Predicting Corneal Oedema from Scheimpflug Images of Fuchs Endothelial Corneal Dystrophy

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BACKGROUND

- Scheimpflug tomography can detect subclinical edema in Fuchs endothelial corneal dystrophy (FECD), i.e., before edema becomes detectable by biomicroscopy[1] (Figure 1).

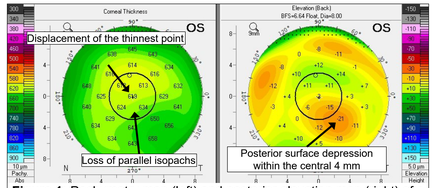


Figure 1: Pachymetry map (left) and posterior elevation map (right) of a cornea with FECD exhibiting tomographic features of edema: loss of normal circular/oval and parallel isopachs (lines joining points of equal thickness), displacement of the thinnest point of the cornea (o) >1 mm from the pupil center (+) or anywhere outside of the inferotemporal quadrant, and posterior surface depression (negative elevation) within the central 3-4 mm of the cornea.

- The tomographic features of edema predict FECD disease prognosis[2] and cornea-related vision.[3]
- We recently validated a special Scheimpflug tomography image analysis model that predicts the improvement in central corneal thickness (CCT) after Descemet membrane endothelial keratoplasty (DMEK) for FECD[4] from preoperative images (Figure 2).

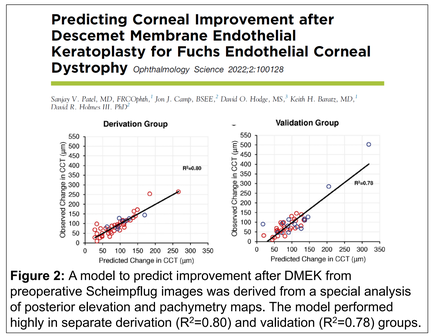


Figure 2: A model to predict improvement after DMEK from preoperative Scheimpflug images was derived from a special analysis of posterior elevation and pachymetry maps. The model performed highly in separate derivation (R^2=0.80) and validation (R^2=0.78) groups.

PURPOSE

In this study, we assessed if adding corneal backscatter and pachymetric progression indices improved the predictive power of the existing model.[4]

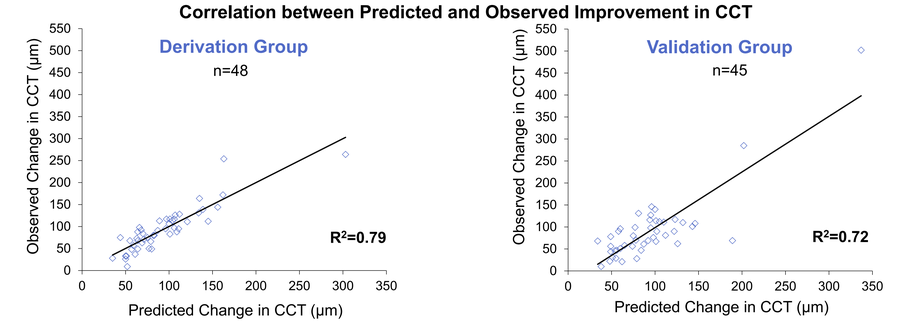
METHODS

- Study design: Derivation and validation study.
- Derivation and validation groups:
  - Eyes with FECD undergoing DMEK.
  - Scheimpflug tomography (Pentacam, Oculus) before and 6 months after DMEK.
- Analysis of preoperative images:
  - ≈90 special parameters were derived from a custom analysis of posterior elevation and pachymetry maps.
  - ≈130 parameters were derived from the instrument software including:
    - Corneal backscatter, determined from the "Corneal Densitometry" analysis of different regions of anterior, mid, and posterior cornea.
    - Pachymetric progression indices, i.e., those derived in the "Belin-Ambrosio Enhanced Ectasia" analysis and typically used for screening for corneal ectasia.
- Model development:
  - Gradient boosting machine models were used to determine relative influence of all 220 parameters.
  - Logistic regression model of highest 5 influencers.
- Statistical analysis:
  - Derivation group parameter estimates were applied to the validation group.
  - Goodness-of-fit of predicted vs. true improvement in CCT after DMEK was assessed from R^2.
  - Agreement was assessed by using Bland-Altman plots and summarized as the mean difference and the limits of agreement (mean difference ± 1.96*standard deviation of the difference).

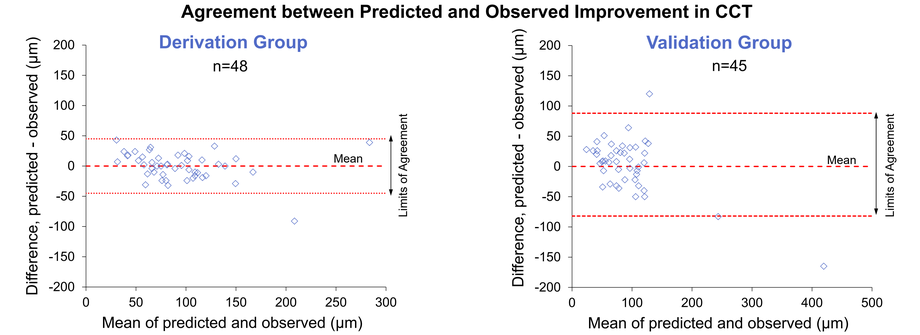
RESULTS

Highest Relative Influencers

From special analysis:	*From software analysis:*	*Note:*
➢ Isopach circularity	➢ Central (0-2 mm) anterior backscatter	➢ Pachymetric progression indices were not good influencers in the GBM model
➢ Isopach eccentricity	➢ Paracentral (2-6 mm) anterior backscatter	➢ Predictive value of any individual parameter was <50%
	➢ Central stromal (mid) backscatter	



Figures 3 and 4: There were strong correlations between predicted and observed improvements in CCT for the derivation and validation groups with high predictive power.



Figures 5 and 6: Bland-Altman plots showed good agreement between predicted and observed improvements in CCT. In the validation group, the mean difference was close to zero, though the limits of agreement were wider than for the derivation group.

CONCLUSIONS

- Corneal backscatter contributes to, but is not necessary for, the predictive model; the original model without corneal backscatter had 78% predictive power in the validation group.
- Corneal backscatter measurements can be variable because of changes in instrument light intensity and camera sensitivity between examinations, over time, and between sites, and this might be one explanation for the lower predictive power.
- Pachymetric progression indices do not contribute to the model.

REFERENCES

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SUPPORT

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DISCLOSURE

SVP:	Consultant to Santen Inc., Emmecell, Design Therapeutics Inc. Developer of V-FUCHS questionnaire, which Mayo Clinic licenses to Santen Inc., Iris Medicine, Trefoil Therapeutics, Kowa Research Institute, and Aerie Pharmaceuticals.
DOH:	None

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