SCHOOL OF OPTOMETRY

Comparison of Higher Order Aberrations Measured Over Scleral Lenses to Higher Order Aberrations of the Posterior Cornea

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This study aims to compare amounts of higher order aberrations (HOAs) in eyes fit in a base scleral lens versus higher order aberrations of the corresponding eye's posterior cornea.

Method

In this study we retrospectively analyzed twenty-one individual eyes with both normal and irregular corneas. Zernicke polynomials of the posterior corneas for a central 6mm pupil diameter were computed with a Pentacam corneal tomographer. Values were gathered for horizontal coma, vertical coma, oblique trefoil, vertical trefoil, spherical aberrations, and RMS. The same eyes were measured while fitted with a base scleral lens, using an OVITZ aberrometer to capture the same values. Quantitative comparisons were conducted using a linear regression model to assess the relationship between the values obtained in both scenarios.

Results

Significant variation in HOAs between and within patients was observed. Horizontal coma (Coefficient = 0.4118, R^2 = .3115, p = 0.0086), vertical trefoil (Coefficient = -0.3934, R^2 = .1266, p = 0.1134), oblique trefoil (Coefficient = -0.2179, R^2 = .01524, p = 0.5939), and spherical aberrations (Coefficient = 0.3212, R^2 = .09908, p = 0.1646) were not found to have any statistically significant relationships or associations. Vertical coma over a scleral lens versus the posterior cornea was found to have a positive correlation (Coefficient = 0.806, R^2 = .3194, p = 0.0076). Adjusting for a single outlier within vertical coma (n=20), there was found to be a stronger correlation (Coefficient = 0.8039, R^2 = .5945, $p < 0.0001$). When accounting for outliers (n=18), overall root mean square (RMS) over a scleral lens versus the posterior cornea was found to be have a direct relationship (Coefficient = 1.045, R^2 = .6671, $p < 0.0001$), though statistical significance was not found within the original patient base (Coefficient = 0.1466, R^2 = .004268, p = 0.7784).

Discussion

Higher order aberrations (HOAs) can induce visual disruptions even in eyes that are optically corrected. Eyes with keratoconus are known to have higher levels of HOAs, specifically vertical coma. While HOAs can originate from any refractive surface within the eye, it is theorized that the posterior cornea is the largest contributor to overall HOAs, especially in irregular corneas. While some patients are sufficiently corrected with scleral lenses alone, there exists a subset with elevated aberrations or heightened sensitivity that need additional HOA correction atop the lens. As not all practitioners routinely fit an HOA compatible lens, exploring a screening tool to predict patients who may benefit from HOA correction in addition to scleral lens correction is valuable.

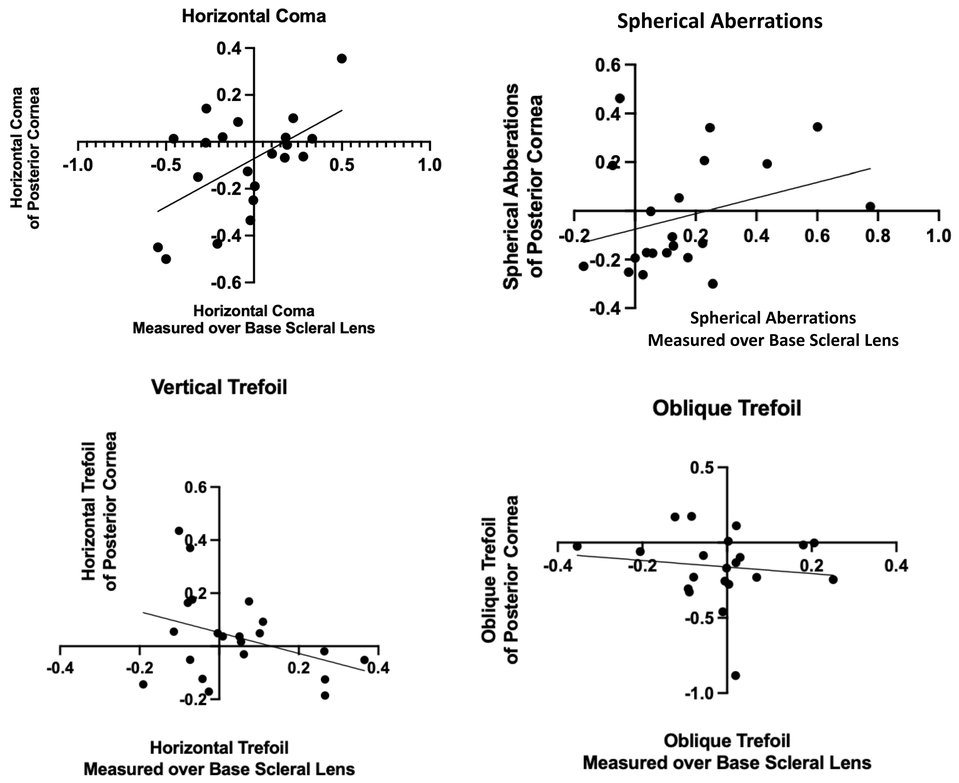

Figure 1: Linear regression models of horizontal coma, spherical aberrations, vertical trefoil and oblique trefoil showing no correlation

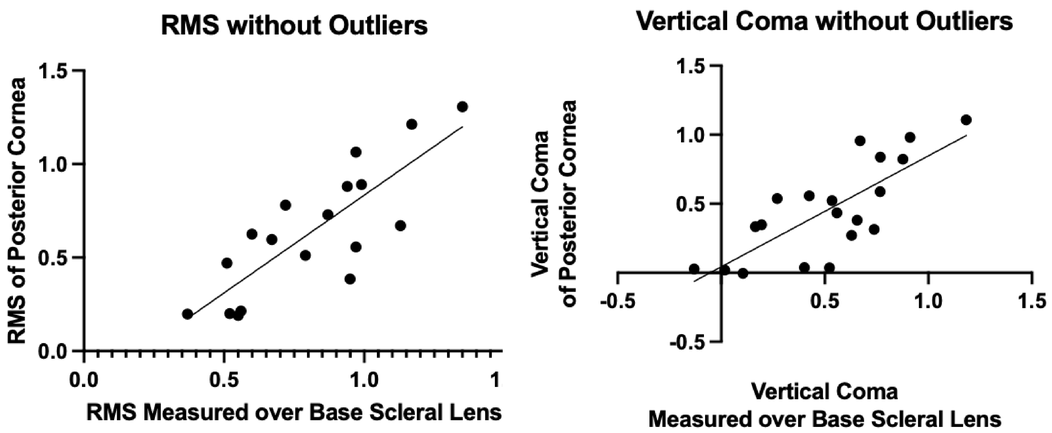

Figure 2: Linear regression models of RMS and Vertical Coma with outliers excluded showing positive correlation

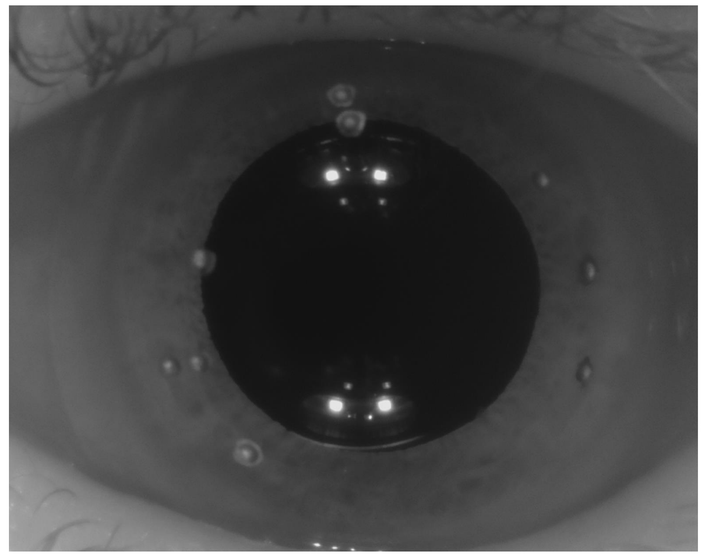

Figure 3: Eye #13 (outlier) with a base scleral lens; decentration of the lens is shown

Conclusion

It remains difficult for clinicians to predict the need for HOA corrections in scleral lenses. It was proposed that wavefront tomography of the posterior cornea may be used as a screening to determine which patients will have high levels of HOA, even after scleral lens correction. However, after removing outliers, only vertical coma and RMS showed a statistically significant positive correlation. As many patients with keratoconus have large amounts of vertical coma (and is a large percentage of most practitioner's scleral population), this may still be valuable information. Most optometrists who routinely fit sclerals are taking corneal tomographies, and should be able to look at vertical coma levels of the posterior cornea; if these are high, this could signal that patient may need HOA correction on top of their lenses. The outliers may have had additional and/or opposite HOAs induced due to scleral lens decentration, as shown in figure 3. This may additionally be the cause of the lack of correlation with other HOAs. It also may indicate that internal structures of the eye are having a large effect on higher order aberrations. It may also indicate that further research needs to be completed, potentially comparing the HOA values from an aberrometer and tomographer of normal eyes, keratoconic eyes, and post-surgical eyes. Despite the utility of wavefront corneal tomography, it does not seem to be reliably predictive of Zernicke polynomial values over a scleral lens.

References:

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