ARTICLE

Effect of manual capsulorhexis size and position on intraocular lens tilt, centration, and axial position

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Purpose: To evaluate the influence of a manual capsulorhexis size, shape, and position on postoperative axial position, tilt, and centration of intraocular lenses (IOLs).

Setting: Hanusch Hospital, Vienna, Austria.

Design: Prospective cases series.

Methods: Patients had cataract surgery and had follow-ups 1 hour and 3 months after surgery. Postoperatively, patients were divided into 3 groups according to the capsulorhexis shape and size as follows: control, symmetrical capsulorhexis between 4.5 mm and 5.5 mm; small group, capsulorhexis smaller than 4.5 mm; and eccentric, all other capsulorhexes. At both follow-ups, a retroillumination image, partial coherence interferometry measurements, and Purkinje meter measurements were performed.

Results: This study comprised 255 eyes. The mean postoperative absolute anterior chamber depth shift in the control, eccentric capsulorhexis, and small capsulorhexis groups was 0.31 mm $\pm$ 0.27 (SD), 0.36 $\pm$ 0.24 mm, and 0.26 $\pm$ 0.24 mm, respectively (P = .419). The mean tilt in the control, eccentric capsulorhexis, and small capsulorhexis groups was 4.08 $\pm$ 2.13 degrees, 3.66 $\pm$ 2.04 degrees, and 2.82 $\pm$ 1.67 degrees, respectively (P = .370), and the mean decentration was 0.38 $\pm$ 0.23 mm, 0.40 $\pm$ 0.21 mm, and 0.17 $\pm$ 0.08 mm, respectively (P = .027).

Conclusions: Capsulorhexis size and shape had little effect on the capsular bag performance of modern IOLs. Only eyes with a severely malformed capsulorhexis had a slightly decentered IOL.

J Cataract Refract Surg 2017; 43:902–908 © 2017 ASCRS and ESCRS

The introduction of the manual continuous curvilinear capsulorhexis (CCC)[1] together with other improvements in surgical technique and intraocular lens (IOL) design have resulted in cataract surgery becoming one of the safest surgical procedures. A new and much-discussed development in the field of cataract surgery is the use of the femtosecond laser to perform the capsulotomy, lens fragmentation, and corneal incisions.[2]

It has been shown that femtosecond laser–assisted cataract surgery capsulotomies are more round than manual capsulorhexes.[3–7] Theoretically, the shape of the capsulorhexis could be critical for the postoperative IOL position, including axial position, tilt, and decentration. However, this has not yet been shown in sufficient numbers of patients and/or by measurement methods with sufficient accuracy and reproducibility for assessment of IOL position. Also, it is not clear whether possible minor improvements with femtosecond laser–assisted cataract surgery also result in a clinical benefit for patients. Potentially, femtosecond laser–assisted cataract surgery could improve performance, especially when an aspheric, toric, or multifocal IOLs is implanted because these IOLs are more dependent on alignment in terms of achieving the best visual quality.[8,9]

The aim of the study was to evaluate the influence of capsulorhexis size, shape, and position on the postoperative axial position, tilt, and centration of an IOL.

PATIENTS AND METHODS

This study included consecutive patients who were scheduled for cataract surgery. Exclusion criteria were a corrected distance visual acuity of less than 0.05 Snellen, patient immobility making it difficult to return for a follow-up examination, and patient unwillingness to participate. The data were collected as part of an ongoing quality-assessment initiative that is routinely performed at the department and was implemented by the quality management group.

Preoperative Assessment

Preoperative assessments included examination at the slitlamp and optical biometry using the IOLMaster 500 system (Carl Zeiss

Submitted: August 21, 2016 | Final revision submitted: April 18, 2017 | Accepted: April 26, 2017

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Published by Elsevier Inc.

0886-3350/$ - see frontmatter
http://dx.doi.org/10.1016/j.jcrs.2017.04.037

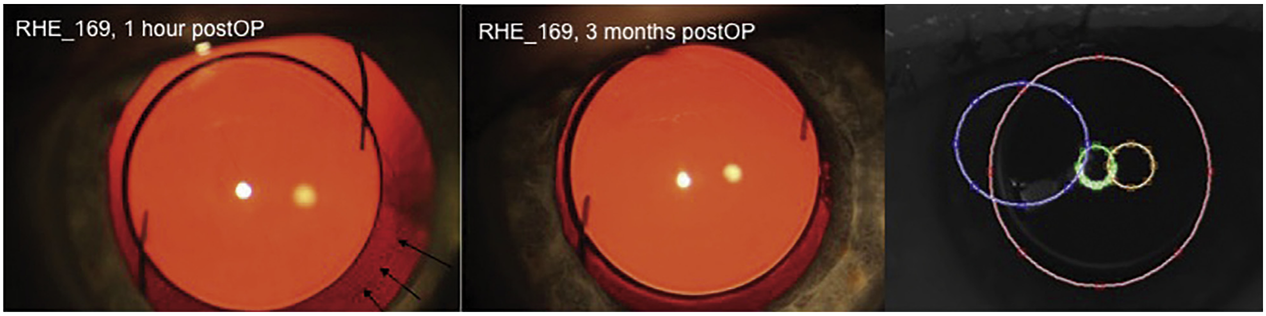

Figure 1. *Left*: Retroillumination image of an eccentric capsulorhexis 1 hour after surgery; black arrows show margin of capsulorhexis; *Middle*: Retroillumination image of an eccentric capsulorhexis 3 months after surgery. *Right*: Purkinje meter image. Each ring represents a Purkinje reflex (green = overlapping first and second reflex; blue = third reflex; yellow = fourth reflex; red = pupil).

Meditec AG) to assess axial length (AL), keratometry, and the preoperative anterior chamber depth (ACD).

Surgical Technique

Surgery was performed using topical anesthesia by 1 of 10 surgeons in the department; surgeons ranged from young trainees to experienced surgeons. A self-sealing clear corneal incision with a 2.8 mm single beveled steel blade was created. This was followed by an injection of an ophthalmic viscosurgical device (OVD), capsulorhexis creation with a needle or forceps according to the surgeon's choice, phacoemulsification, and irrigation/aspiration (I/A) of cortical material. After instillation of the OVD, the IOL of the surgeon's choice was implanted. Next, the OVD was aspirated using coaxial or bimanual I/A. Postoperative therapy within the first month was bromfenac (Yellox) twice daily for 4 weeks.

Surgical Outcomes Assessment

To assess quality of surgical outcomes, retroillumination photographs and partial coherence interferometry measurements (ACMaster, Carl Zeiss Meditec AG) of the ACD were performed 1 hour and 3 months after surgery. Purkinje meter measurements were taken 3 months after surgery.

Partial Coherence Interferometry Measurements Partial coherence interferometry has been shown to be highly reproducible for ACD measurements in pseudophakic eyes.[10] The data analysis used in this study has been described.[11] In short, each scan is analyzed manually by marking each peak of all 60 measurements at each follow-up of each patient depicting the optical path length (OPL). This OPL is then converted to the geometric ACD using the refractive index of the measured medium.

Purkinje Meter Measurements Details of the Purkinje meter have been described.[12,13] In short, the Purkinje reflexes that represent the anterior surface and posterior surface of the cornea (overlapping first reflex and second reflex) and the anterior surface and posterior surface of the lens (third reflex and fourth reflex) are captured by a camera. The position and size of the reflexes are used to calculate IOL decentration and tilt.

Image Acquisition

A high-resolution digital retroillumination system (digital coaxial retroillumination photography) was used. The system consists of a slitlamp and a retrolux illumination module connected with the system using a fiber-optic cable (all Carl Zeiss Meditec AG). This system allows coaxial illumination imaging. A digital color camera (Canon 5D Mark II) was connected to the system.[14]

All images were taken in a standardized fashion. The patients were asked to look straight into the collimated light. Several images focused on the anterior capsule were taken (magnification ×12), and the images with the best quality (focus, exposure, position of reflexes) were stored on a hard disk.

Image Analysis

Images were analyzed to classify patients regarding their capsulorhexis size and shape (Figure 1). Eyes with complete capsulorhexis–IOL overlap, a symmetric capsulorhexis, and a capsulorhexis size of 4.5 to 5.5 mm were classified as the control capsulorhexis group. Patients with a capsulorhexis smaller than 4.5 mm were classified as the small capsulorhexis group. Patients with a capsulorhexis larger than 5.5 mm or an asymmetric capsulorhexis with incomplete overlap of the capsulorhexis with the IOL edge were classified as the eccentric capsulorhexis group.

In addition, an objective scoring software Automated Quantification of After-Cataract software[15] (AQUA) was used to analyze the capsulorhexis–IOL overlap as well as the capsulorhexis circumference and area to calculate the capsulorhexis shape factor. In short, the retroillumination images were imported into the AQUA software and the capsulorhexis was marked manually in a first step. The software then created a circle-like shape that fit the marking points of the capsulorhexis. This circle-like shape consisted of multiple points that were readjusted manually. After this final adjustment, the AQUA soft-

Table 1. Preoperative descriptive data of the study population and of capsulorhexis groups (N = 232).

	Mean ± SD				
Group	Age (Y)	AL (mm)	Kmean (D)	ACD (mm)	WTW (mm)
Control	72.5 ± 8.2	24.0 ± 1.5	43.1 ± 1.5	3.2 ± 0.4	12.1 ± 0.4
Eccentric	72.7 ± 9.8	23.5 ± 1.3	43.1 ± 1.2	3.1 ± 0.4	12.1 ± 0.4
Small	76.2 ± 7.8	23.4 ± 1.9	42.8 ± 2.4	2.9 ± 0.4	11.9 ± 0.3
Total	73.2 ± 8.9	23.7 ± 1.5	43.1 ± 1.7	3.1 ± 0.4	12.0 ± 0.4
P value*	.019	.083	.486	<.001	.032

ACD = anterior chamber depth; AL = axial length; K = keratometry; WTW = white to white
*Analysis of variance