MEASUREMENT OF THE RELATIVE ACCURACY OF THE CORNEAL ANALYSIS SYSTEM VERSUS KERATOMETRY AND AUTO KERATOMETRY

by Matthew Kisabeth

INTRODUCTION:

With the advent of new surgical techniques to correct refractive error, the need to accurately measure the anterior corneal surface in a reproducible fashion has led to a revolution of new instrumentation. The computerized video keratographer has been in some instances able to supplant more conventional means (keratometry, keratoscopy and photokeratography) of measuring the corneal curvature. Each instrument uses a different technique so there always arises the possibility that one instrument is not as accurate or reproducible as another.

Several studies have been published to address this issue with special attention focused on the computerized topographer. This instrument uses mathematical equations called algorithms to interpret the distance between reflected placido rings to assess the corneal curvature at any point on the cornea. The Corneal Analysis System (EYESYS) has been determined to be very accurate when using calibrated spherical steel balls. Since the algorithm complexity increases for trying to interpret aspheric corneas, the chance for error also goes up.

The purpose of the study is to assess the validity of these algorithms on the very irregular shape of a human cornea. Another factor to consider is the inability to determine the absolute accuracy of any instrument when measuring the human cornea. Since the absolute power of any given cornea is not known, one can only relatively compare the accuracy of any given technique.

PATIENTS & METHODS:

To begin, 15 volunteers were randomly selected. No entry criteria was needed since the basis of the study was a comparison of the accuracy of the 3 instruments. No slit lamp was performed though 1 patient had been previously diagnosed with pellucid marginal degeneration. Also, contact lens wear was prevalent among the volunteers, but none were rigid gas permeable or PMMA wearers. Each patient had not worn their contact lenses for at least 15 minutes before the measurements were taken.

The readings for each patient were performed within 30 minutes of each other to rule out any diurnal variation in the cornea. Also, the sets of measurements were not always done in the same order to randomize the study to some degree.

As I stated before, I obtained measurements from 3 different instruments per eye. This included 1 Corneal Analysis System topographical map (EYESYS) with keratometric data at the 3 mm zone, 3 keratometer readings (BAUSCH & LOMB), and an average keratometer reading using an automated keratometer (NIDEK). The manual keratometer readings were performed carefully for greater accuracy and alternately between the right and left eyes of each subject.

No computerized map of the cornea was disallowed. All central 3 mm zones of each patient were effectively mapped with no gaps from an incomplete tear film or blinkage of the lids.

The data consisting of both flat and steep meridians and the astigmatic values are listed in Table 1 and 2.

RESULTS:

The purpose of this study was to refute or substantiate the notion that the Eyesys topographer underdetermines the level of corneal astigmatism. My results supports this claim, especially with highly toric corneas.

With each set of data for one eye, an astigmatic value was calculated for all 3 instruments. An average value was determined for each instrument for the entire sample. The Eyesys was on average over 0.30D less than both the (B & L) keratometer and the (NIDEK) auto keratometer and only 30% of the time was the Eyesys greater than both the B & L and the Nidek for an individual cornea. The Nidek read only slightly higher than the B & L, and this was supported by the fact that only 17% of the Eyesys readings were higher than the Nidek. Other deductions can be made including when the Nidek calculated a corneal astigmatism more than 0.50D, the Eyesys never recorded a higher value. A similar statement can be made about the B & L.

A summary of the tables is as follows:

Table 3 shows the percentage of corneas measured lower astigmatically with the Eyesys.

Table 4 demonstrates when the Eyesys does measure a higher astigmatic value, the difference is small and the value is usually less than 1D.

Table 5 shows when the Eyasys measures a lower astigmatic value, the difference is much greater and the value is usually greater than 1D.

Table 6 is a breakdown of corneal astigmatism based upon the magnitude. It clearly illustrates that with increasing corneal astigmatism, the Eyesys will proportionately measure less astigmatism than the other two instruments

With the remaining tables, I tried to find a correlation between the corneal curvature of both the flat and steep meridians in comparing all 3 instruments. No relationship was found.

CONCLUSION:

Computer-assisted corneal topography has provided information essential for understanding pathologic and surgical alteration of the shape of the anterior corneal surface. The objective of this investigation was to test the relative accuracyof this instrument versus more conventional means. The data points to a probable error in the algorithm used to compute corneal astigmatism. Of course, there can be flaws in any study when human error is involved such as in this case when measurements are taken. Wilson et al. have also performed a similar accuracy test with the Eyesys and have questioned the accuracy of determining the amount of corneal astigmatism.

So as technology advances, the credibility and clinical necessity of increasing cost of more information of these new instruments must be justified.

TABLE 1 (n=30)

PATIENT #	B & L	NIDEK	EYESYS
1 OD	-1.37X007	-1.00X171	-0.96X169
1 OS	-1.12X002	-1.25X018	-0.84X001
4 OD	-1.12X173	-1.25X018	-1.14X170
4 OS	-1.25X173	-1.00X172	-0.82X161
5 OD	-0.87X177	-0.75X013	-0.57X173
5 OS	-0.87X168	-0.75X177	-0.63X161
8 OD	-8.50X070	-8.50X067	-5.97X066
8 OS	-4.50X121	-4.50X117	-3.38X110
9 OD	-0.25X180	-0.25X038	-0.43X177
9 OS	-0.00X000	-0.00X000	-0.31X058
10 OD	-0.62X180	-0.75X177	-0.54X161
10 OS	-0.62X180	-0.50X177	-0.67X169
11 OD	-4.75X026	-5.25X027	-4.17X018
11 OS	-5.50X162	-5.75X160	-4.21X153
12 OD	-0.87X176	-1.25X003	-0.74X173
12 OS	-0.37X176	-0.50X019	-0.45X176
13 OD	-1.75X005	-2.00X007	-1.78X173
13 OS	-1.50X173	-1.50X171	-1.38X167
14 OD	-1.25X025	-1.00X042	-0.71X028
14 OS	-2.37X139	-2.50X142	-1.73X139
15 OD	-3.25X018	-3.00X015	-2.37X009
15 OS	-2.75X168	-2.75X162	-2.19X154
16 OD	-0.62X173	-o.75X173	-0.51X157
16 OS	-0.50X178	-0.50X011	-0.41X171
17 OD	-0.50X180	-0.50X010	-0.65X173
17 OS	-0.37X180	-0.25X007	-0.33X168
18 OD	-0.50X017	-0.50X175	-0.48X169
18 OS	-0.87X172	-0.75X178	-0.66X161
19 OD	-0.37X090	-0.50X074	-0.36X160
19 OS	-0.00X000	-0.50X005	-0.42X160

$\bar{x} = -1.64$ $\bar{x} = -1.68$ $\bar{x} = -1.33$

TABLE 1 (cont.)

PATIENT #	B & L + NIDEK (avg.)
1 OD	-1.18X179
1 OS	-1.18X010
4 OD	-1.18X177
4 OS	-1.12X173
5 OD	-0.81X180
5 OS	-0.81X173
8 OD	-8.50X068
8 OS	-4.50X119
9 OD	-0.25X019
9 OS	-0.00X000
10 OD	-0.68X179
10 OS	-0.56X179
11 OD	-5.00X026
11 OS	-5.62X161
12 OD	-1.06X179
12 OS	-0.43X007
13 OD	-1.87X006
13 OS	-1.50X172
14 OD	-1.12X033
14 OS	-2.43X140
15 OD	-3.12X016
15 OS	-2.75X165
16 OD	-0.68X173
16 OS	-0.50X005
17 OD	-0.50X005
17 OS	-0.31X004
18 OD	-0.50X006
18 OS	-0.81X175
19 OD	-0.43X082
19 OS	-0.25X002

TABLE 2 - CORNEAL CURVATURE (n=28)

PATIENT #	EYESYS		NIDEK		B & L	
	FLAT	STEEP	FLAT	STEEP	FLAT	STEEP
1 OD	44.34	45.30	44.50	45.50	44.50	45.87
1 OS	44.58	45.52	44.50	45.75	44.50	45.62
4 OD	45.54	46.68	45.75	47.00	45.50	46.62
4 OS	45.60	46.42	45.50	46.50	45.25	46.50
5 OD	41.51	42.08	41.50	42.25	41.25	42.12
5 OS	41.87	42.50	42.25	43.00	41.50	42.37
9 OD	42.29	42.72	42.50	42.75	42.25	42.50
9 OS	42.08	42.39	42.25	42.25	42.25	42.25
10 OD	45.12	45.66	45.25	46.00	45.25	45.87
10 OS	45.24	45.91	45.25	45.75	45.25	45.87
11 OD	39.94	44.11	39.50	44.75	39.62	44.37
11 OS	40.13	44.34	39.75	45.50	39.75	45.25
12 OD	43.26	44.00	43.25	44.50	43.12	44.00
12 OS	43.21	43.66	43.25	43.75	43.37	43.75
13 OD	43.10	44.88	43.25	45.25	43.50	45.25
13 OS	43.26	44.64	43.50	45.00	43.75	44.75
14 OD	44.11	44.82	44.00	45.00	43.37	44.62
14 OS	44.06	45.79	43.75	46.25	43.75	46.12
15 OD	43.54	45.91	43.50	46.50	42.87	46.12
15 OS	43.60	45.79	43.50	46.25	43.00	45.75
16 OD	43.60	44.11	43.75	44.50	43.62	44.25
16 OS	43.88	44.29	44.00	45.00	44.00	45.00
17 OD	42.61	43.26	42.75	43.25	42.87	43.37
17 OS	43.10	43.43	43.00	43.25	43.00	43.37
18 OD	42.25	42.93	42.75	43.25	42.50	43.00
18 OS	42.77	43.43	42.75	43.50	42.37	43.25
19 OD	44.64	45.00	44.50	45.00	44.50	44.87
19 OS	44.34	44.76	44.50	45.00	44.75	44.75

COMPARISON TABLES

		MEAN($\bar{x}$)	MEAN DIFFERENCE($\bar{x}$)	RANGE of DIFF
B & L	EYESYS(73%)	-2.03	0.53	(0.01-3.53)
B & L	EYESYS(27%)	-0.58	0.16	(0.02-0.42)
NIDEK	EYESYS(83%)	-1.94	0.49	(0.02-3.53)
NIDEK	EYESYS(17%)	-0.30	0.16	(0.08-0.31)
Avg	EYESYS(77%)	-2.06	0.51	(0.02-3.53)
Avg	EYESYS(23%)	-0.32	0.14	(0.02-0.31)
B & L	NIDEK(30%)	-1.19	0.19	(0.12-0.37)
B & L	NIDEK(40%)	-1.85	0.23	(0.12-0.50)
TOTAL	1D(50%)	-0.50	-0.01	(-0.25-+0.31)
TOTAL	1-2D(27%)	-1.28	-0.23	(-0.41--0.04)
TOTAL	2D(23%)	-4.56	-1.27	(-3.53--0.56)
TOTAL	1D(50%)	-0.50	-0.01	(-0.25-+0.31)
TOTAL	1D(50%)	-2.81	-0.72	(-3.53 -0.04)

KEY:
- MEAN($\bar{x}$) is the average astigmatic value of the instrument in the far left hand column.
- Avg is an average of the astigmatic value of the B & L and the NIDEK for any given cornea.
- TOTAL is a combination of the two readings in any of the groups above and meet the diopter specification.
- For MEAN DIFFERENCE and RANGE of DIFF, (-) sign means greater astigmatic value than EYESYS and (+) sign means less than EYESYS.

TABLE- COMPARISON of CORNEAL CURVATURE

	FLAT	STEEP
OD-EYESYS	43.29	44.39
OS-EYESYS	43.41	44.48
OD-NIDEK	43.34	44.68
OS-NIDEK	43.41	44.75
OD-B & L	43.19	44.49
OS-B & L	43.29	44.61

NIDEK

Avg. FLAT	43.38 ± 1.47
Avg. STEEP	44.72 ± 1.36
Avg.	44.05

B & L

Avg. FLAT	43.24 ± 1.48
Avg. STEEP	44.55 ± 1.35
Avg.	43.90

EYESYS

Avg. FLAT	43.35 ± 1.39
Avg. STEEP	44.43 ± 1.23
Avg.	43.89

TOTAL AVERAGE = 43.95D

REFERENCE #1 = 43.97 ± 1.54

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