TECHNIQUES

Preoperative simulation of postoperative iris-fixated phakic intraocular lens position and simulation of aging using high-resolution Scheimpflug imaging

Mana Tehrani, MD, Matthias Schaefer, Johannes Koeppe, H. Burkhard Dick, MD

To increase postoperative safety after implantation of iris-fixated phakic intraocular lenses (pIOLs), optimal preoperative evaluation and patient selection is mandatory. We present a new software tool in a high-resolution Scheimpflug imaging device that precisely simulates the postoperative position of an iris-fixated pIOL and also simulates the effect of aging on the pIOL's position.

J Cataract Refract Surg 2007; 33:11–14 © 2007 ASCRS and ESCRS

Phakic intraocular lenses (pIOL) have been established as an effective and safe surgical option for the correction of myopia, hyperopia, and astigmatism. One of the currently available pIOLs is the iris-fixated Artisan (Ophthec; Verisyse, AMO), which has been successfully implanted over several years in phakic eyes for the correction of refractive errors. The rigid poly(methyl methacrylate) model has received approval by the U.S. Food and Drug Administration. The foldable model (Artiflex/Veriflex), which can be implanted through a self-sealing 3.2 to 3.5 mm clear corneal incision, is available in Europe.[1,2]

Ensuring safe intraocular distances between the pIOL and crucial intraocular tissues (eg, corneal endothelium and crystalline lens) postoperatively is mandatory for the long-term safety of this type of refractive correction. To exclude poor candidates for pIOL implantation (ie, those with a protruding iris or a poor peripheral anterior chamber depth [ACD]), careful preoperative selection is required.[3] Because of the increasing need for advanced technology to image and investigate the anterior segment to ensure mid-term and long-term safety after pIOL implantation, we have developed a Pentacam software tool to precisely simulate the postoperative position of the iris-fixated pIOL and also to simulate the effect of aging on the pIOL's position. To our knowledge, this is the first report of such a tool integrated into the Scheimpflug device.

TECHNIQUE

The Pentacam images the anterior segment of the eye using a rotating Scheimpflug camera with a noncontact measurement. Two types of the device are commercially available. The newer HR (high resolution) Pentacam offers increased image resolution. The rotating Scheimpflug camera provides a series of 50 Scheimpflug images in 2 seconds, showing the anterior segment of the eye from the anterior corneal surface to the posterior surface of the crystalline lens. From each of these images, over 1000 true elevation points are extracted by the software, obtaining 138 000 true elevation points for each surface, including the center of the cornea. The software generates a 3-dimensional

Accepted for publication July 16, 2006.

From the Department of Ophthalmology (Tehrani, Koeppe, Dick), Johannes Gutenberg-University, Mainz, and Oculus (Schaefer), Wetzlar, Germany.

M. Schaefer is employed by Oculus. No other author has a financial or proprietary interest in the mentioned products.

Corresponding author: Mana Tehrani, MD, Johannes Gutenberg-University, Department of Ophthalmology, Langenbeckstrasse 1, 55131 Mainz, Germany. E-mail: tehrani@augen.klinik.uni-mainz.de.

Published by Elsevier Inc.

0886-3350/07/$-see front matter
doi:10.1016/j.jcrs.2006.07.039

(3-D) model of each surface as a basis for corneal topographic and chamber analysis.

The new Pentacam software module simulates the positioning of a pIOL in the anterior chamber 3-D model measured by Pentacam and makes it visible to the surgeon. The pIOL is selected from an IOL database and automatically aligned on the iris surface, centered on the pupil. In each Scheimpflug image, the outlines of the simulated pIOL are drawn, including the distortion of the shape typically caused by optical refraction in Scheimpflug imaging. From each surface point of the pIOL, the distances to adjacent eye structures are calculated 3-dimensionally by the software, which results in real minimum values. These distances are presented in color maps that show every point of the pIOL in top view and as minimum space values for critical areas of the pIOL. The color maps also represent the actual simulated position in the *x*–*y* plane relative to the apex and the pupil.

The surgeon carries out the alignment of the pIOL by dragging and dropping in every direction in the color maps. With the help of online refreshed distance values and images, the optimum pIOL position and axis alignment will be defined and the compliance of the minimum distances supervised. When the pIOL is moved in the *x*–*y* direction or the axis angle is changed, the software aligns it on the iris surface. Final corrections in height and tilt can then be carried out by the surgeon to compensate for incorrect positioning caused by irregular iris spots.

The decrease in ACD due to aging can lead to a reduction in the minimum distance between the pIOL and the endothelium. This reduction can be predicted by the software for a selected patient's age to avoid future complications. Other contraindications such as irregular iris structures or a small chamber angle are also presented by the software.

Case Report

A 25-year-old woman presented with a subjective refraction in the right eye of -11.0 -2.0×40, with an uncorrected visual acuity (UCVA) of counting fingers and a best spectacle-corrected visual acuity of 20/40. The anterior chamber depth was 3.60 mm by IOLMaster (Carl Zeiss Meditec), the endothelial cell count was 3244 cells/mm^2, and the intraocular pressure was 11 mm Hg. Preoperative Scheimpflug imaging with the HR Pentacam was performed to evaluate anterior segment dimensions. The required iris-fixated pIOL model (biometric data such as diopters and material) and correction of the patient's refractive error were determined. Using the new pIOL simulation software program, the selected pIOL model was simulated preoperatively (Figures 1 and 2). After a complete evaluation, the patient was selected for pIOL implantation in our clinic. In February 2006, an Artiflex pIOL with a power of -12.5 diopters was implanted in the right eye.

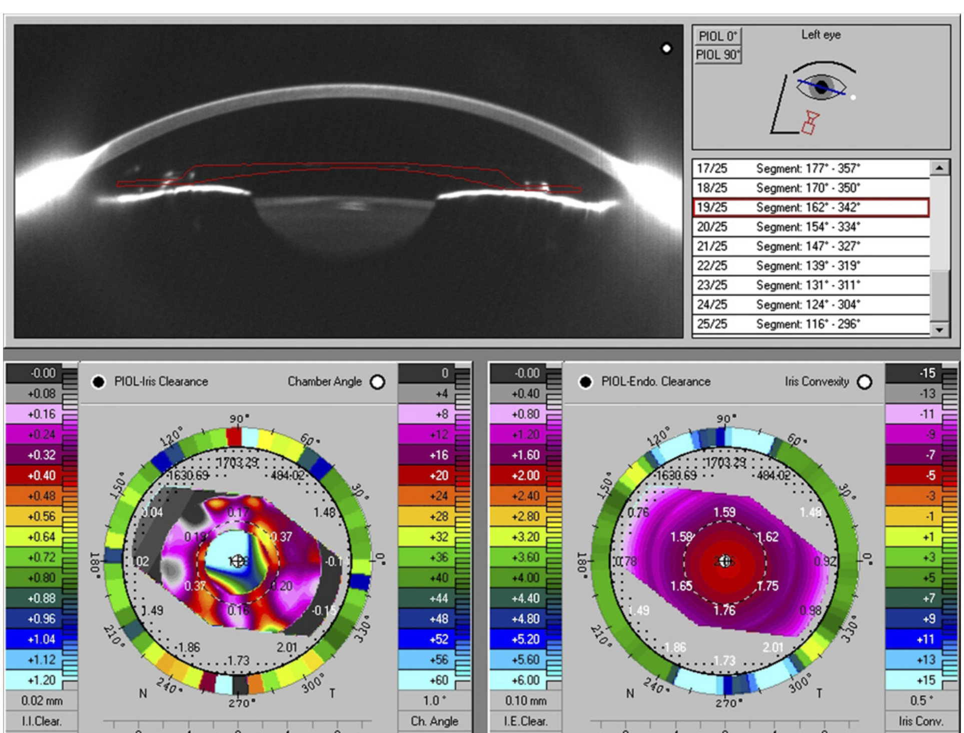

Figure 1. Preoperative anterior chamber image with simulation of postoperative pIOL position.

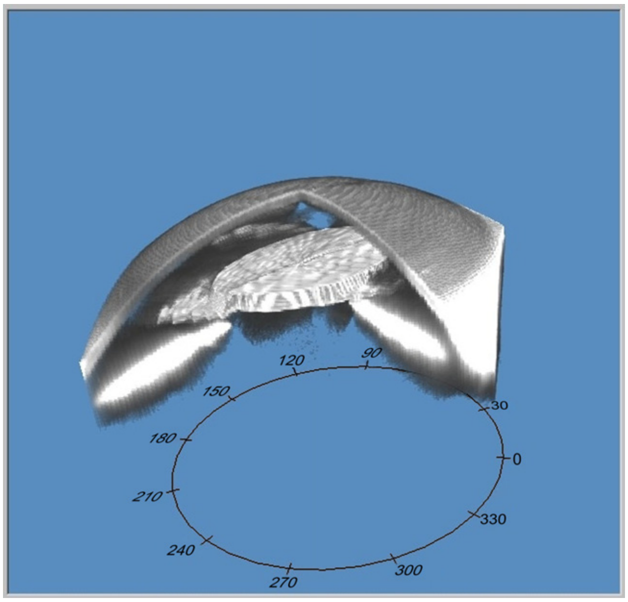

Figure 2. Three-dimensional image showing the position of the pIOL in the anterior chamber.

After surgery, the UCVA was 20/40. Scheimpflug imaging was repeated (Figure 3). The preoperative simulation was compared with the actual postoperative pIOL position, which showed a 50 μm deviation of the central optic and haptics from the actual postoperative position. In the simulation, the pIOL was 50 μm higher, which occurred because the simulation was aligned on the upper iris surface whereas the pIOL was actually enclavated in the iris and would therefore be closer to the iris.

In addition, simulation of the pIOL position in this patient 30 years after surgery was done (Figure 4). The simulation revealed a safe pIOL position with no contact with the crystalline lens or corneal endothelium.

DISCUSSION

Because intraocular refractive surgery is performed in healthy eyes, precise patient selection is crucial to exclude poor candidates. Analysis of anterior chamber dimensions via Scheimpflug imaging is an important step to ensure that sufficient distances between critical tissues are respected postoperatively. Simulation of the required

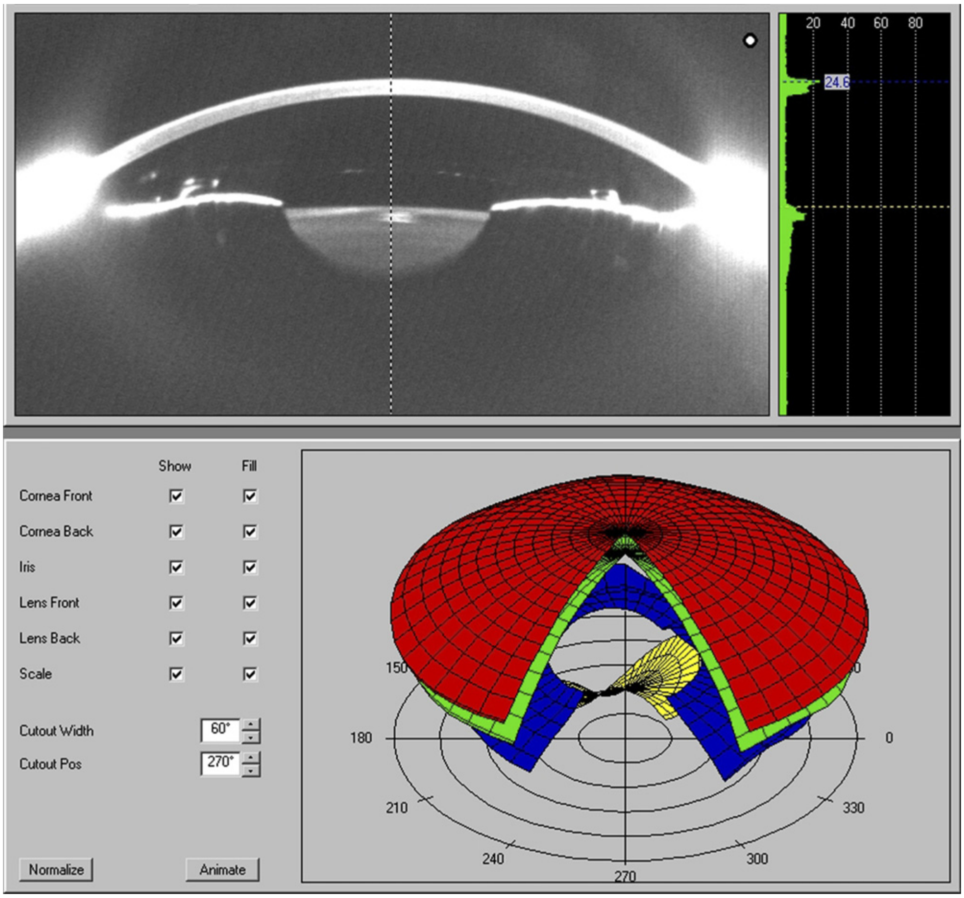

Figure 3. Scheimpflug image taken 1 week after uneventful pIOL implantation.

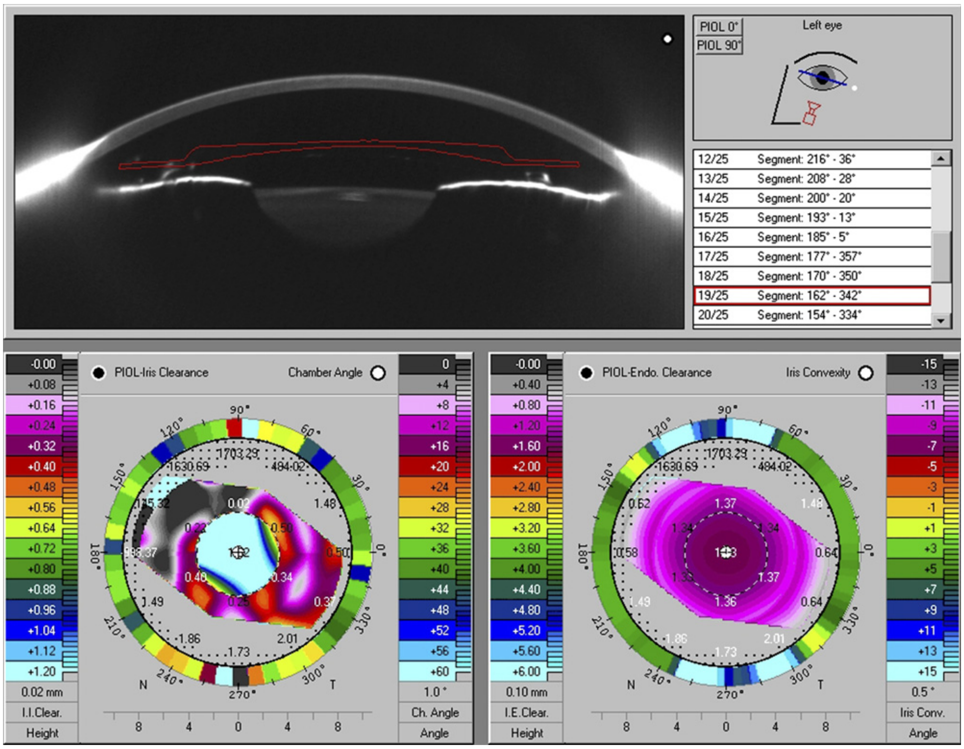

Figure 4. Simulation of pIOL position after 30 years.

iris-fixated pIOL model (including complete biometric data such as thickness and height) during the patient selection progress is another important step toward increasing the safety of this surgical option. The new features in the Pentacam will be especially beneficial in patients with irregular iris formation and poor central and peripheral anterior chamber dimensions. The image can be used to show the patient why he or she is not a good candidate for iris-fixated IOL implantation.

Besides projection of the selected IOL power/type in the patient's anterior chamber, the software program gives exact values, in millimeters, for the minimum distances between the endothelium and the IOL optic and haptics, the posterior surface of the IOL and the iris, and the posterior surface of the IOL and the crystalline lens. Distances between the IOL and other tissues can be read from any point on the IOL by placing the cursor on specific points of the IOL.

Clinical results of the pIOL module are ongoing in our department and will be presented in a prospective study. It will include preoperative simulation of the postoperative pIOL position and simulation of the pIOL position during the aging process (position of the pIOL from the time of implantation until the patient is 80 years old). Another feature under development is the option to simulate the toric models (Model A and B), allowing the surgeon to decide which model would fit better in a patient's anterior chamber anatomy.

The pIOL simulation software for the Scheimpflug imaging device represents a useful tool for preoperative detection of postoperative pIOL positioning and anterior chamber analysis. This tool improves preoperative selection/exclusion of patients, and the aging simulation tool may help ensure a safe pIOL position, not only after surgery, but also for the next 30 to 50 years.

REFERENCES

1. Dick HB, Tehrani M. Phake Intraokularlinsen; Aktueller Stand und Limitationen. Ophthalmologe 2004; 101:232–245
2. Tehrani M, Dick HB. Short-term follow-up after implantation of a foldable iris-fixated intraocular lens in phakic eyes. Ophthalmology 2005; 112:2189–2195
3. Tehrani M, Dick HB. Scheimpflug biometry of the anterior segment after implantation of foldable iris-fixated lenses. J Refract Surg 2006; 22:243–246