COMPARISON STUDY OF AUTOMATED AND MANUAL KERATOMETRY READINGS

by

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ABSTRACT

Background: This research study seeks to explore the relationship between clinical readings attained from an automated keratometer and from a manual keratometer. With the advent and popularity of automated equipment, the question arises as to how the new technology's diagnostic data compares to that gained from the current, well-established methods. Little research has been conducted on this topic, though the information is valuable to the practice that provides contact lens services and is considering purchasing automated equipment. *Methods:* This study took place at the Michigan College of Optometry, comparing the Grand Seiko automated keratometer to the manual keratometer. A total of 40 eyes (n = 40) were used to gather data, with both forms of measurement acquired on the same day. Three separate readings were taken from both keratometers, for an average measurement from each. *Results:* The results unveiled a significant difference between the automated and manual keratometers, however, the clinical relevance of the actual variance was minor. *Discussion*: This study revealed that an experienced clinician could utilize measurements from either form of keratometer when compiling diagnostic data.

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INTRODUCTION:

There is little research currently available regarding variation in manual and automated keratometry readings. However, a couple studies have previously been conducted. In one such study, all manual and keratometry readings were performed on the same patient. The outcome of this study showed that the automatic keratometer yielded less variation than the manual keratometer when measuring a steel ball, though comparable amounts of variation were found when measuring the human eye.

The purpose of this study is to compare the Grand Seiko automated keratometer to the Marco manual keratometer, to determine similarity of measurements.

METHODS:

Data was collected from a sample of 40 eyes (n = 40), using the Grand Seiko automated keratometer and the Marco manual keratometer located at the Michigan College of Optometry. One clinician performed all measurements (40) on the automated keratometer; another clinician performed all measurements (40) on the manual keratometer. A steel ball of known curvature was used to determine the accuracy of both forms of measurement. Three readings were obtained by each keratometer on the steel ball, as well as from each eye of the 20 subjects (40 eyes). For manual keratometry readings the keratometer was misaligned after each measurement, to more accurately imitate actual clinical data. The subjects were in good physical health and included 6 males and 14 females. All subjects had healthy eyes, without corneal disease or abnormalities.

RESULTS:

Three measurements were obtained on a steel ball, with a known curvature of 42.50 Diopters (D). The automated keratometer yielded an average dioptric reading of 42.70 D, with an average of 0.08 D. in cylinder. The manual keratometer yielded an average dioptric value of 42.54 D., with an average of 0.25 D. in cylinder.

The averages of these readings indicated that both keratometers were slightly steeper than the known dioptric value, with the automated keratometer being 0.16 Diopters (D) steeper than the manual, on average. Both keratometers measured some cylindrical component on the steel ball, with the manual keratometer averaging 0.17 D. more cylinder than the automated. These measurements indicate that both keratometers are acceptably accurate, with a small range of error.

Table 1 and Table 2 below reveal the dioptric average of the three measurements from both keratometers (separated into horizontal and vertical meridians) obtained from each subject. This data was then used to arrive at the dioptric difference between the automated and manual keratometer readings in the horizontal and vertical meridians, for the right eye (Table 1) and the left eye (Table 2).

Table 1 measurements of the right eye indicated that the horizontal meridian had a mean difference of 0.85 Diopters (D) between the two keratometers, with a standard deviation of 0.45 D, and a median value of 0.75 D. The vertical meridian of the right eye had a mean difference of 0.96 D between the two keratometers, with a standard deviation of 0.54 D, and a median value of 1.00 D.

Table 2 measurements of the left eye indicated the horizontal meridian had a mean difference of 0.66 Diopters (D) between the two keratometers, with a standard deviation of 0.59 D and a median value of 0.50 D. The vertical meridian of the left eye had a mean difference of 0.99 D between the two keratometers, with a standard deviation of 0.71 D, and a median value of 0.83 D.

Table 3 and Table 4 below reveal the mean of the total dioptric cylinder and axis (analyzed separately) from the three measurements obtained from each instrument. This data was then used to arrive at the dioptric cylinder difference and axis difference in degrees between the automated and manual keratometer, for the right eye (Table 3) and the left eye (Table 4).

Table 3 measurements of the right eye indicated the mean dioptric cylinder difference was 0.21 Diopters (D) between the two keratometers, with a standard deviation of 0.23 D, and a median value of 0.25 D. The mean axis difference between the two keratometers was 12.95 degrees, with a standard deviation of 11.83, and a median value of 9 degrees.

Table 4 measurements of the left eye indicated the mean dioptric cylinder difference was 040 Diopters (D) between the two keratometers, with a standard deviation of 0.33 D, and a median value of 0.25 D. The mean axis difference between the two keratometers was 12.50 degrees, with a standard deviation of 11.16, and a median value of 10 degrees.

TABLE 1: Total Dioptric Difference OD, Horizontal and Vertical Meridians

Subject Number	Manual OD Horizontal	Auto OD Horizontal	Horizontal Dioptric Difference	Manual OD Vertical	Auto OD Vertical	Vertical Dioptric Difference
1	40.75	41.00	0.25	42.00	42.25	0.25
2	44.50	46.25	1.75	45.25	47.00	1.75
3	44.00	44.50	0.50	44.25	44.50	0.25
4	45.25	45.75	0.50	45.50	45.25	0.25
5	41.50	42.50	1.00	42.50	43.50	1.00
6	42.25	43.00	0.75	43.00	44.00	1.00
7	42.75	43.25	0.50	44.00	44.25	0.25
8	43.00	44.00	1.00	43.50	42.25	1.25
9	44.50	45.00	0.50	45.75	46.50	0.75
10	45.00	46.00	1.00	45.75	47.25	1.50
11	47.50	49.00	1.50	49.50	51.00	1.50
12	42.50	43.25	0.75	43.00	43.75	0.75
13	41.25	43.00	1.75	42.00	44.00	2.00
14	42.50	43.25	0.75	43.50	45.00	1.50
15	47.50	48.00	0.50	47.75	49.00	1.25
16	46.25	47.75	1.50	47.50	49.00	1.50
17	44.25	44.50	0.25	44.75	45.25	0.50
18	39.00	40.00	1.00	40.00	41.00	1.00
19	42.50	43.25	0.75	44.00	44.50	0.50
20	42.50	43.00	0.50	42.75	43.25	0.50

TABLE 2: Total Dioptric Difference OS, Horizontal and Vertical Meridians

Subject Number	Manual OS Horizontal	Auto OS Horizontal	Horizontal Dioptric Difference	Manual OS Vertical	Auto OS Vertical	Vertical Dioptric Difference
1	40.25	40.25	0	41.25	41.75	0.50
2	45.00	45.50	0.50	45.25	46.00	0.75
3	44.00	45.00	1.00	44.25	45.50	1.25
4	45.50	45.50	0	45.25	46.25	1.00
5	42.25	43.00	0.75	43.00	43.75	0.75
6	42.50	43.25	0.75	43.25	43.75	0.50
7	42.50	43.00	0.50	44.00	44.50	0.50
8	43.50	43.50	0	43.50	44.00	0.50
9	45.00	46.50	1.50	46.50	47.75	1.25
10	45.50	47.00	1.50	45.75	48.75	3.00
11	47.25	48.00	0.75	49.00	50.00	1.00
12	42.75	43.25	00.50	43.50	43.75	0.25
13	41.50	43.75	2.25	42.00	44.50	2.50
14	42.50	42.50	0	43.50	43.75	0.25
15	48.00	49.00	1.00	48.50	50.00	1.50
16	47.00	47.25	0.25	48.00	48.75	0.75
17	44.25	44.50	0.25	45.00	45.00	0
18	39.25	39.25	0	40.00	41.00	1.00
19	43.00	44.00	1.00	43.50	44.75	1.25
20	42.25	43.00	0.75	42.50	43.75	1.25

Manual Horizontal = Dioptric curvature measured in horizontal meridian with manual keratometer
Auto Horizontal = Dioptric curvature measured in horizontal meridian with auto-keratometer
Manual Vertical = Dioptric curvature measured in vertical meridian with manual keratometer
Auto Vertical = Dioptric curvature measured in vertical meridian with auto-keratometer
Dioptric Difference = Dioptric difference between manual and auto-keratometer measurements for each meridian

Table 3: Total Dioptric Cylinder and Axis Difference, OD

Subject	Manual Dioptric Cylinder	Auto Dioptric Cylinder	Dioptric Cylinder Difference	Axis Difference In Degrees
1	-1.25 x 177	-1.25 x 171	0	6
2	-0.75 x 175	-0.75 x 004	0	9
3	-0.25 x 178	Pl	0.25	2
4	-0.25 x 177	Pl	0.25	3
5	-1.00 x 177	-1.00 x 173	0	4
6	-0.75 x 179	-1.00 x 170	0.25	9
7	-1.25 x 179	-1.00 x 164	0.25	15
8	-0.50 x 177	-0.25 x 157	0.25	20
9	-1.25 x 001	-1.50 x 180	0.25	1
10	-0.75 x 180	-1.25 x 042	0.50	42
11	-2.00 x 179	-2.00 x 177	0	2
12	-0.50 x 178	-0.50 x 143	0	35
13	-0.75 x 178	-1.00 x 145	0.25	33
14	-1.00 x 004	-1.75 x 022	0.75	18
15	-0.25 x 180	-1.00 x 162	0.75	18
16	-1.25 x 177	-1.25 x 175	0	2
17	-0.50 x 174	-0.75 x 007	0.25	13
18	-1.00 x 168	-1.00 x 165	0	3
19	-1.50 x 169	-1.25 x 164	0.25	5
20	-0.25 x 176	-0.25 x 157	0	19

Table 4: Total Dioptric Cylinder and Axis Difference OS

Subject	Manual Dioptric Cylinder	Auto Dioptric Cylinder	Dioptric Cylinder Difference	Axis Difference In Degrees
1	-1.00 x 001	-1.50 x 171	0.50	10
2	-0.25 x 177	-0.50 x 015	0.25	18
3	-0.25 x 178	-0.50 x 176	0.25	2
4	-0.25 x 088	-0.75 x 074	0.50	14
5	-0.75 x 177	-0.75 x 005	0	8
6	-0.75 x 180	-0.50 x 003	0.25	3
7	-1.50 x 179	-1.50 x 008	0	9
8	Pl	-0.50 x 020	0.50	20
9	-1.50 x 001	-1.25 x 002	0.25	1
10	-0.25 x 178	-1.75 x 015	1.50	17
11	-1.75 x 001	-2.00 x 177	0.25	4
12	-0.75 x 177	-0.50 x 005	0.25	8
13	-0.50 x 177	-0.75 x 008	0.25	11
14	-1.00 x 177	-0.75 x 148	0.25	29
15	-0.50 x 001	-1.00 x 173	0.50	8
16	-1.00 x 178	-1.50 x 166	0.50	12
17	-0.75 x 178	-0.50 x 008	0.25	10
18	-0.75 x 175	-1.75 x 009	1.00	14
19	-0.50 x 177	-0.75 x 178	0.25	1
20	-0.25 x 177	-0.75 x 126	0.50	51

DISCUSSION:

The results presented in Table 1 and Table 2 reveal a significant difference between the automated and manual keratometry dioptric measurements. However, the clinical significance is minimal considering the measurements are to be used as an estimate, and not a definitive value. An interesting observation noted in Table 1 and Table 2 is the consistently steeper measurements obtained by the automated keratometer. Of all measurements from the horizontal and vertical meridians that revealed a discrepancy between the automated and manual keratometer, 100 percent of the automated readings were steeper, with the exception of the vertical meridian in the right eye, which had 90 percent of the automated readings being steeper. Although generally only slightly steeper, the clinician relying on an automated keratometer may take note of this and compensate if needed.

The results presented in Table 3 and Table 4 indicate that the total dioptric cylinder difference between the automated and manual keratometer is negligible. This is confirmed by the calculated mean and standard deviation values. However, the axis (in degrees) associated with the dioptric cylinder amount revealed increased variation. Although the mean and standard deviation appear high, the measurements are still within acceptable proximity to be deemed reliable.

As with any clinical measurements that rely on human operation of equipment, it is necessary to have experienced clinicians collecting data. It is also necessary for the operator to have some knowledge of what may be extreme and inaccurate data, as this will result in the most reliable information. What was viewed as extreme and inaccurate

data was not thrown out in this study in order to comply with our study method guidelines, which only allowed three measurements to be taken on each subject with each keratometer. In the clinical setting, extemporaneous data can easily be identified and thrown out by the experienced clinician, resulting in less variance between the keratometers than what this study indicated.

In conclusion, the variation found between the automated and manual keratometer is clinically minute. It is the opinion of the authors that the data obtained from either keratometer is acceptable for an experienced clinician to use in his battery of diagnostic data.

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