The Relationship Between Peripheral Corneal Flattening as Measured by the Keratometer vs. the EyeSys Corneal Topographer

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INTRODUCTION

For many years practitioners of orthokeratology have used the rule that greater reduction in myopia may be achieved on eyes that have greater peripheral flattening of the cornea. They estimated peripheral corneal flattening by taking keratometer readings at two points on the cornea. The first point was the central corneal curvature measured in the standard manner, with the patient fixating on the central target of the keratometer. The second point was taken while the patient fixated on the nasal plus mire. In this position the keratometer was measuring curvature at a point on the temporal cornea.

Presumably, the greater the difference between central and temporal keratometry readings (hereinafter referred to as "central-K" and "temporal-K" respectively), the greater the rate of peripheral flattening which occurs throughout the entire cornea. (This difference will be called <CK-TK> throughout the remainder of this report). Therefore, the greater the <CK-TK>, the greater is the maximum possible reduction in myopia for an eye undergoing orthokeratology.[1,2,3,4,5]

Furthermore, "sphericalization" (equality of central-K and temporal-K) after a period of treatment is often used as an indicator that further treatment is unlikely to result in further myopia reduction.[1,4,5]

There are several proposed mechanisms for the central corneal flattening induced by orthokeratology. The mechanism most frequently cited is that direct mechanical pressure on the apex of the cornea from the orthokeratology lens molds the cornea into a flatter shape with less refractive power. Another theory proposes that the flattening is secondary to a change in hydraulic pressure within the anterior chamber. Decreased ciliary spasm is a third proposed mechanism. A fourth suggestion is that the reduction in axial length due to a posterior movement of the corneal apex is responsible for the myopia reduction.[5]

Modern corneal topographers have revolutionized the study of corneal curvature. Topographers are now used routinely by many practitioners in the fitting of rigid contact lenses. The EyeSys corneal topographer automatically calculates the eccentricity of the cornea after measuring approximately 72% of the corneal surface.[7] The average e-value of the human cornea is approximately 0.5,[6] which means the cornea approximates an ellipsoid rather than a sphere.

It is commonly accepted that the e-value as calculated by a corneal topographer is the most accurate measurement of peripheral corneal flattening available with current clinical instruments. Therefore, some practitioners might argue that it is the only instrument that should be used for evaluation of corneal curvature during the course of orthokeratology. The availability of a new and possibly more accurate measurement of peripheral corneal flattening than traditional "<CK-TK>" poses a question to practitioners of orthokeratology: Will their prognosis for the success of orthokeratology treatment be more accurate if they abandon the keratometer in favor of the topographer? The purpose of this study is to see if the amount of peripheral flattening as measured by two points on the keratometer (<CK-TK>) correlates with the more sophisticated calculation done by EyeSys.

METHODS

This study was conducted on 10 subjects (20 eyes). Both eyes of each patient were measured for corneal curvature, twice with the keratometer and once with the EyeSys topographer.

Keratometer readings were taken in the 180° meridian only. The first keratometer reading was taken in the standard manner, with the subject fixating on the central target of the keratometer to get the central-K reading. The second keratometer reading was taken with the subject fixating on the nasal "plus" mire on the faceplate of the keratometer to get the temporal-K reading.

The reading on EyeSys topographer was taken in the standard manner with the subject fixating on the central target.

For all measurements, the non-tested eye was occluded.

All subjects were optometry students at the Michigan College of Optometry. They ranged in age from 22 to 35 years. None of the patients had ever undergone corneal surgery or orthokeratology, or been diagnosed with any corneal dystrophy or degeneration. Refractive error was not a criterion for exclusion from this study.

The keratometer used in this study was made by Bausch & Lomb. It was calibrated by this researcher using three stainless steel balls of known curvature. The keratometer was found to be within plus/minus 0.125 diopters for all three sizes.

The data collected is summarized in Table 1. Table 1 also lists□<CK-TK> - the difference (in diopters) between central-K and temporal-K for each eye.

RESULTS

The regression analysis between <CK-TK> and e is represented in Figure 1, along with an x:y scattergram and a best-line plot. The coefficient of correlation is 0.76 (R = 0.76), which is a statistically significant result. A linear relationship can be expressed by the following equation: <CK-TK> = 7.77e - 1.00.

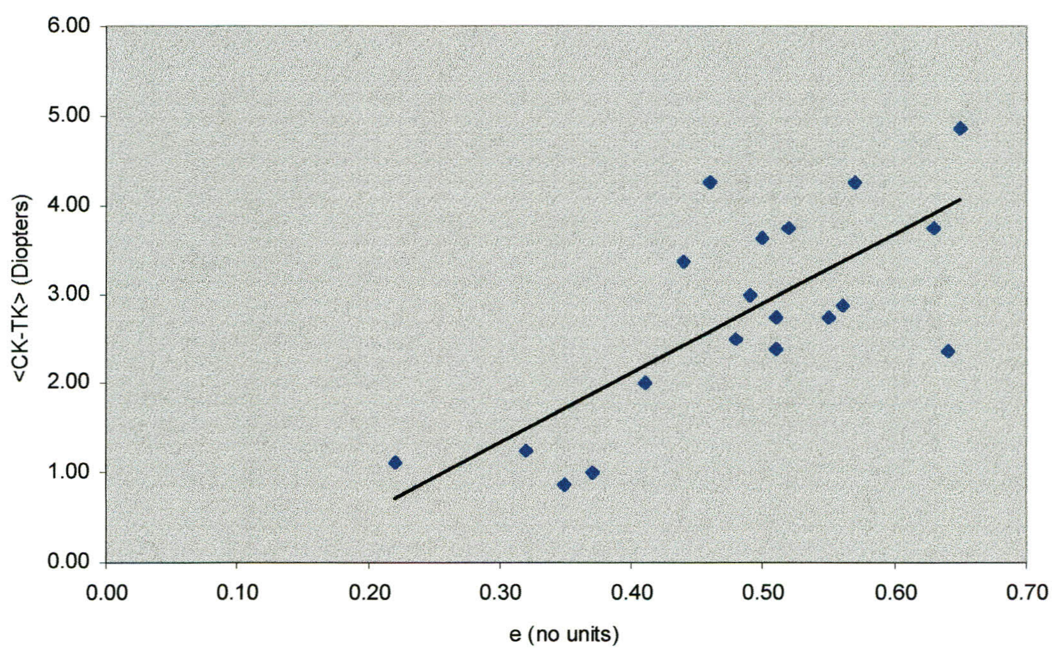
Table 1

Data from 20 eyes: Central keratometry (CK), Temporal keratometry (TK), the difference between CK and TK (<CK-TK>), and eccentricity (e).

CK		TK		<CK-TK>		e
45.37		42.50		2.87		0.56
45.50		42.75		2.75		0.55
43.25		39.00		4.25		0.46
43.00		40.50		2.50		0.48
46.25		45.00		1.25		0.32
46.50		45.25		1.25		0.32
43.25		39.62		3.63		0.50
43.25		40.50		2.75		0.51
42.62		41.50		1.12		0.22
42.87		41.87		1.00		0.37
42.37		39.00		3.37		0.44
42.25		39.25		3.00		0.49
43.00		41.00		2.00		0.41
42.87		42.00		0.87		0.35
49.00		44.75		4.25		0.57
48.87		44.00		4.87		0.65
42.37		38.62		3.75		0.63
42.12		39.75		2.37		0.64
42.37		38.62		3.75		0.52
42.25		39.87		2.38		0.51

Figure 1

Regression line for <CK-TK> as it relates to e (eccentricity).



DISCUSSION

SOURCES OF ERROR - MEASUREMENT

It is well documented that the keratometer is prone to measurement error. Some studies have ranged as high as plus/minus 0.37D.[7,8,9] There are several ways in which inaccuracies may be introduced into keratometry:

Patient Factors Patient fixation must be stable and directed to the appropriate target. In this study, fixation is even more problematic when taking the temporal-K reading because the plus mire is too close for most patients to bring into focus, and the mire is not designed to be a fixation target. Inadequate blinking can lead to distorted mires and inconsistent readings.

Examiner Factors The examiner must give proper instructions on fixation and blinking. The examiner must also be sure to focus the eyepiece properly and focus the mires properly. Interpolation between marks on the keratometer knobs can lead to rounding error.[7,9]

Corneal topographers such as the EyeSys have been studied and found to be on average no more consistent than the keratometer:

Patient Factors As with the keratometer, it is important for the patient to maintain stable fixation on the central target and to blink frequently enough to maintain a stable precorneal tear film.

Examiner Factors The examiner must give proper instructions to the patient. The examiner must focus the instrument properly on the patient's cornea. Since there is no image doubling system as on the keratometer, an exact focus point is harder to determine.

SOURCES OF ERROR - THEORETICAL

The keratometer does not directly measure any identifiable surface area. It measures only two points on the cornea approximately three millimeters apart, and the cornea is assumed to be spherical in the local area. The reading gives no useful topographic information; it only estimates corneal curvature in a given zone.

A corneal topographer measures only that part of the corneal surface directly beneath the projected rings; the greater the number of rings and the closer they are together, the greater the ability to detect variations in the corneal topography. Numerous assumptions about the cornea and numerous mathematical assumptions underlie the analysis of the images captured.[7,9]

CONCLUSIONS

There is a strong correlation between <CK-TK> as measured by the keratometer and e as measured by the EyeSys corneal topographer. In the opinion of this researcher, it is reasonable for a practitioner of orthokeratology to continue to use the keratometer both as a basis for predicting the amount of myopia reduction possible and for determining an endpoint for treatment. The numbers in this study are small (20 eyes) and further study may be helpful.

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