

# Experiments on PMMA model to predict the impact of corneal refractive surgery on corneal shape: Reply

Carlos Dorrnsoro and Susana Marcos

Instituto de Óptica "Daza de Valdés",  
Consejo Superior de Investigaciones Científicas, Serrano 121, 28006 Madrid  
[cdorrnsoro@io.cfmac.csic.es](mailto:cdorrnsoro@io.cfmac.csic.es), [susana@io.cfmac.csic.es](mailto:susana@io.cfmac.csic.es)  
<http://www.vision.io.csic.es>

**Abstract:** A reply to the comment by Jiménez *et al.* directed to the paper of "Experiments on PMMA model to predict the impact of corneal refractive surgery on corneal shape" by Dorrnsoro *et al.*, *Opt. Express*, **14**, 6142-6156 (2006).

©2007 Optical Society of America

**OCIS codes:** (170.1020) Ablation of tissue; (170.3890) Medical optics instrumentation; (120.6650) Surface measurements, figure; (140.3390) Laser materials processing; (330.5370) Physiological optics; (330.4460) Ophthalmic optics; (220.1000) Aberration compensation.

---

## References and links

1. C. Dorrnsoro, D. Cano, J. Merayo-Llotes, and S. Marcos, "Experiments on PMMA models to predict the impact of corneal refractive surgery on corneal shape," *Opt. Express* **14**, 6142-6156 (2006).
- 

This letter is intended as a reply to the comment of Jiménez *et al.* directed to our original paper [1] describing an extension of the data analysis of our experimental data of ablation on PMMA artificial corneas. The understanding of the physical factors leading to differences between the expected and real post-ablation corneal shape is of tremendous clinical interest, since optical quality (and ultimately vision quality) in patients that undergo refractive surgery depends on the achieved corneal shape.

Our original paper [1] addressed experimentally the efficiency losses of laser energy caused by the geometry of the cornea. We obtained an experimental efficiency factor for PMMA as the ratio between ablation profiles on flat surfaces and ablation profiles on spherical surfaces. This factor is not based on any assumption and it accurately reproduces post-ablation shapes on PMMA artificial corneas (Fig. 7 on the original paper). Jiménez *et al.* replotted our experimental data as a function of the Beer Lambert law to study potential derivations of this law in the range of fluences of relevance in refractive surgery. While the question is of interest, this approach relies on a strong assumption: that all differences between theoretical and experimental efficiency factors come from the deviations of the Beer Lambert Law, and that all contributions of other effects that potentially affect the changes in laser efficiency (spot size and shape, overlapping of pulses, beam divergence changes from the center to the periphery, beam scanning effects, polarization, defocus, etc...) are negligible. Rather than using experimental data aimed at other purposes, a much more direct approach to studying potential deviations of the Beer Lambert law should rely on experimental techniques well known to the polymer photoablation community, involving direct measurements of the etch depth or the nonlinear absorption coefficient in the fluence range of interest.

In their comment, Jiménez *et al.* perform the analysis on PMMA and apply the deviations from linearity found for PMMA directly to the cornea to assess the visual impact of this effect. This procedure is highly speculative, as the ablation efficiency factors are significantly different for cornea and PMMA, essentially because ablation thresholds and ablation rates are different between PMMA and corneal tissue. In fact, in our original paper [1], we estimated the ablation efficiency factor for the cornea from the experimental measurements on PMMA,

and Fig. 6 shows the expected differences of efficiency factors between these two materials. While potential deviations of the Beer-Lambert law may have a refractive impact on the cornea, caution must be taken to extrapolate this deviation on PMMA to the cornea, and therefore the estimated discrepancy of -0.8 D (for an intended correction of 12 D) obtained by Jimenez *et al.* requires further validations.

We thank the authors of the comment for emphasizing the importance of experimental measurements on plastic corneal models. Given that no assumption is involved, we agree that they are useful calibration models and provide quantitative factors for optimization of corneal ablation profiles. We plan to extend our experiments to other polymers with closer ablation properties to that of the cornea, laser systems operating at other fluence regimes and different ablation algorithms.