Increase in Refractive Index after Corneal Crosslinking: Theoretical Analysis and Clinical Validation

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Purpose

To investigate the difference in Optical Coherence Tomography (OCT) reporting less change in central corneal thickness (CCT) after corneal crosslinking (CXL) than Scheimpflug Tomography (ST).

Methods

The observed corneal thickness in an OCT image (d_o) appears larger than actual CCT due to the optical path length measurement with $CCT*n = d_o$, where n is index of refraction. ST includes a side view, so the posterior surface is viewed through the anterior surface with refraction, making the observed CCT in the image appear smaller than actual. (FIGURE) Equations to predict CCT as a function of n in the respective images for both devices were written for simultaneous solution. Subjects with ectasia, scheduled for CXL, were prospectively recruited for pre and post-CXL exams, at baseline immediately prior to CXL and at follow-up. CCT was quantified using anterior segment OCT (ANTERION) and ST (Pentacam). CCT was compared between baseline and follow-up with paired t-test for each device, and between devices using Wilcoxon Signed Rank Tests for nonparametric data with significance threshold, $p < 0.05$. Device specific equations for CCT and n were solved simultaneously and iteratively on n, at follow-up time for those subjects with minimal difference in CCT at baseline to avoid including measurement error.

Results

For 24 eyes of 22 subjects at baseline, there was no statistically significant difference ($p = 0.06$) in CCT between OCT (median with IQR, 470.8 [445.9, 519.3] μ) and ST (475.5 [449.3, 515.1] μ). At follow-up, CCT was significantly greater ($p = 0.01$) when measured with OCT (473.0 [431.6, 517.6] μ) than with ST (464.8 [434.0, 511.2] μ). There was no statistically significant difference in CCT ($p = 0.74$) for OCT between baseline (474.6 ± 49.4 μ) and follow-up (474.1 ± 50.2 μ). For ST, CCT was significantly greater

($p < 0.001$) at baseline (480.0 ± 45.5 μ) than at follow-up. (469.0 ± 50.9 μ). There were16 eyes with 6 μ or less difference in CCT between OCT and ST at baseline. The range of predicted percent change to n was 0% (zero difference in CCT between devices post-CXL) to 3.57% increase (33 μ difference in CCT), with OCT larger.

Conclusions

The larger the difference in measured CCT between devices after CXL, the larger the increase in corneal refractive index that has occurred. The actual CCT is between those reported, with OCT overestimating and Scheimpflug underestimating.