Repeatability and Accuracy of the Oculus Pentacam HR® Corneal Topographer in Measuring Radius of Curvature and Shape Factor

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Introduction

Measurements of central and peripheral corneal curvatures and asphericity are useful parameters for assisting with diagnosing keratoconus and other degenerative conditions of the cornea, monitoring the shape of the corneal contour following LASIK or for other refractive procedures. It is also useful for the fitting and evaluation of contact lenses and for evaluating the effectiveness of orthokeratology.1

Measurement of these parameters has typically used reflection-based technologies. However, numerous limitations exist with this approach, including limiting curvature measurements to the central 3.75 mm and underestimating the corneal curvature following LASIK with traditional instruments. 2,3 The recent introduction of Scheimpflug-imaging has gained popularity among researchers and eye care practitioners.4

To-date, there are several reports on curvature measurements on human corneas, but no available data on surfaces of known shape.

Purpose

To determine the repeatability and accuracy of the Oculus Pentacam HR® (Wetzlar, Germany) based on six polycarbonate aspheric surfaces of known radius of curvature and shape factors.

Methods

Six polycarbonate aspheric surfaces were mounted on a transparent rectangular plastic block. These were colour coded (red, white, blue, brown, green, yellow) and their radius of curvature (r) and shape factor (p) were measured and repeated. The aspheric surfaces were cylindrically shaped with a total diameter of approximately 13mm, which is similar to the normal human cornea (Figure 1).

The polycarbonate aspheric surfaces were randomly selected and their surfaces were gently cleaned with a lens cloth both before the measurements. The transparent polycarbonate block was firmly attached to the Oculus Pentacam HR® unit to align with the optics and the internal target of the Scheimpflug camera for easy measurement and evaluation. The room lights were switched off to reduce the reflection from the transparent surface and a piece of dark cardboard was used to cover the edges of the block, leaving only the aspheric surfaces for the measurements to be taken.

The examiner focused and adjusted the joystick until the real-time image of the aspheric surface was shown on the computer monitor, with the instrument showing the centre of the surface. The block displayed on the screen guided the investigator to perfectly align the horizontal and vertical (crosshairs) axes at the centre of the aspheric surface. To reduce investigator variability, the automatic mode was used to take all the measurements.

The rotating camera was set to capture 25 Scheimpflug slit images at 360 degrees in approximately 2 seconds. This procedure was repeated in approximately 2 minute intervals for each scan. After every measurement, the Oculus Pentacam HR® was moved backwards and realigned for the next scan, to eliminate interdependence of the readings. Three scans were taken on each aspheric surface. Since the test objects involved in this research were plastic aspheric surfaces, any scan that registered as “modell!” “blinking!” and “ok” were considered according to the Examination Quality Specifications within the standard of the instrument. This was to ensure that the scans were not affected by poor alignment/misalignment with the optics of the instrument. Any misalignment observed was readjusted before the measurement. This procedure was repeated on all six surfaces. The measurements were repeated on three separate days, with an interval of at least 48 hours.

The radii of curvature measurements were taken from the central 3mm, while the shape factor measurements were taken within 20 degrees, as this range was found to give the most consistent readings.

The true radii of curvature and shape factors were given by the manufacturer for each of the six surfaces.

Results

The mean radius of curvature values obtained for the surfaces were slightly higher than the true radius of curvature values, with the exception of the blue surface. The average radii of curvature for blue were 7.78mm, 7.75mm and 7.73mm for day 1, 2 and 3 respectively and were lower than the true radius of curvature values on day 2 and 3. There were no statistically significant differences in the measurements among the three day sessions (p=0.05). The coefficient of variation (CV%) for the three day sessions were found to be 0.30% (Figure 2a and 2b). 0.30% and 0.50%.

Table 2 shows the mean and SD of the shape factors for all the three day sessions. There were no statistically significant differences among the three day sessions, with the exception of the brown surface (p<0.01). The mean shape factor obtained for red (0.52) on the third day was quite high, however, there was no significant difference compared to the first and the second day sessions (p=0.15). The CV% for the three day sessions were 15.20% (Figure 3a and 3b), 16.40% and 22.40% respectively.

Discussion

The slight variations in the means of the three day sessions observed could be explained by the fact that the mild reflection and the internal reflection of the polycarbonate aspheric surfaces may have affected the instrument’s ability to measure the various parameters accurately. (Figures 4a and 4b) Unlike the human cornea, the blue light emitting diode used in the Oculus Pentacam HR® has to pass precisely through a symmetric contour and through a thick transparent polycarbonate block. Reflections from the surface as well as the internal reflection may be accountable for such variations. However, polycarbonate has a reflectance of 11%, which is similar to that of human eye. Potvin et al.in their study on polycarbonate and steel ball surfaces found that the reflection on a test surface (especially a steel ball) is likely to affect the instrument’s output and polycarbonate provided better results.

According to McCoy et al., the object centration and a target off-centre by more than 0.25 mm can result in unreliable data and increasing the focal distance by greater than 1 mm beyond the focal point results in a sharp decrease in accuracy of the data collected. In the case of this study, centration was achieved by mounting the polycarbonate aspheric surface to the headrest with a clamp and any variation in the results may be the result of using the automated measurement mode. The focusing power and algorithm could not be determined and therefore could not be assessed as to whether they played a role in the accuracy of the results.

Conclusions

In conclusion, the Oculus Pentacam HR® was a repeatable and accurate instrument in this experiment for the majority of radii of curvature and shape factors. It was unpredictable as to whether either the range of radii or shape factors were over or under-estimated by the instrument, as no clear trends were detected.

References


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