MEASUREMENT OF OFF-AXIS REFRACTIVE ERROR WITH THE GRAND SEIKO WR-5100K AUTOREFRACTOR

by

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ABSTRACT

PURPOSE. To investigate if the Grand Seiko WR-5100K autorefractor will take measurements at positions of 10°, 20°, and 30° of horizontal eccentricity, and if it does, is measurement error induced. METHODS. A series of distance measurements were taken at varying degrees of off-axis positions to the right and to the left of the line of sight at increments of 10°, 20°, and 30° and compared to the primary gaze baseline measurement. RESULTS. Readings were successfully taken at 10°, 20°, and 30° from primary position, with readings of increased eccentricity showing increased variability. CONCLUSION. Care needs to be taken to assure proper patient alignment so that measurements taken are accurate.

INTRODUCTION: Autorefractors are computerized instruments that measure harmless infrared light rays as they pass through the eye and estimate the eye's refractive error. Most autorefractors simulate a visual environment that the patient views, which is optically at infinity even though enclosed in a small box, however, the Grand Seiko WR-5100K autorefractor uses an open view binocular design that allows the patient to view the actual environment at both distance and near. Studies have shown the instrument to be valid and reliable when testing adults[1,2], but a potential complication of this system is that the patient has the opportunity to view any object in view and not necessarily the target the examiner desires.

The Grand Seiko WR-5100K autorefractor has three measurement modes including autorefraction and keratometry simultaneously, autorefraction only, and keratometry only. Vertex distance can be set manually to 0, 10, 12, 13.5, and 15 mm. The instrument is capable of taking refractive error measurements of +/-22.00 diopters sphere and +/-10.00 diopters of cylinder in steps of 0.125 diopters and 1 degree for cylinder axis. Keratometry measurements of 5.0 to 10.0mm for radius of curvature and 33.75 to 67.50 diopters for corneal refractive power in steps of 0.01mm or 0.12/0.25 diopter increments can also be taken. The manufacturer's recommendation for minimum pupil size is 2.9mm. Refractive error is measured in two stages by imaging a ring target of near infrared radiation (850nm) that is reflected off the retina[1,2]. First, a lens is moved along a motorized track to approximately focus the ring and then the image is analyzed digitally in multiple meridians to calculate the prescription[1,2].

Peripheral refractive error and peripheral optics are not well understood. Peripheral resolution is poor because of the high degrees of optical aberration and limited resolving ability of the peripheral retina[3]. Studies have been conducted to determine the effect of emmetropization on the peripheral refractive error and the differences between myopic, hyperopic, and emmetropic patients[4]. Seidemann and Schaeffel found general peripheral myopia when the high amounts of astigmatism were converted to spherical equivalents[4]. Atchison found that nasal refractions tended to be more myopic, while temporal refractions were relatively unchanged from baseline[5]. A temporal refraction was the refractive error taken through the temporal portion of the cornea corresponding to nasal retina and a nasal refraction was the refractive error through the nasal cornea and temporal retina.

Autorefractors are used in optometric offices and are relied upon to provide accurate information about a patient's refractive error. Possible sources of error when using the Grand Seiko WR-5100K autorefractor would be an improperly trained technician operating the instrument or an uncooperative patient who fixates a target eccentric to the target they were instructed to fixate. The purpose of this study is to investigate if the Grand Seiko WR-5100K autorefractor will take measurements at positions of 10°, 20°, and 30° of horizontal eccentricity, and if it does, is measurement error induced.

METHODS: This study was approved by the Human Subjects Review Committee at Ferris State University. 8 subjects participated in the study and 16 eyes were tested. All subjects were emmetropic or corrected with contact lenses, were between the ages of 20 and 28, and enrolled in a post-graduate professional program. After each subject signed a consent form and had an opportunity to ask questions, preliminary data was collected to determine if the subject was a candidate to participate in the study. This data included: Von Herrick angles greater than one, distance visual acuities of 20/30 or better, and an initial distance autorefractor reading to verify the subject had 1.0 diopter or less of astigmatism. Subjects who met all of the inclusion criteria were randomized into two treatment groups. Based on pre-arranged, randomized assignment, one eye was treated with anesthetic and cyclopentolate solutions and the other eye with cylopentolate ointment. Different drug vehicles were used because of the requirements for another phase of the experiment that will be reported in a different paper. After allowing thirty minutes for patients to achieve full cycloplegia, autorefractor measurements were taken.

The testing room was set up so that the autorefractor was aligned with a central distance fixation target. Fixation targets were placed along the wall at calculated distances horizontally to establish eccentric viewing positions of 10°, 20°, and 30° to the right and to the left. First subjects were instructed to fixate the central distance target and five measurements were taken on each eye. The average of the five readings for each eye established the baseline refraction for which the off-axis measurements were compared. Next a series of readings were taken on each eye at varying degrees of off-axis positions to the right and left of the line of sight at increments of 10°, 20°, and 30° by instructing the subjects to fixate different targets arranged in the room.

RESULTS: Measurements were successfully taken in 32/32 attempts at 10°, 32/32 attempts at 20°, and 26/32 attempts at 30° of eccentric fixation. Table 1 below shows the percentage of readings taken that were within 0.25 diopters of the baseline, primary gaze measurement. Table 2 shows the average difference of the varying degrees of eccentricity from primary position. This was determined by taking the average of spherical and cylindrical components of the baseline, primary gaze readings and comparing them to the spherical and cylindrical components of the off-axis measurements. Table 3 compares the spherical equivalent of the baseline readings to the eccentric measurements. The variability of the readings is shown in Table 4 where the standard deviations of different positions of gaze are calculated.

Table 1. Percentage of Readings Within 0.25 Diopters of Primary Gaze

Sphere @ 10°	13/32	40.6%
Cylinder @ 10°	15/32	46.9%
Sphere @ 20°	7/32	21.9%
Cylinder @ 20°	8/32	25.0%
Sphere @ 30 °	6/26	23.1%
Cylinder @ 30°	3/26	11.5%

Table 2. Average Difference From Primary Position in Diopters (Sphere and Cylinder)

Sphere 10° Nasal	-0.06 D	Cylinder 10° Nasal	-0.04 D
Sphere 10° Temporal	+0.25 D	Cylinder 10° Temporal	-0.05 D
Sphere 20° Nasal	+0.12 D	Cylinder 20° Nasal	-0.27 D
Sphere 20° Temporal	+0.95 D	Cylinder 20° Temporal	-0.26 D
Sphere 30° Nasal	+0.80 D	Cylinder 30° Nasal	-1.93 D
Sphere 30° Temporal	+1.54 D	Cylinder 30° Temporal	-0.77 D

Table 3. Spherical Equivalent Differences From Primary Gaze

10° Nasal	-0.07 D	10° Temporal	+0.22 D
20° Nasal	-0.02 D	20° Temporal	+0.82 D
30° Nasal	-0.16 D	30° Temporal	+1.17 D

Table 4. Standard Deviations of Differences From Primary

(Sphere, Cylinder, and Spherical Equivalent)

Sphere 10° N	0.34	Cylinder 10° N	0.41	SE 10° N	0.34
Sphere 10° T	0.39	Cylinder 10° T	0.40	SE 10° T	0.31
Sphere 20° N	0.68	Cylinder 20° N	0.51	SE 20° N	0.71
Sphere 20° T	0.86	Cylinder 20° T	0.55	SE 20° T	0.69
Sphere 30° N	1.13	Cylinder 30° N	2.37	SE 30° N	1.65
Sphere 30° T	1.15	Cylinder 30° T	0.74	SE 30° T	0.92

DISCUSSION: Measurements were easily made on the subjects up to 30° of eccentricity. All of the subjects in this study were able to hold steady fixation on the eccentric targets and may not be characteristic of an uncooperative patient. At 30° of eccentricity it was apparent that the subject was not fixating a straight ahead target because of the distortion shown on the instrument's monitor, however, at 10° this was much less obvious. If the examiner were not paying attention, unintended off-axis measurements could easily be taken.

Table 1 lists the percentage of readings within 0.25 diopters of baseline and shows a difference between the primary gaze and eccentric readings. At 10° of eccentric fixation less then half of the readings were within 0.25 diopters of baseline.

The overall trend with increasing eccentricity was for increased positive spherical power and increased cylinder, as illustrated in Table 2. The finding of increased cylinder power in eccentric refraction is consistent with other studies[4].

When taking the spherical equivalent and comparing the averages, as shown in Table 3, an interesting trend appears in that the temporal refractions increased in plus power with increasing eccentricity, but the nasal refractions did not. This finding differs from Atchinson's study where he found an increase in minus power of the nasal refraction with increasing eccentricity[5]. However, each study worked with a relatively small number of subjects and drawing broad conclusions is difficult.

Another trend that developed with increasing degrees of eccentricity was an increased variability of the readings, including range and standard deviation. Table 4 shows the standard deviations of the spherical and cylindrical components, as well as the spherical equivalents. From 10° up to 30° the standard deviation of the values steadily increased. The following scatter plots of the spherical equivalent differences from primary at 10°, 20°, and 30° also illustrate the increasing variability. The plots take the difference of readings from eccentric and baseline for both nasal and temporal refractions. The figures show the increase in variability and range of values as well as the overall trend of increased plus power with increasing eccentricity. This is illustrated by comparing Figure 1 (10° of eccentric fixation), with an average of +0.08 diopters and a range of values of -0.60 to +0.70 diopters, to Figure 3 (30° of eccentric fixation), with an average of +0.48 diopters and a range of -3.91 to 2.88 diopters.

Figure 1. Average +0.08 diopters, Range -0.60 to +0.70 diopters

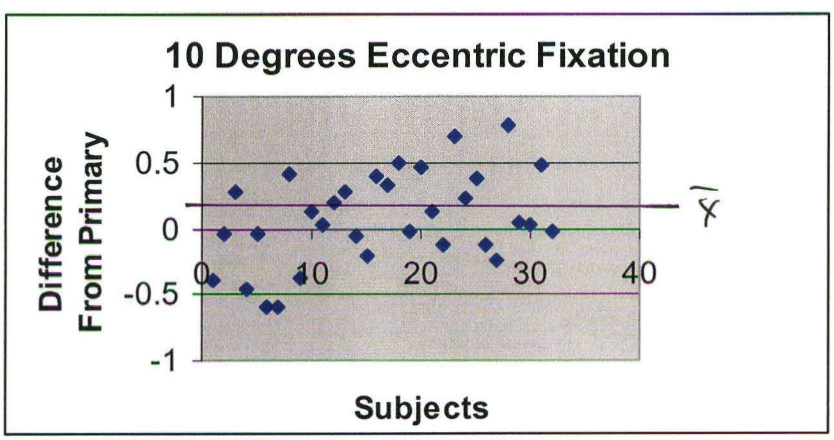


Figure 2. Average +0.38 diopters, Range -1.63 to +2.12 diopters

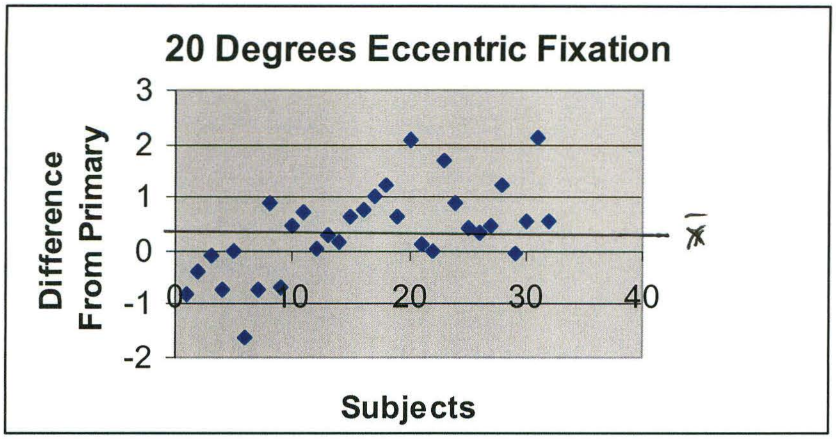
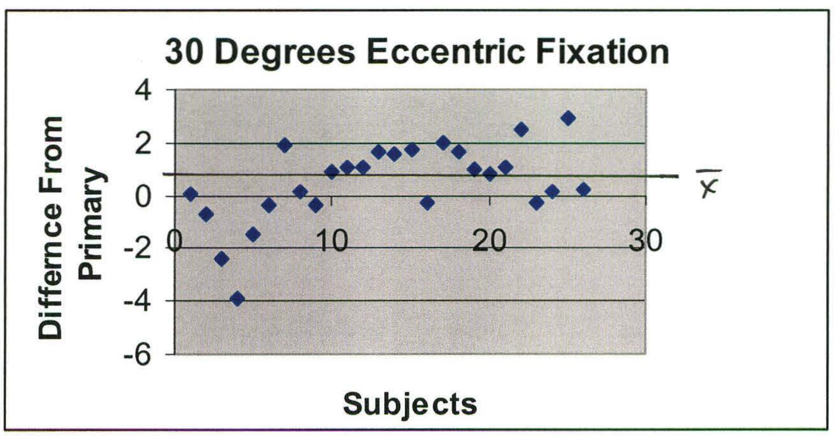


Figure 3. Average +0.48 diopters, Range -3.91 to +2.88 diopters



Care should be taken when interpreting data from the Grand SeikoWR-5100K autorefractor as it will take readings up to 30° of eccentricity and these readings become variable and unreliable. This can be especially problematic when an untrained technician is operating the instrument, or the patient is uncooperative. If the patient is not fixating the proper target or the alignment of the instrument is off, the readings are of very little use to the clinician.

CONCLUSION: The Grand Seiko WR-5100K autorefractor is a useful instrument in measuring the refractive error of patients and has been shown to be valid and reliable[1,2]. However, because of the open view design patients have the opportunity to fixate any object in their field of view. This study showed that readings can be taken on dilated patients in up to 30° of eccentricity and that these off-axis readings showed considerable variability from baseline, even at 10°. With this information in mind, care must be taken to assure proper patient alignment and fixation so that measurements are accurate.

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