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A comparative study between manifest, cycloplegic and wavefront refraction in myopia

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Aim. to compare between manifest, cycloplegic and wavefront refraction in different grades of myopia.

Methods. 100 myopic eyes were included. The data collected included: age, sex, manifest refraction, cycloplegic refraction, wavefront refraction and pupil diameter. Manifest refraction was acquired by autorefractometer (NideK). Cycloplegic refraction was acquired after applying cyclopentolate eye drops 1% for an hour. Wavefront refraction was acquired by the iDesign aberrometer (Hartmann Shack Aberrometer) (Visx, USA) using a 32 × 32 lenslet array and near infra-red light with a wavelength of 780 nm.

Results. The study showed that the wavefront refraction using the iDesign aberrometer (Hartmann-Shack aberrometer) gives higher values for each of sphere, cylinder and spherical equivalent followed by the manifest autorefraction using the Nidek autorefractometer and lastly cycloplegic refraction in all grades of myopia.

Conclusions. Regarding the three methods of refraction (manifest, cycloplegic and wavefront), our results showed that the wavefront refraction acquired by the iDesign aberrometer (Hartmann Shack Aberrometer) shows higher values for each of sphere, cylinder and spherical equivalent, followed by manifest refraction acquired by autorefractometer (NideK) and lastly cycloplegic refraction in all grades of myopia.

Introduction

The imprecision in determining accurate refraction provokes a number of problems in daily clinical routine, especially when planning refractive correction with spectacles or contact lenses. Moreover, if the purpose of evaluation is to plan a surgical refractive correction, the accuracy in doing so is crucial to minimize the need for enhancement procedures.[1] Manifest refraction, in terms of spectacle sphere and cylinder, is a "traditional" subjective way of assessing the eye's refraction and is still considered the gold standard.[2] Subjective cycloplegic refraction, in which the ciliary body is paralyzed and therefore in a completely relaxed state, is usually performed in younger patients or in hyperopic patients, where a significant amount of accommodation is expected, yielding more positive values for refraction when compared to the manifest refraction.[3]

With technological advancements in recent years, increased efforts have been invested in developing objective autorefractors with the intention of either complementing, or eventually substituting, the manual refraction process.[4] The recent surge of wavefront sensors, which can measure all of the eye's aberrations, are an additional source used to objectively determine sphere and cylinder.[5] These wavefront sensors are considered precise in the determination of the eye's refractive state, and a comparison with subjective refraction leads to the question of whether the "gold standard" is less reliable than the wavefront measurement.[2] In the normal population, the aberrometry based "auto-refraction" has been found to match well with subjective refraction.[2,6,7] The aberrometry auto-refraction is derived using an appropriately tilted sphero-cylinder that compensates for the best fitting wavefront across all the measured monochromatic aberrations.[2]

The most common type of aberrometer used in clinical research is based on the Hartmann-Shack principle.[8,9]

The aim of our study was to compare between manifest, cycloplegic and wavefront refraction in different grades of myopia.

2. Patients and Methods

- Study Setting:

Laser Eye center for refractive surgery in Sohag.

-Type of study:

Comparative observational retrospective analytical study.

-patients:

Inclusion criteria:

Age : 18 – 40 years old

Refraction:

All grades of myopia were included:

(According to mainifest refraction)

- low ([0] – ≤ [-3] diopters)
- Moderate ([-3] – ≤ [-6] diopters)
- High ([-6] – [-10] diopters)

With cylinder ≤ [-1.5] D

Exclusion criteria: Any ocular surgery or medication, corneal opacities, pregnancy, lactation and keratoconus.

-methods of the study:

100 myopic eyes were included. The data collected included: age, sex, manifest refraction, cycloplegic refraction, wavefront refraction and pupil diameter. Data collected from January 2016 to july 2017.

A slit lamp bio-microscope examination was conducted for all cases to exclude any ocular surgery or corneal opacities. Also fundus examination and intra-ocular pressure measurement were performed.

Manifest refraction was acquired by autorefractometer(NideK) 3 times trial and best corrected visual acuity was acquired. A monocular subjective refraction was performed on all subjects to an accuracy of ±0.25 D for sphere and cylinder powers. The maximum plus lens accepted whilst maintaining optimal visual acuity was used to arrive at the endpoint refraction. The endpoint refraction was checked with a +1.00 DS blur test.

Cycloplegic refraction was acquired after applying cyclopentolate eye drops 1% for an hour.

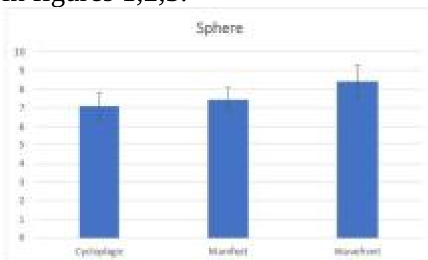
Wavefront refraction was acquired by the iDesign aberrometer(Hartmann Shack Aberrometer) (Visx, USA) using a 32 × 32 lenslet array and near infra-red light with a wavelength of 780 nm. All aberrometry measurements were made within 2 mins of completing the subjective refraction routine and pupil size measurements. Wavefront errors were recorded under monocular conditions with the room lighting switched off.

The protocol is approved by the ethical committee of Sohag Univerity Hospital and follows the tenets of Helsinki Declaration.

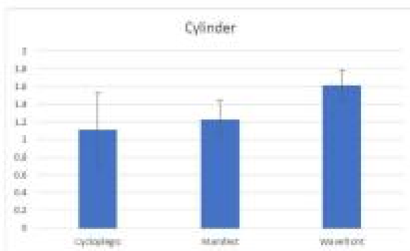
Results

Results of the high myopia group:

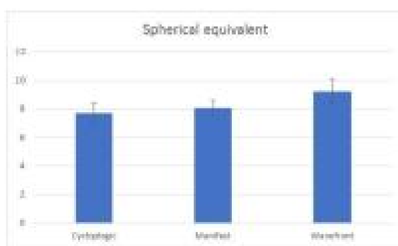
In the high myopia group, comparing the three methods (cycloplegic, manifest and wavefront) shows that wavefront method shows higher values for each of sphere, cylinder and spherical equivalent (SE), followed by manifest and lastly cycloplegic method. The difference was statistically significant for all of the above comparisons with the exception of manifest versus cycloplegic methods regarding cylinder assessment, which was non significant. These results are summarized in figures 1,2,3.



(Figure 1): The results of the high myopia group in sphere regarding the three methods of refraction (manifest, cycloplegic and wavefront).



(Figure 2): The results of the high myopia group in cylinder regarding the three methods of refraction (manifest, cycloplegic and wavefront).

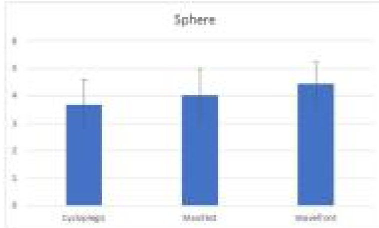


(Figure 3): The results of the high myopia group in SE regarding the three methods of refraction (manifest, cycloplegic and wavefront).

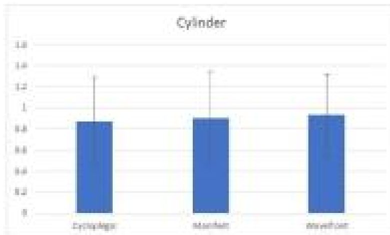
Results of the moderate myopia group:

In the moderate myopia group, comparing the three methods (cycloplegic, manifest and wavefront) shows that wavefront method shows higher values for each of sphere, cylinder and SE, followed by manifest and lastly cycloplegic method.

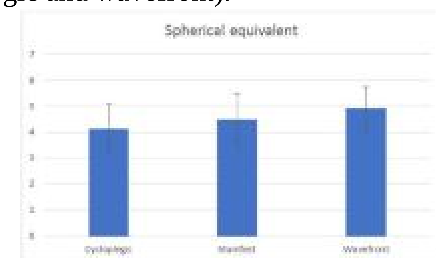
The difference was statistically significant for sphere and SE, while non significant for cylinder. Figures 4,5,6 summarize these results.



(Figure 4): The results of the moderate myopia group in sphere regarding the three methods of refraction (manifest, cycloplegic and wavefront).



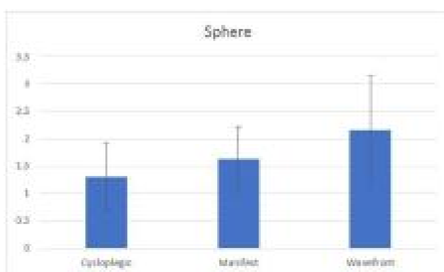
(Figure 5): The results of the moderate myopia group in cylinder regarding the three methods of refraction (manifest, cycloplegic and wavefront).



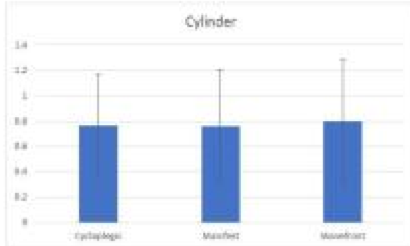
(Figure 6): The results of the moderate myopia group in SE regarding the three methods of refraction (manifest, cycloplegic and wavefront).

Results of the low myopia group:

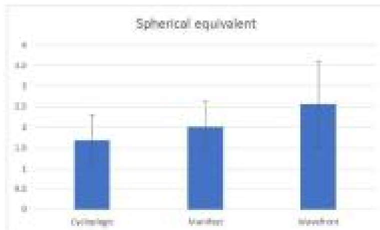
In the low myopia group, comparing the three methods (cycloplegic, manifest and wavefront) shows that wavefront method shows higher values for each of sphere, cylinder and SE, followed by manifest and lastly cycloplegic method. The difference was statistically significant for sphere and SE, while non significant for cylinder. Figures 7,8,9 summarize these results.



(Figure 7): The results of the low myopia group in sphere regarding the three methods of refraction (manifest, cycloplegic and wavefront).



(Figure 8): The results of the low myopia group in cylinder regarding the three methods of refraction (manifest, cycloplegic and wavefront).



(Figure 9): The results of the low myopia group in SE regarding the three methods of refraction (manifest, cycloplegic and wavefront).

Spherical equivalent (SE) ± 0.25 difference:

- Comparing the wavefront and manifest methods, the percentage of SE difference ± 0.25 D in high, moderate and low myopia groups was 0%, 25% and 21.2% respectively.
- Comparing the wavefront and cycloplegic methods, the percentage of SE difference ± 0.25 D in high, moderate and low myopia groups was 0%, 10% and 0% respectively.
- Comparing the manifest and cycloplegic methods, the percentage of SE difference± 0.25 D in high, moderate and low myopia groups was 33.3%, 45% and 57.6% respectively.

Discussion

Compared with traditional autorefractors, there is a tendency for some wavefront aberrometers to over minus refractions owing to instrument myopia[10,11] and therefore the results may not be as accurate.[12] Cylindrical refraction also shows increased variability with wavefront aberrometers.[13]

Our study showed that the wavefront refraction using the iDesign aberrometer (Hartmann-Shack aberrometer) gives higher values for each of sphere, cylinder and spherical equivalent followed by the manifest autorefraction using the Nidek autorefractometer and lastly cycloplegic refraction in all grades of myopia.

Nayaket al.[14] studied a comparison of cycloplegic and manifest refractions on the Nikon Auto Refractometer NR-1000F (AR). The manifest and cycloplegic refractions of 50 eyes of 25 patients aged 8 to 28 years were studied. The results showed that the fixation target in the NR-1000F induces significant instrument myopia during manifest refraction in the younger patients with lower refractive errors.

Rotsos et al.[15] study was conducted to compare the accuracy of readings of the RMA-3000 autorefractometer (Topcon, Tokyo, Japan) with traditional retinoscopy as a means of determining the approximate subjective refraction in children after cycloplegia. Results of this study showed that from 69 right eyes with negative sphere, the sphere power was significantly higher (more than 0.5 diopters) in autorefraction (AR) than in cycloplegic autorefraction (ARC) and retinoscopy (RC). From the 73 normal and hyperopic right eyes the sphere power was significantly lower (more than 0.5 diopters) in AR than in ARC and RC. The study concluded that the use of the autorefractometer in children (in whom accommodation is more active than older patients) without cycloplegia may underestimate the actual hyperopia and overestimate the actual myopia.

The results of these studies may correlate with the results of our study in that the manifest autorefraction (AR) gives higher values than cycloplegic refraction in myopia and this may be attributrd to instrument myopia.

Jung et al[16] compared the measurements of refractive errors and ocular aberrations obtained using iDesign and WaveScan (Abbott Medical Optics, Inc., Santa Ana, CA). Ninety myopic eyes of 45 normal patients were evaluated using both the iDesign and WaveScan to measure spherical and cylindrical errors, spherical equivalents, and Zernike coefficients of ocular aberrations. The results showed that the iDesign produced significantly higher myopic values for refractive errors than the WaveScan, as well as significantly lower levels of total higher order, third, fourth, and fifth order root mean square values and Zernike coefficients of vertical coma and spherical aberration.

The results of this study agree with ours in that the thewavefront method using the iDesign aberrometer (Hartmann-Shack aberrometer) gives higher values for myopia.

Perez-straziota et al.[17] studied the Objective and subjective preoperative refraction techniques for wavefront-optimized and wavefront-guided laser in situ keratomileusis. This retrospective analysis of LASIK analyzed sphere, cylinder, and spherical equivalent (SE) refractions generated from 3 methods (manifest refraction, aberrometer autorefraction [CustomVue WaveScan], corneal analyzer autorefraction [Nidek ARK-10000 OPD]). In the wavefront-guided group (63 eyes, 33 patients), manifest refraction and aberrometer autorefraction generated similar deviation for sphere and SE; both were significantly better than corneal analyzer autorefraction. Aberrometer autorefraction generated less cylinder deviation than the other methods. In the wavefront-optimized group (61 eyes, 36 patients), manifest refraction generated less deviation for sphere and SE than aberrometer autorefraction or corneal analyzer autorefraction. Manifest refraction and aberrometer autorefraction cylinder generated similar deviation, while aberrometer autorefraction was less than corneal analyzer autorefraction.

Zhu et al.[18] compared the refractive errors measured by the VISX WaveScan, OPD-Scan III and the subjective refraction. Seventy-six patients (152 eyes) were recruited. 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. The diopter of sphere power measured by WaveScan was lower than that of the subjective refraction and the difference was 0.13 ± 0. 30D. While the diopter of cylinder power was higher and the difference was 0.13 ±0.43D. There was no significance for sphere, cylinder and spherical equivalent between OPD-Scan III and subjective refraction. The study concluded that the results of sphere and cylinder measured by WaveScan and subjective refraction were different.

Salmon et al.[19] studied measurement of refractive errors in young myopes using the COAS Hartmann-Shack aberrometer to evaluate the Complete Ophthalmic Analysis System (COAS; WaveFront Science) for accuracy, repeatability, and instrument myopia when measuring myopic refractive errors. The study measured the refractive errors of 20 myopic subjects (+0.25 to -10 D sphere; 0 to -1.75 D cylinder) with a COAS, a phoropter, and a Nidek ARK-2000 autorefractor. Measurements were made for right and left eyes, with and without cycloplegia, and data were analyzed for large and small pupils. The study used the phoropter refraction as the estimate of the true refractive error, so accuracy was defined as the difference between phoropter refraction and that of the COAS and autorefractor. Instrument myopia was defined as the difference between cycloplegic and non cycloplegic refractions for the same eyes. Results showed that Without cycloplegia, both the COAS and autorefractor had mean power vector errors of 0.3 to 0.4 D. Cycloplegia improved autorefractor accuracy by 0.1 D, but COAS accuracy remained the same. The study concluded that when measuring myopes, COAS accuracy, repeatability, and instrument myopia were similar to those of the autorefractor.

Our study showed that the wavefront method using the iDesign aberrometer (Hartmann-Shack aberrometer) gives higher values for myopia in sphere, cylinder and spherical equivalent than the manifest autorefraction method using the Nidek autorefractometer. So our study does not correlate with the previous studies. This may be attributed to many factors including the use of different aberrometers and different circumstances during examination including change in pupil diameter.

This study did not address which of the three methods of refraction was better at obtaining the true spectacle corrected visual acuity (BCVA) which is the main determinant of accuracy of refraction. Yet our results gave us an insight about the overestimation of wavefront refraction which should be taken into consideration when prescribing glasses or preparing refractive surgery.

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