Correcting the correction:

Intraocular lens calculations after laser refractive surgery

On May 28, 2021, Bjørn Gjerdrum defended his thesis "Improvement in refractive precision for intraocular lens power calculations in patients with a history of laser vision correction for myopia" at the Department of Optometry, Radiography and Lighting Design, Faculty of Health and Social Sciences University of South-Eastern Norway (USN). The PhD project was conducted at Ifocus Øyeklinikk in Haugesund and Memira Clinics in Norway, Sweden, and Denmark. The supervisors were Bente Monica Aakre and Per Olof Lundmark, both associate professors at USN, and Kjell Gunnar Gundersen MD PhD Ifocus Øyeklinikk.

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In planning cataract surgery and refractive lens exchange (RLE), calculations of the intraocular lens (IOL) power depend on, at a minimum, the measurement of corneal curvature and the axial length of the eye. In general, the refractive accuracy of the procedure is high. However, for patients with previous laser vision correction (LVC), the precision is much lower because the empirical formulas do not account for the individual altered shape in these patients' corneas. Erroneous keratometric measurement due to an unstable tear film may be an additional confounding factor.

Traditionally, corneal power is predicted from reflection-based paracentral keratometry. An artificial corneal refractive index is used to account for the refractive contribution of the posterior cornea. For eyes with previous LVC, this assumption is wrong because the anterior surface of the cornea has been altered, making the prediction of the posterior corneal power erroneous. In addition, the prediction of central corneal power from paracentral measurements may be inaccurate. Special post-LVC formulas have been developed to correct for these errors, either using historic data, regression equations, or posterior corneal measurements. However, accurate IOL calculations remain challenging in these patients.

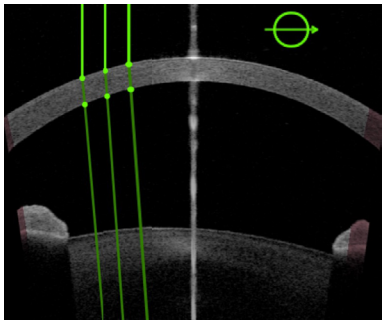

Figure 1. OCT image of anterior segment. Green lines illustrate ray-tracing calculations through different refractive surfaces at varying axes and radial distances.

An alternative approach to IOL calculations is ray tracing, where single rays at varying radial distances are calculated exactly using Snell's law (**Figure 1**). The calculation is based on individual measurements without relying on population-based assumptions or optical approximations. Instead of IOL power, the calculations use manufacturer provided lens radius, refractive index, asphericity, and thickness.

This thesis aimed to improve refractive precision for cataract or RLE in patients with previous myopic LVC. Four studies were conducted to investigate the objectives of the thesis.[1–4] Our retrospective analysis of previous RLE after LVC showed better refractive results than previously seen in the literature. However, further improvement could be achieved using a refined protocol with optimized lens constants and a target nomogram.[1] The prevalence of dry eye 5–15 years after refractive surgery suggested that LVC may induce tear film instability.[2] This was indicated by tear film osmolarity, even for subjects with few subjective symptoms of dry eye. However, a repeatability study found no evidence that the results of keratometry were influenced by tear film osmolarity.[3] A prospective treatment study showed that ray-tracing IOL calculations based on individual optical coherence tomography (OCT) measurements showed better prediction accuracy compared to reflection-based formulas in post-LVC patients (**Figure 2**).[4] Ray-tracing calculations are based on individual measurements and are independent of the patient's ocular history; therefore, they are also suitable for patients without previous refractive surgery.

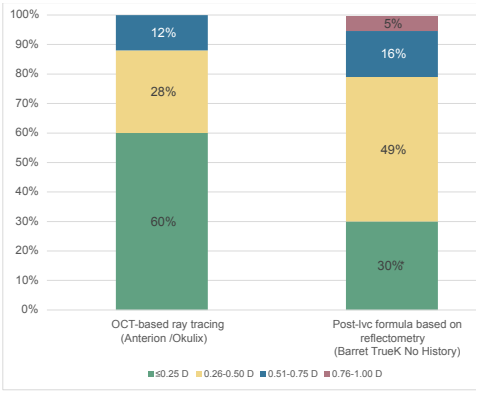

Figure 2. Percentages of refractive prediction error within certain ranges. Ray tracing showed the highest percentages of eyes with prediction errors within ±0.25, ±0.5, and ±0.75.

Key points:

- Even with few subjective symptoms, laser vision correction (LVC) may increase dry eye risk up to 15 years after surgery.
- The repeatability of keratometry with OCT-, reflection-, or Scheimpflug-based devices was not influenced by tear film osmolarity.
- Ray-tracing IOL calculations show better predictability than traditional post-LVC formulas. Calculations are based on measurements and independent of patient history.

References

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