinder diopters were higher with 0.13D on average. Based on the analysis, the data above was from the patients receiving refractive surgery correction whose age was different between patients in China and other parts of the world. The age of the non-Chinese patients was usually older than Chinese patients. In the studies of Kim and Claudia, the average age of the patients was 35 to 37 years, while the average age of patients studied by Feng et al[7] in China was 24.9 years, which was very close to the average age of patients in the current study (24.7 years).

In China, for some special needs of army enrollment and school admission, the refractive diopters of some of the younger patients may not be stable when receiving refractive surgeries. Mild overcorrection of diopters of some patients may occur before subjective refraction to prevent postoperative myopia again, thus leading to diopters of subjective refraction in domestic research being slightly higher than that of the WaveScan measurement.

Kim et al[8] found that the cylinder diopters measured by OPD-Scan were higher than the results of WaveScan and subjective refraction and the spherical diopters were the same[8].

Nissman et al[17] and Pesudovs et al[18] also found that the results of refractive error diopters measured by OPD-Scan were highly consistent with the subjective refraction results. With the application of the latest device OPD-Scan III, it was found in the study of McGinnigle et al[9] that the spherical diopters measured by OPD-Scan were higher than that of subjective refraction with 0.19D and the cylinder diopters had no significant difference. This study found no significant difference between spherical, cylinder and spherical equivalent diopters measured by OPD-Scan III and subjective refraction.

As for cylinder axial diopters, the measured results of OPD-Scan III were closer to the results of subjective refraction of WaveScan. The difference between OPD-Scan III and WaveScan were that the results of subjective refraction (including sphere, cylinder and axis position) could replace the measurement results of OPD-Scan III when aberrations guided customized ablation was performed, while when it was guided by WaveScan, the results of subjective refraction could be applied as the sphere and cylinder diopters but spherical axis diopters could only be measured by the latter instrument itself. Therefore, when the difference of spherical and axial diopters measured by subjective refraction and WaveScan are large, it is necessary to compare the corrected vision of patients under both measurement results. If the corrected vision of patients is poor under the measurement result of WaveScan, the WaveScan-guided customized ablation surgery should be considered of being abandoned.

Conclusions

We have found differences in refractive errors measurement of WaveScan and OPD-Scan III. The difference of spherical and axial diopters between subjective refraction and WaveScan-guided customized ablation should be paid attention to before any further action is taken. As the latest integrated equipment, OPD-Scan III is highly accurate on optometry degrees. But, a multicenter study with a large sample size is needed to validate further the result.

Conflicts of interest

The authors declare no conflicts of interest.

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