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Modeling Aberrations From Surface Measurements of *ex-vivo* Isolated Human Crystalline Lenses

C. Schwarz[1], E. Acosta[2], J. M. Bueno[1], C. Molero[3] and P. Artal[1]

[1]Laboratorio de Optica, Universidad de Murcia, Murcia, Spain
[2]Facultad de Fisica, Universidad de Santiago de Compostela, Santiago de Compostela, Spain
[3]Servicio de Oftalmologia, Hospital Virgen de la Arrixaca, Murcia, Spain

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Abstract

Purpose: To measure the shape of the anterior and posterior surfaces of ex-vivo isolated (accommodated) human crystalline lenses and to quantify their contribution to the optical aberrations.

Methods:A shadow photography technique was used to measure both surfaces of human lenses from donor eyes (10 ± 6 hours postmortem) with ages ranging from 41 to 64 years. The lenses were back-illuminated and shadow photographs were recorded with a CCD camera through a telecentric objective. The lenses were immersed in a chamber filled with culture medium that was positioned on a micrometric rotation stage. Series of images were recorded for meridians 10° apart. From each one, the anterior and posterior surface profiles were fitted over the central 6-mm region using conic functions. The radius of curvature and asphericity of both surfaces, as well as the central lens thickness were determined. These data were used to reconstruct 3D information of the central region of the lens by adjusting splines to the series of conic functions for all sections. The optical power and aberrations of the lenses were calculated by ray-tracing from the measured geometrical data (3D-fitted) assuming a constant refractive index of 1.4. The optical power and aberrations of each lens were also measured using a Hartmann-Shack sensor and an interferometric technique.

Results: For all the lenses, the best fit to both surfaces was a circumference, with a fitting error for individual data points lower than 20 microns. The average radii of curvature were found to be 10.7 ± 1.7 mm and 6.2 ± 0.9 mm for the anterior and posterior surface respectively. These values varied over the projection angle reflecting the impact of astigmatism and other asymmetric aberrations. The predicted aberrations for the 3D lens reconstruction showed a prevalence of astigmatism and spherical aberration. The comparison of these modeling results with actual measurements in the lenses would indicate the relative contribution of the shape and structure to the lens aberrations.

Conclusions: The shape of isolated human crystalline lenses was measured using a custom built shadow photography technique. Effective optical power and aberrations were determined by ray-tracing from the 3D shape reconstructed lenses. The main aberrations calculated from the measured surfaces were astigmatism and spherical aberration.

Keywords: aberrations • optical properties • image processing