RAY-TRACING PREDICTION OF INTRAOCULAR LENSES POWER: EFFECT OF CORNEAL ABERRATIONS

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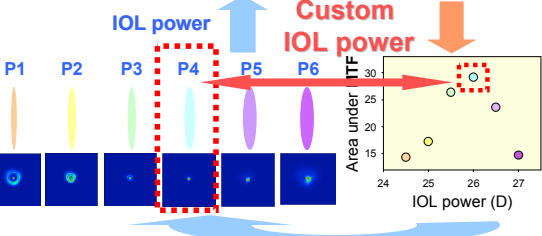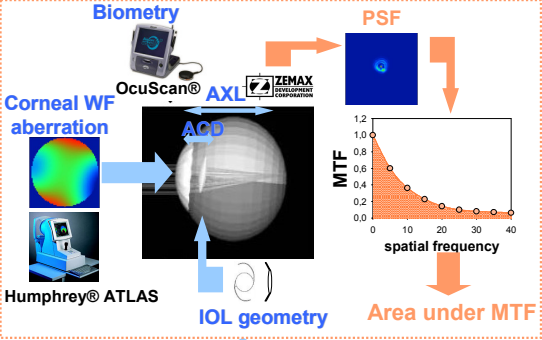
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INTRODUCTION

- IOL power calculations based on empirical approaches are usually suitable for normal patients. However, these procedures typically fails in those patients that had undergone previously refractive (LASIK) surgery.

- We have developed a customized ray-tracing method to predict the optimum IOL power. The accuracy and limitations of this procedure is evaluated for both normal and post-LASIK patients.
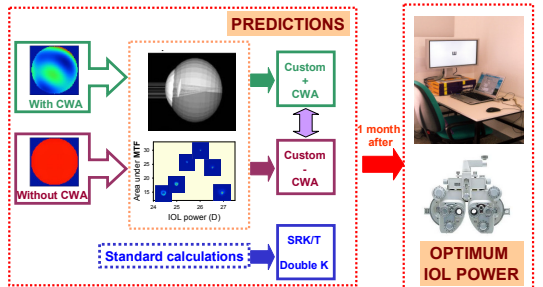
METHODS

Computational ray-tracing procedure

Polychromatic **exact ray-tracing procedure** using individualized data (4.0 mm diameter pupil)

Biometry
PSF
OcuScan®
ZEMAX DEVELOPMENT CORPORATION
AXL
Corneal WF aberration
ACD
MTF
1,2 1,0 0,8 0,6 0,4 0,2 0 0 10 20 30 40
spatial frequency
Humphrey® ATLAS
IOL geometry
Area under MTF

P1 P2 P3 P4 P5 P6

Custom IOL power

IOL power

Area under MTF
30 25 20 15
24 25 26 27
IOL power (D)

Experimental procedure

We evaluated 18 cataract normal patients with different refractive states and 9 post-LASIK patients (including both myopic and hyperopic LASIK). In each patient, the IOL power was predicted from ray-tracing with and without considering corneal aberrations. The predictions were compared with the actual optimum IOL power.
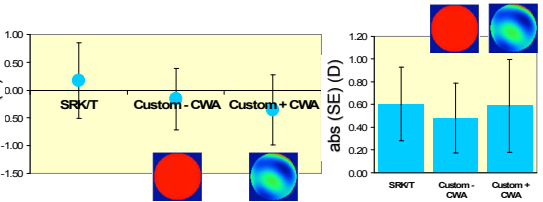
PREDICTIONS

With CWA
Without CWA
Area under MTF
IOL power (D)
Custom + CWA
Custom - CWA
1 month after
SRK/T Double K
Standard calculations
OPTIMUM IOL POWER

Spherical Equivalent (SE) = OPTIMUM IOL POWER - Prediction

CWA Influence = (Custom + CWA) – (Custom – CWA)

RESULTS

1) Normal cataract patients

Final spherical equivalent of the ray-tracing power predictions was similar to that obtain with standard calculations. Ray-tracing predictions with or without considering corneal aberrations were also similar.
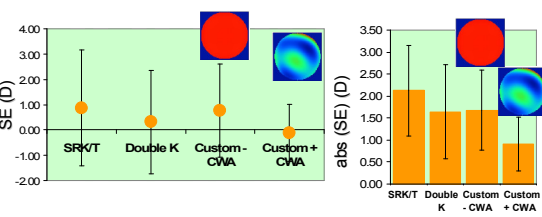
SE (D)
1.00 0.50 0.00 0.50 1.00 1.50
SRK/T Custom - CWA Custom+CWA

abs (SE) (D)
1.20 1.00 0.80 0.60 0.40 0.20 0.00
SRK/T Custom - CWA Custom + CWA

The difference between the IOL powers predicted by ray-tracing with and without aberrations was lower 0.5D, with small dependence on the amount of corneal aberrations (figure below).

CWA_influence (D)
0.90 0.50 0.10 -0.10 -0.30 -0.50
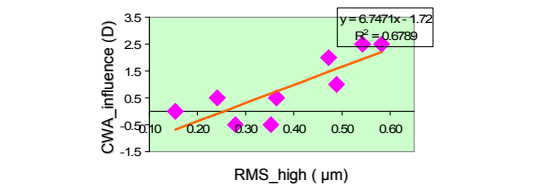0.00 0.10 0.20 0.30 0.40
RMS_high (μm)
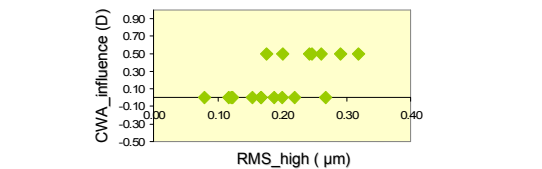
2) Post-LASIK cataract patients
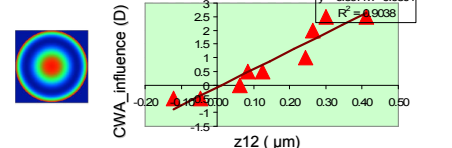
In these patients, ray-tracing predictions with corneal aberrations were more accurate than both single and double – K empirical approaches.

SE (D)
4.00 3.00 2.00 1.00 0.00 -1.00 -2.00
SRK/T Double K Custom - CWA Custom + CWA

abs (SE) (D)
3.50 3.00 2.50 2.00 1.50 1.00 0.50 0.00
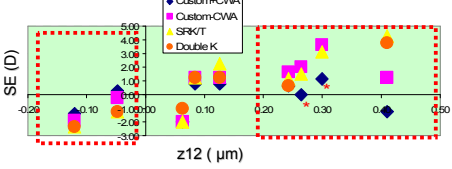SRK/T Double K Custom - CWA Custom + CWA

The impact of corneal aberrations in the IOL power prediction is clearly correlated with the amount of corneal aberrations. Those patients with abnormally elevated corneal aberrations will experience the larger benefit of a ray-tracing approach.

CWA_influence (D)
y = 6.7471x - 1.72
R² = 0.6789
3.5 2.5 1.5 0.5 -0.5 -1.5
0.10 0.20 0.30 0.40 0.50 0.60
RMS_high (μm)

In particular, improved predictions occurs in those eyes with larger values of corneal spherical aberration (SA).

CWA_influence (D)
y = 6.5977x - 0.0801
R² = 0.9038
3 2.5 2 1.5 1 0.5 0 -0.5 -1 -1.5
-0.20 -0.10 0.00 0.10 0.20 0.30 0.40 0.50
z12 (μm)

Residual refractive error as a function of the corneal SA for all patients and the various predictive methods.

SE (D)
Custom+CWA
Custom-CWA
SRK/T
Double K
5.00 4.00 3.00 2.00 1.00 0.00 -1.00 -2.00 -3.00
-0.20 -0.10 0.00 0.10 0.20 0.30 0.40 0.50
z12 (μm)

CONCLUSIONS

- We have developed a robust customized ray-tracing procedure to predict the optimum IOL power.

- The procedure produces similar results in normal cataract patients compared to the empirical calculations. The reason may be a larger effect of errors in the biometric data than the actual calculation approach. This is reinforced by the fact that considering corneal aberrations does not improve in average the predictions.

- However, in the case post-LASIK patients, ray–tracing is clearly superior to standard calculations, especially in those patients with large amounts of corneal spherical aberration.