Lasik-Induced Posterior Corneal Changes Measured by Scheimpflug Imaging: Validation on Model Corneas and Measurements on Patients

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1 Background & Purpose

Background:
Although the contribution of the posterior corneal surface to ocular aberrations has often been neglected, there is evidence that it plays a role in normal eyes (i.e., compensatory role of astigmatism and other aberrations[1,2]) and many reports discuss changes of the posterior corneal shape following refractive surgery[3,4,5] with implications to understand biomechanical effects. Most of the literature regarding posterior corneal shape changes with refractive surgery referred to scanning slit topography. Concerns of the reliability of this instrument have been raised[6], and some of the reported changes may be subject to artifacts. Scheimpflug imaging provides images of the anterior chamber of the eye with greater depth-of-focus, although these are also subject to distortions (geometrical, due to the geometric configuration of the camera and optical, due to the refraction from the preceding ocular surfaces). A validation of the correction of the images is needed before it can be reliably used to obtain posterior surface shapes and study changes with refractive surgery[7].

Purpose:
1. To check the reliability of the Pentacam (Oculus), to measure posterior corneal surface using corneal models on plastic material. We will assess whether the changes in the anterior surface (by laser ablation) affect measurements in the posterior surface.
2. To measure potential changes of the posterior corneal surface with LASIK in patient’s eyes (before and after LASIK, as well as longitudinally after LASIK).

2 Methods

Scheimpflug Imaging
Scheimpflug cameras allow capture of cross-sectional images of the eye’s anterior chamber, although these are subject to geometrical and optical distortions from the preceding ocular components[8]. We used a Pentacam system (Oculus), which nominally corrects for these distortions. 2-D elevation maps were reconstructed from 25 section images.

Custom algorithms were developed in Matlab to fit posterior elevation maps with biometric functions:

\[ R_{ch}(x,y) = k_{ch} R_{ch0} - f_{ch} \]

Rch: Radius along the meridional axis, 
Rch0: Radius along the equator, 
fch: Axial deviation from the best fitting sphere.

Radius of curvature k against distance to the apex.

Shape factor p against distance to the apex.

Radius of curvature and asphericity before and after ablation were compared with results from the commercial software.

Paired t-tests were used to assess significant differences before and after ablation. Study was done to assess potential longitudinal changes and correlations with corrected spherical error. The level of significance was set at p<0.05.

3 Results

Corneal models
We found an adequate material to measure both the anterior and posterior corneal surfaces with the Pentacam.

Custom routines
We found a good agreement between our custom routines and the Pentacam.

No significant changes in the posterior corneal surface shape on plastic model corneas before and after ablation. Optical distortions from the anterior corneas appear to be properly corrected by the Pentacam.

LASIK patients
Average data across all eyes
Changes in the posterior corneal surface: radius and asphericity are only significant immediately following the refractive surgery.

All eyes but one experience a decrease in posterior corneal radius (increased curvature), and all eyes experience a decrease in asphericity one day after surgery. The largest increase in corneal radius (from pre to one-day-post) occur for eyes with largest corrections (>6, -7, -25D).

Largest changes occur with largest spherical correction on day after surgery, there is a significant correlation decrease in posterior corneal radius and myopic spherical correction. Thus effect disappeared one month after surgery.

4 Conclusions

1) We developed a corneal model for validations of the Pentacam posterior corneal shape
2) We did not find statistical significant changes in the posterior corneal surface on plastic model corneas before and after ablation. This means that posterior corneal radius of curvature is unaffected by changes in the anterior cornea, i.e. that optical distortion from the anterior cornea is properly corrected in the system
3) We only found statistical significant changes (decrease) in radius of curvature and asphericity in patients one-day-post surgery. Differences tended to be higher for the highest corrections. Differences one week and one month post surgery are not significant
4) Using a calibrated Scheimpflug system (which did not introduce distortions) we found smaller changes in posterior corneal surface than previously reported with others system (Orbscan). These results have implications to understand optical and corneal biomechanical changes following refractive surgery.