Central corneal thickness changes after crosslinking combined with photorefractive keratectomy and associated predictive factors

L. Haines,[1*] O. Kralj,[2] S. Marschall,[3] A. Gawish,[4] P. Fieguth,[4] N. Singal,[5] H.F. Chew,[5] D. Rootman,[5] A. Slomovic,[5] W. Hatch,[5] K. Bizheva,[1,2,4] L. Sorbara[1]

[1]School of Optometry & Vision Science, [2]Dept. of Physics and Astronomy, [3]Oculus, Wetzlar, Germany, [4]Systems Design Engineering Dept., University of Waterloo, Waterloo, Ontario, Canada; [5]Dept. of Ophthalmology and Vision Sciences, University of Toronto, Toronto, Ontario, Canada

*lhaines@uwaterloo.ca

Introduction

- Keratoconus (KC) treatments typically manage patients' symptoms of poor vision, often using specialty contact lenses.[1] Corneal crosslinking (CXL) surgery is a more recently developed treatment option that aims to reduce the progression of KC.[2] CXL can be combined with other surgical procedures such as photorefractive keratectomy (PRK) to improve refractive outcomes.
- CXL and CXL + PRK surgeries have proven to be safe and effective treatments for eyes with progressive KC in early and moderate stages.[2,3] Although uncommon, some complications that have been reported after CXL include reduced visual acuity, corneal scarring and decreases in corneal thickness.[2,3]
- Previous studies have shown that age, baseline thinnest pachymetry measurements, pre-operative visual acuity and baseline maximum keratometry (K) readings were associated with an increased risk of complications.[4,5]
- Despite the increasingly large number of studies on CXL, there is little knowledge of the effect of CXL or CXL+PRK on the morphology of the cornea and its sublayers. This information could provide a better understanding of CXL complications and post-operative corneal shape changes. Pre-operative factors that can predict thickness changes in the cornea caused by CXL surgery could be used to help guide treatment decisions and maximize patient outcomes.

Purpose

The purpose of this study is to investigate changes in epithelial thickness (ET) and total corneal thickness (TCT) one year after CXL+PRK surgery and whether age and baseline corneal topography measurements affect these changes

Methods

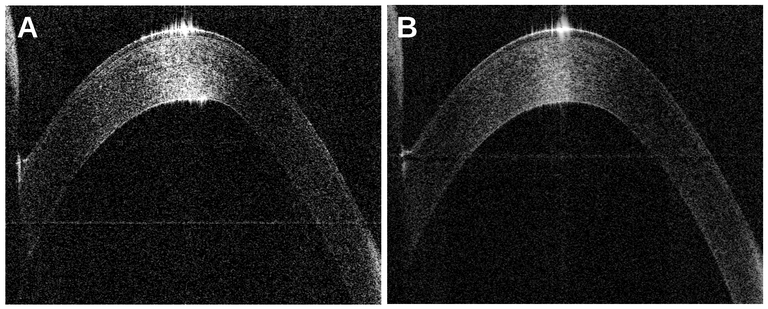
10 eyes with keratoconus from 10 subjects were imaged with a Scheimpflug topographer and a swept-source optical coherence tomographer (SS-OCT) no more than one month prior to receiving CXL+PRK surgery and again one year later. SS-OCT images were acquired using a research-grade SS-OCT system which provided 5 µm axial, ~15µm lateral resolution, and ~4 mm scanning depth in corneal tissue. Volumetric OCT images of the KC cornea were acquired at the speed of 100,000 A-scans/sec. The images were analyzed with a custom image processing algorithm that segmented the anterior and posterior surfaces of the cornea, as well as the posterior epithelial boundary. The thicknesses of the total cornea (TCT) and epithelial layer (ET) at the point of minimum total corneal thickness were acquired from the SS-OCT images using custom processing software. Regression analysis was performed to determine predictive factors for epithelial and total thickness changes one year after surgery. Statistical analysis was carried out with Origin 2013 and Excel 2013.

Results

Number of subjects/Eyes	10
Male:Female	8:2
Mean Age (years ± SD)	26.3 ± 5.5
Kmax (Dioptres ± SD)	57.5 ± 3.2
Mean Flat K (Dioptres ± SD)	46.8 ± 2.9
Mean Steep K (Dioptres ± SD)	50.7 ± 2.3
Min Corneal Thickness (µm ± SD)	478.0 ± 33.2
Epithelial Thickness (µm ± SD)	54.5 ± 3.4

Table 1. Baseline data for the keratoconic eyes prior to receiving CXL+PRK surgery.

Figure 1: Representative SS-OCT images for subject #6 at the pre-operative (A) and at the 12 month follow up (B) visits. The anterior and posterior corneal borders (yellow lines), as well as the posterior epithelial boundary (blue line), are segmented in B. The images displayed are shown before distortion correction.



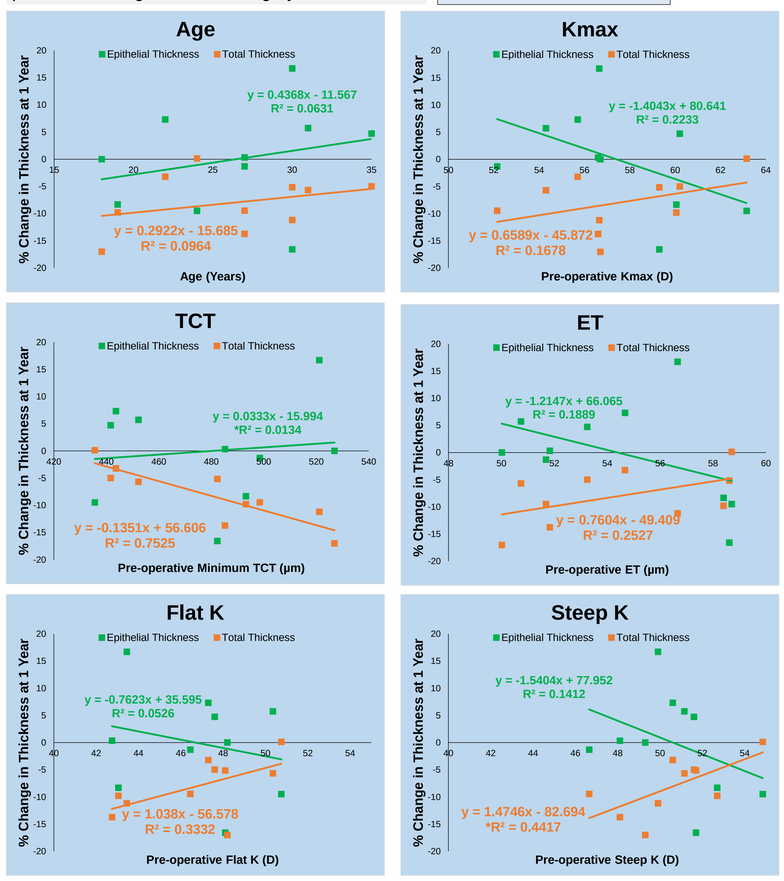


Figure 2: Scatterplots showing linear regression analysis for the percent changes in ET and TCT at one year plotted against the indicated pre-operative factor. The mean pre-operative ET (54.5±3.4µm) was not significantly different than the same measurement at one year (54.3±5.0µm; p=0.46). The mean pre-operative TCT (478.0±33.2µm) was significantly smaller at the one-year follow-up (438.5±15.4µm; p=0.00065). Plotting of individual data shows increases and decreases in ET and TCT measurements of up to 17%. Regression analysis demonstrates changes in TCT at one-year were significantly associated with baseline measures of TCT (R^2=0.75, p=0.001) and steep K (R^2=0.74, p=0.036). Age and baseline topographical measurements were not significantly associated with changes in ET (P>0.05 for all). * = Statistically significant (p<0.05).

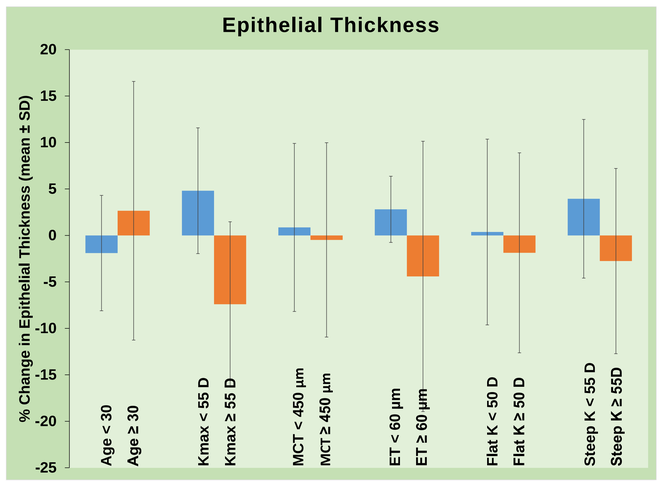


Figure 3: Relative changes in ET between baseline and one year after CXL + PRK in the subcategories indicated. Differences between subcategories were not statistically significant (p>0.05).

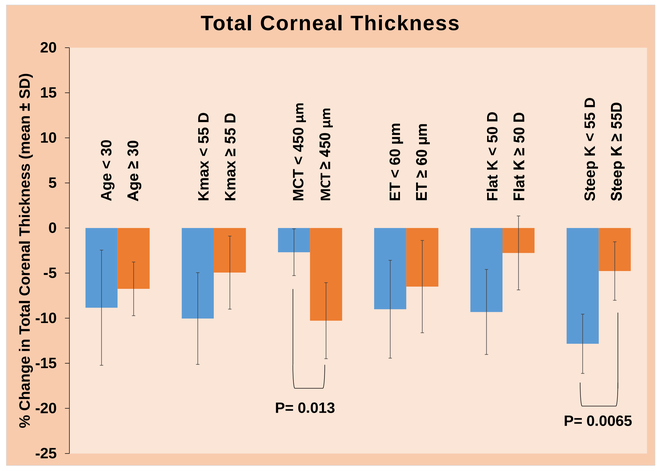


Figure 4: Relative changes in TCT between baseline and one year after CXL + PRK in the subcategories indicated. Unless indicated, differences between subcategories were not statistically significant (p>0.05).

Discussion

- Changes in the thickness of the cornea and its sublayers after CXL + PRK can influence refractive outcomes and is monitored for potential complications. Large variations in individual results makes it difficult to predict treatment outcomes.
- Corneas with larger TCT and smaller steep K values at baseline were significantly associated with larger decreases in TCT one year after CXL + PRK surgery. This result may be due to the surgeons limiting the amount of corneal tissue that could be safely removed from thinner corneas during the PRK procedure. Since larger steep K readings are associated with more advanced KC and, thus, thinner corneas, the decreases in TCT were not as large for these corneas with smaller TCT and larger steep K readings at baseline.
- The other pre-operative factors of age, maximum keratometry, pre-operative ET, and Flat K were not significantly associated with changes in TCT. None of these pre-operative factors were significantly associated with changes in ET.
- This study found baseline thinnest pachymetry to be related to corneal thickness changes. Maximum keratometry readings and age were not significantly associated with changes in corneal thickness. Visual acuity was not studied in this report. These pre-operative factors have been shown to be associated with increased risk of complications in other studies.[4,5]

Conclusion

Mean TCT measurements were significantly less at the one year follow up but ET did not show a significant change. Both increases and decreases in individual thickness data were observed but only changes in TCT were significantly associated with baseline steep keratometry values and pre-operative minimum TCT. Corneas with greater TCT and flatter steep keratometry values demonstrated larger decreases in TCT.

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