A Comparison of the EyeSys Corneal Analysis System with Conventional Keratometry on Human subjects

by

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Technology is producing some of the most important advances of our time to aid in the detection and in following the progression of disease processes. One such advance is the EyeSys Corneal Analysis System. It is a computer-assisted corneal topography system using photokeratography to measure corneal power. This is accomplished by projecting up to eight keratoscopic rings onto the cornea and measuring corneal power at multiple points around the circumference of each ring. The actual measuring of corneal power is based upon separation of the reflected rings off the cornea. These rings cover approximately 10mm of corneal surface and therefore can give us valuable information about the peripheral as well as central corneal curvature. The instrument can then take the following data to construct a color coded contour map of the corneal surface. These contour maps are extremely important for example, in the detection and in following the progression of Keratoconus. These maps show the size, location, and degree or amount of protrusion of the cone. Keratometric data such as average power, location, and the difference in power of the two main astigmatic meridians are other information that may be obtained by this marvel of diagnostic equipment.

The instrument most widely used to obtain information about power and location of the two main astigmatic meridians is the Keratometer. It has been found to be accurate in the evaluation of central corneal curvature, and therefore is the instrument to measure others by. This study compared the keratometric readings of the B&L Keratometer to the EyeSys Corneal Analysis System. These comparisons were carried out on 10 individuals or a total of 20 eyes. The purpose of the study is to compare the two instruments for accuracy, repeatability, and finally reliability.

METHOD

Measurements were made on 20 corneas of 10 individuals using both the B&L Keratometer and the EyeSys Corneal Analysis System. Three readings were taken with each instrument on all 20 corneas. Before any of the measurements, both of the instruments were calibrated using the B&L Keratometer's set of three steel spheres for calibration. Between the readings on a single cornea, both instruments were taken out of the previous focusing position and then refocused for the proceeding measurement. Finally, an average was calculated from the three readings for both instruments. Standard deviations were also calculated from these averages. It is these averages of the three readings that were then compared between the two instruments. Only subjects whose corneas gave clear non-irregular mires were used in this study. Any evidence of corneal disease or abnormality in any subject was not included to dissolve the possibility of contaminating the data.

The EyeSys Corneal Analysis System when presenting keratometric data, does so with information from three zones. The three zones displayed are 3mm zone (central), 5mm zone (para central), and finally the 7mm zone (peripheral). While all three zones are very useful in diagnosing and following the progression of various anterior segment diseases, in this study only the central zone is of importance. This is so a direct comparison can be made between the two instruments, since the Keratometer only measures approximately a 3mm zone.

Results

Power measurements and standard deviation in Diopters

Eye		Horizontal		Vertical	
		EyeSys	Keratometer	EyeSys	Keratometer
1	Mean	42.30	42.08	43.70	43.67
	s.d.	.09	.12	.05	.12
2	Mean	41.87	42.08	43.90	44.83
	s.d.	.11	.12	.05	.24
3	Mean	42.61	42.92	43.38	44.00
	s.d.	.05	.12	.00	.20
4	Mean	42.30	43.16	42.57	43.67
	s.d.	.04	.12	.05	.12
5	Mean	45.06	45.25	44.60	45.00
	s.d.	.08	.20	.10	.00
6	Mean	44.27	45.08	43.58	44.67
	s.d.	.02	.12	.02	.12
7	Mean	44.15	44.17	44.46	44.25
	s.d.	.12	.12	.17	.00
8	Mean	43.45	43.50	43.58	44.08
	s.d.	.10	.00	.16	.12
9	Mean	43.69	44.00	44.67	44.83
	s.d.	.22	.00	.05	.12
10	Mean	43.64	44.00	44.82	45.50
	s.d.	.10	.00	.20	.00
11	Mean	43.87	43.92	44.13	44.50
	s.d.	.15	.12	.16	.00
12	Mean	43.82	44.00	44.00	44.08
	s.d.	.21	.00	.17	.12
13	Mean	43.38	43.33	44.13	44.25
	s.d.	.12	.12	.10	.00
14	Mean	42.07	42.50	42.68	43.25
	s.d.	.04	.00	.11	.00
15	Mean	44.44	44.42	46.35	46.83
	s.d.	.03	.12	.05	.24
16	Mean	43.94	44.58	45.52	46.67
	s.d.	.12	.12	.06	.12
17	Mean	44.44	44.50	45.18	45.42
	s.d.	.03	.00	.05	.12
18	Mean	43.77	44.58	44.56	45.42
	s.d.	.08	.12	.07	.12
19	Mean	43.53	43.67	45.18	45.83
	s.d.	.14	.12	.17	.12
20	Mean	43.37	43.67	45.00	45.83
	s.d.	.12	.12	.05	.12

Fig. 1

Location of steep meridian and standard deviation

Eye		EyeSys	Keratometer
1	Mean	101	102
	s.d.	3.3	0.0
2	Mean	059	066
	s.d.	1.7	1.25
3	Mean	091	101
	s.d.	1.7	5.73
4	Mean	089	104
	s.d.	7.12	4.32
*5	Mean	001	180
	s.d.	.94	0.0
*6	Mean	158	160
	s.d.	2.62	7.07
*7	Mean	081	088
	s.d.	11.22	2.05
8	Mean	076	076
	s.d.	19.33	1.41
9	Mean	083	095
	s.d.	2.5	.09
10	Mean	084	093
	s.d.	4.71	3.68
11	Mean	092	091
	s.d.	8.99	.94
*12	Mean	055	093
	s.d.	11.81	4.78
13	Mean	103	114
	s.d.	5.18	2.62
14	Mean	065	075
	s.d.	10.14	.47
15	Mean	075	079
	s.d.	2.87	.82
16	Mean	080	090
	s.d.	2.49	.47
17	Mean	090	100
	s.d.	2.62	2.20
18	Mean	080	088
	s.d.	4.92	1.62
19	Mean	088	092
	s.d.	3.30	2.87
20	Mean	077	095
	s.d.	2.49	.47

* Less than .50 D difference between meridians.

Fig. 2

When reviewing the results from this study, the concept of repeatability, accuracy, and reliability must be considered. Not only for the power of the two main astigmatic meridians but also the location. The attempt will then be, to present the results under the three main interest points with the aid of figures 1 and 2.

Repeatability or the ability to attain data on one subject a number of times with little variance, is best addressed by looking at standard deviation. When looking at the EyeSys, the range in variance for the two meridians was as low as .02 D and as high as .20 D. The Keratometer had a low of .00 D and a high of .24 D. For location of the two meridians, the EyeSys ranged from $.94^{o}$ to 19.33^{o} of variance and the variance of the Keratometer was 0.0^{o} to 5.09^{o}. In each case the variance was based on at least .50 D difference between the two meridians.

In order for us to look at accuracy in this study, we must use the Keratometer as the norm for the comparison. It has after all been the "norm" and has proven its accuracy over the years. A direct comparison of keratometric values can be seen in fig. 1. The data shows, when comparing vertical measurements the EyeSys ranged from .21 D steeper to 1.15 D flatter than the Keratometer. The horizontal measurement comparison, shows a range from .22 D steeper to .81 D flatter. While the range shows the extremes for the two meridians, the average of all the eyes shows the general trend. In the horizontal data the average is .27 D flatter, and in the vertical measurement .53 D flatter than the Keratometer. Meanwhile, the range for major meridian location of the EyeSys differed from 0^{o} to 18^{o} when compared to the Keratometer (fig. 2). This is for differences between the two meridians of at least .50 D. The overall average of differences for all eyes in the project was 7.58^{o}.

Finally, to look at the aspect of reliability, we must consider both repeatability and accuracy. To have a low amount of variance as well as a very close comparison to the norm would be ideal, and deemed very reliable. Repeatability for the EyeSys shows a very close resemblance to the Keratometer. Both instruments showed an average variance of approximately .12 D for subjects in the study when measuring the power of the major meridians. But, the EyeSys had a much larger variance when locating the major meridian when compared to the Keratometer. The EyeSys gave an average variance of approximately 10^{o} to the Keratometer's 2.5^{o}. Accuracy for the EyeSys was compared directly with measurements from the Keratometer. The average difference between the two instruments, showed the EyeSys measuring .53 D flatter in the vertical meridian and .27 D flatter in the horizontal meridian. Also, the EyeSys had an average difference of 7.58^{o} when trying to locate the major meridian. While the area of repeatability was very good the accuracy portion left a little to be desired, giving us a few more things to consider before determining complete reliability.

DISCUSSION

In a previous study involving both instruments measuring calibration hemispheres, the EyeSys was found to correlate well with the Keratometer.[1] But, this was not the case when measuring human eyes in this study. This is especially evident when measuring the accuracy of the EyeSys to the Keratometer. Here, the EyeSys differed by as much as 1.15 D flatter than the Keratometer. Even more important there was an average difference of at least .53 D flatter in the vertical meridian and .27 D flatter in the horizontal meridian for all subjects in the study. This is significant because in order to determine if something is reliable it must be both accurate and repeatable. The good thing about the EyeSys is that it is very repeatable. Unfortunately, it is not acceptable to say the EyeSys is reliably at least .50 D flatter than the Keratometer.

In conclusion I found the EyeSys to be repeatable in determining the power of the major astigmatic meridian and a little less so in finding the location. For accuracy, the EyeSys seemed to read flatter than the Keratometer for almost all subjects and in some cases by quite a bit. Again, there seemed to be more variability in finding the location of the main meridians. After considering these two important areas, it seems to me that the EyeSys is not very reliable for determining keratometric data. This is at least on human eyes, but it is on calibration spheres. This variance between human eyes and calibration spheres may be related to blink rate, tear quality or possibly tear quantity. But, this small set back in central corneal measurements should not overshadow the importance of overall corneal measurements. That is, the ability to generate a contour map of the cornea without molding the cornea is an invaluable piece of equipment. Especially for the following of Penetrating Keratoplasty, progression of Keratoconus, and the various methods used for reshaping the cornea to correct refractive errors. Thus, some sort of adjustment needs to be considered to normalize the keratometric results for this minor setback with the EyeSys.

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