Changes in Pupil Size and Centroid Shift in Eyes With Uncomplicated In-the-Bag IOL Implantation

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ABSTRACT

PURPOSE: To determine changes in entrance pupil size and pupil center shift under low mesopic and photopic conditions of illumination in eyes with in-the-bag intraocular lens (IOL) implantation.

METHODS: Entrance pupil size and pupil center shift were measured under low mesopic (0.06 lux) and photopic (60 lux) conditions of illumination in 55 patients with unilateral pseudophakia (study group) and 55 age- and sex-matched patients with bilateral cataracts (control group) using the NIDEK OPD-Scan. Pseudophakic eyes had an uncomplicated intraoperative and postoperative course and best spectacle-corrected visual acuity of 20/20. Cataractous eyes had no additional ocular or systemic problems affecting the pupil. Both groups were analyzed with respect to pupil size and shift in both conditions of illumination.

RESULTS: Mean patient age was 64.2±6.8 and 63.6±4.3 years in the study and control groups, respectively (P=.45). In the study group, differences in pupil size under low mesopic (5.12±1.02 and 5.13±0.96 mm for pseudophakic and phakic eyes, respectively) and photopic (3.44±0.39 and 3.45±0.39 mm for pseudophakic and phakic eyes, respectively) conditions of illumination were not statistically significant (P=1.00 and P=.95 for pseudophakic and phakic eyes, respectively). Differences in pupil shift between pseudophakic (0.11±0.08 mm) and phakic (0.12±0.10 mm) eyes were not statistically significant (P=.83) in the study group. In the control group, differences in pupil size under low mesopic (P=.59) and photopic conditions of illumination (P=.60) in the right and left eyes as well as pupil shift (P=.71) were not statistically significant.

CONCLUSIONS: Uncomplicated in-the-bag IOL implantation has no influence on pupil size and shift. [J Refract Surg. 2007;23:796-799.]

Pupil size has been shown to affect ocular aberrations significantly.1-3 Physiologically, the pupil dilates nonconcentrically and its geometric center moves as the pupil diameter changes.1,4 Although significant improvements in surgical techniques as well as in the material and design of intraocular lenses (IOLs) have been made, IOL implantation is still expected to influence pupillary mechanics including pupil size and shift.1,4 Implantation of an IOL has been shown to produce significant aberrations depending on the pupil size.1,3 Pupil shift is essential in determining the optical effects of refractive surgery.1,4 Reports of pupil size and shifts, especially in pseudophakic eyes, are relatively sparse and show variability.1,7

This study examined changes in pupil size and shift in eyes with uncomplicated in-the-bag IOL implantation.

PATIENTS AND METHODS

This study was conducted at the ophthalmology department of the Gülhane Military Medical Academy and Medical School between January and December 2005. Informed consent was obtained from all participants after the nature of the procedure was explained. Inclusion criteria were patients between ages 50 and 70 years who were nonsmokers and had undergone unilateral in-the-bag IOL implantation centered behind a 5- to 6-mm circular capsular opening at least 3 months previously with an IOL power between 18.00 and 24.00 diopters (D) and best spectacle-corrected visual acuity (BSCVA) of 20/20 in the pseudophakic eye and 20/20 to 20/40 in the phakic eye (including 2+ nuclear sclerosis).

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Exclusion criteria were other ocular pathologies including inflammation, glaucoma and pseudoexfoliation, previous anterior or posterior segment surgery, and astigmatism >1.00 D for pseudophakic and cataractous eyes as well as medications and habits affecting pupil size and motility. Patients who had intraoperative and postoperative complications including corneal burn and trauma to the iris, transillumination defect in the iris, posterior capsular opacification, capsular ring, and capsular fibrosis or Soemmerring’s ring formation also were excluded.

All operations were performed using the Alcon Legacy phacoemulsification machine (Alcon Laboratories Inc, Ft Worth, Tex) by the same surgeons (G.S., U.E.). Topical anesthesia was administered before surgery. A 3.2-mm, self-sealing limbal tunnel was created. A 5- to 6-mm continuous curvilinear capsulorhexis was made with Utrata forceps (G-31305; Geuder, Heidelberg, Germany or Storz E1898CM; Bausch & Lomb, San Dimas, Calif), and the nucleus was removed by the divide-and-conquer method. All IOLs (AcrySof MA30BA; Alcon Laboratories Inc) were implanted with folder and holder. The limbal wound was not sutured. Antibiotic (ofloxacin) and steroid (prednisolone) drops were prescribed for 1 month postoperatively.

The study population consisted of two groups of patients. The study group included 55 patients with pseudophakia in one eye and phakia in the contralateral eye, and the control group included 55 age- and sex-matched patients with bilateral cataracts.

Pupil size and shift were measured under low mesopic (0.06 lux) and photopic (60 lux) conditions of illumination using the OPD-Scan (ARK 10000; NIDEK Co Ltd, Gamagori, Japan). Pupil shift refers to a shift in pupil center between photopic and low mesopic states. These measurements were taken only postoperatively in the pseudophakic eyes. Patients were evaluated in a closed, darkened room with illumination ≤0.07 lux in the afternoon (3:00 PM to 5:00 PM). Video images were captured, and pupil sizes and shift were calculated with OPD-Scan software. Pupil diameter and the distance and angle between the pupil center (line of sight) and visual axis were measured automatically with digital infrared pupillometry. The OPD-Scan has automated check of measurement quality, and alignment procedures can be checked manually.

Findings were analyzed for both groups with respect to pupil size and shift under both conditions of illumination using a two-tailed Student t test or Mann-Whitney U test. A P value <.05 was considered significant.

**RESULTS**

Demographics and spherical equivalent refractions for both groups are shown in Table 1. Pupil size and shift values for both groups are shown in Table 2.

There were no significant differences in pupil diameter under low mesopic and photopic conditions between men and women (P > .05) (Table 2) or between pseudophakic and cataractous eyes (P > .05) (Table 3).

In the study group, pupil center location tended to shift in the inferotemporal direction when the pupil went from a photopic constrained to a low mesopic dilated state. The Figure shows a case with inferotemporally shifted pupil center.

**DISCUSSION**

We found uncomplicated IOL implantation does not affect pupil size and shift significantly. In a prospective study of pupil motility in patients who underwent extracapsular cataract extraction with IOL implantation, Bonomi et al found no substantial alteration in pupil size with the exception of enlargement by 17% in photopic diameter. This study, which included patients with uncomplicated phacoemulsification and IOL implantation, showed pupil size and pupil center...
shift alterations were similar in implanted and cataractous eyes in low mesopic and photopic conditions. Koch et al, also demonstrated preoperative pupil size is not useful in predicting the postoperative pupil size of patients who undergo phacoemulsification with posterior chamber lens implantation.

The OPD-Scan uses an established method of measuring aberrations in the eye. We found a mean 0.11-mm pupil center shift in the inferotemporal direction. Other investigators have reported pupil shift in the supertemporal direction. Differences of the pupil center location in studies may be the result of asymmetrical dilation of the pupil caused by different illumination levels or differences in refractive errors.

Both groups in this study were homogeneous in regard to age and spherical equivalent refraction (Table 1). Because optical aberrations from IOLs have been reported to differ with respect to entrance pupil size and type of IOL, we implanted the same type of IOL and measured pupillary changes at least 3 months after surgery to minimize the influence of factors such as inflammation associated with IOL implantation on pupillary mechanics. In addition to the findings for the phakic eyes in the study group, the findings for the cataractous eyes in the control group suggest pupillary changes are not dependent on intraintividual factors, and the pupil in uncomplicated cataractous and pseudophakic eyes behaves similarly.

Although Camellin et al found the mean pupil size was greater in myopic eyes than in hyperopic eyes, the difference was statistically significant only under mesopic conditions of illumination. We found changes in pupil size and center location were similar in men and women with similar spherical equivalent refractions in the study group (Tables 1 and 2). Regarding entrance pupil size, no significant differences have
been reported between men and women or physiologic myopes and emmetropes.\textsuperscript{4} We found the spatial shift of the pupil center, as the pupil dilates, was relatively small and similar in phakic and pseudophakic eyes with similar spherical equivalent refractions. Therefore, the pupil center in uncomplicated in-the-bag IOL implanted eyes may be used as a good anatomical landmark in phakic eyes for traditional refractive surgery and wavefront-guided treatments.

It has been determined that controls of optical aberrations, defraction, retinal illumination, pupil centration, and modulation transfer function are affected by pupil size.\textsuperscript{12,14,17,10} Implantation of IOLs has been shown to elevate spherical aberration, with the magnitude of effect increasing as the pupil size increases, although pupillary dilation alone has been ineffective.\textsuperscript{3} Our findings suggest the role of the pupil in the formation of retinal image in pseudophakic eyes and phakic eyes is similar.

In conclusion, uncomplicated in-the-bag IOL implantation seems to have no adverse effect on pupillary dynamics including pupil size and shift.


REFERENCES


