Pupillary Functions After Cataract Surgery Using Flexible Iris Retractor in Patients With Small Pupil

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Purpose: To quantitatively assess pupillary functions after small pupil cataract surgery using the flexible iris retractor.

Methods: Subjects were 11 patients (12 eyes) with small pupils who underwent phacoemulsification and intraocular lens implantation. Pupils were enlarged using the flexible iris retractor intraoperatively, and postoperative iriscorder data were compared with the data of 20 normal controls who underwent standard phacoemulsification and intraocular lens implantation.

Results: Although pupillary area before light stimulus did not differ between the groups, contraction rate after light stimulus was significantly lower in the small pupil group than in the normal controls. The velocity of contraction and dilation was also significantly slower in the small pupil group. Wider pupillary stretching during surgery resulted in deteriorated pupillary functions after surgery. Eyes of patients on long-term miotic therapy with pilocarpine showed poorer pupillary reaction postoperatively.

Conclusion: Inappropriate use of the flexible iris retractor causes an atonic, chronically enlarged postoperative pupil. To avoid postoperative pupillary complications, miotic pupils should not be stretched to larger than a 5.0 × 5.0 mm square. **Jpn J Ophthalmol 1999; 43:20–24** © 1999 Japanese Ophthalmological Society

Key Words: Cataract surgery, iriscorder, iris retractor, miosis, small pupil.

Introduction

Small, fixed pupil can present significant obstacles to safe phacoemulsification by restricting the surgeon's view behind the iris plane and by limiting the working space. A variety of methods have been reported to perform cataract surgery in patients with insufficiently dilated pupils, such as modification of the phacoemulsification technique,[1,2] use of sector iridectomy,[3] radial iridectomy,[4,5] multiple small sphincterotomies,[6] stretch pupilloplasty,[7–9] the rigid iris hook/retractor,[10,11] silicone ring pupil expander,[12] or flexible iris retractor.[13–15] Of these, use of the flexible iris retractor is considered to be one of the most effective and safe methods. When properly used, the retractor enables the surgeon to achieve excellent results, and the pupil retains its shape and function postoperatively. On the other hand, excessive pupillary enlargement may lead to flaccid sphincter muscle, causing semimydriatic, nonreacting pupils postoperatively.[16] Postoperative pupillary irregularity is often associated with aesthetic deformation and visual disability as potential consequences.[17] There have been no studies of pupillary functions after cataract surgery in patients with small pupils, and it remains unknown how widely the pupil can be stretched without inducing severe pupillary abnormality after surgery.

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Table 1. Pupillary Dynamics After Cataract Surgery in Patients with Small Pupil and Normal Controls

Patients	A1 (mm^2)	A2 (mm^2)	CR	VC (mm^2/s)	VD (mm^2/s)
Small pupils (n = 12)	15.1 ± 5.8	13.6 ± 6.2*	0.12 ± 0.12*	7.0 ± 3.7*	3.1 ± 0.9*
Normal controls (n = 20)	14.0 ± 4.2	7.2 ± 3.2	0.50 ± 0.10	25.6 ± 6.1	6.0 ± 1.4

A1: Pupillary area before light stimulus, A2: minimum pupillary area caused by stimulus, CR: contraction rate, (A1-A2)/A1, VC: maximum velocity of contraction, VD: maximum velocity of dilation.
*Significantly different from values of normal controls ($P < 0.001$).

In the current study, we used the infrared iriscorder and assessed pupillary dynamics after phacoemulsification and intraocular lens implantation, employing the iris retractor to enlarge the miotic pupils.

Subjects and Methods

Subjects were 11 patients (12 eyes) who had small pupils and were to undergo cataract surgery. Their ages ranged from 57–84 years (mean ± SD, 73.8 ± 12.0 years). Three patients had pseudoexfoliation, 5 primary angle-closure glaucoma, 2 primary open-angle glaucoma, and 1 uveitis. All patients with angle-closure glaucoma had undergone laser iridotomy. Two patients with open-angle glaucoma (3 eyes) and 1 patient with pseudoexfoliation (1 eye) had been on long-term miotic therapy with pilocarpine. Apparent posterior synechias were observed in 1 eye with pseudoexfoliation, 3 eyes with angle-closure glaucoma, 1 eye with open-angle glaucoma, and 1 eye with uveitis. Pupillary diameter at the maximum dilation averaged 3.4 ± 0.6 mm (range, 2.5–4.5 mm). Twenty patients (20 eyes) undergoing standard cataract surgery served as normal controls. Their ages ranged from 56–78 years (mean ± SD, 67.5 ± 5.3 years). Their maximum pupillary diameter was 8.2 ± 0.3 mm (range, 8.0–9.0 mm).

Preoperatively, 0.5% tropicamide and 0.5% phenylephrine hydrochloride (Mydrin®P, Santen Pharmaceutical, Osaka) and 5% phenylephrine hydrochloride (Neosynesin®, Kowa Pharmaceutical, Tokyo) were instilled every 15 minutes, starting 2 hours and 30 minutes before surgery. To reduce intraoperative miosis, 0.1% diclofenac sodium (Diclod®, Wakamoto Pharmaceutical, Tokyo) was applied topically at the same time. Intraoperatively, epinephrine was not placed in the irrigation bottle.

Phacoemulsification and intraocular lens implantation were carried out in each eye. The anterior chamber was filled with the viscoelastic material and synechiolysis was performed as necessary. The eye was videotaped with a caliper to show calibration, and the intraoperative pupillary area was measured later on the video image. Four flexible iris retractors (Grieshaber, Schaffhausen, Switzerland) were placed through limbal stab incisions and the pupil was enlarged to 29.4 ± 7.7 mm^2 (range, 18.0–45.0 mm^2). The degree of enlargement depended on eye condition and surgeon judgment. Following phacoemulsification, the acrylic foldable intraocular lens (AcrySof™ MA60BM, Alcon Laboratories, Fort Worth, TX, USA) was implanted within the continuous curvilinear capsulorrhexis. The normal controls underwent standard phacoemulsification and implantation of an acrylic foldable intraocular lens.

Pupillary dynamics were measured with an infrared iriscorder (Binocular Iriscorder Model C-2515, Hamamatsu Photonics, Shizuoka).[18] This device projects a light stimulus of 1 second and calculates several parameters, including pupillary area before

Table 2. Degree of Intraoperative Pupillary Stretching and Postoperative Pupillary Dynamics

Pupillary Area	A1 (mm^2)	A2 (mm^2)	CR	VC (mm^2/s)	VD (mm^2/s)
>25 mm^2 (n = 6)[a]	19.0 ± 5.1*	17.5 ± 6.0*	0.09 ± 0.09	7.1 ± 4.2	3.3 ± 1.1
≤25 mm^2 (n = 6)	11.3 ± 3.5	9.7 ± 3.5	0.15 ± 0.14	6.9 ± 3.6	2.9 ± 0.6

A1: Pupillary area before light stimulus, A2: minimum pupillary area caused by stimulus, CR: contraction rate, VC: maximum velocity of contraction, VD: maximum velocity of dilation.
[a]Pupil stretched to >25 mm^2 intraoperatively.
*Significantly different between groups ($P < 0.05$).

Jpn J Ophthalmol
Vol 43: 20–24, 1999

Table 3. Preoperative Long-Term Miotic Therapy and Postoperative Pupillary Dynamics

Therapy	A1 (mm^2)	A2 (mm^2)	CR	VC (mm^2/s)	VD (mm^2/s)
Miotics (+) (n = 14)	21.0 ± 4.7*	20.2 ± 5.2*	0.04 ± 0.04	4.9 ± 3.0	2.8 ± 1.0
Miotics (−) (n = 8)	12.2 ± 3.8	10.3 ± 3.5	0.16 ± 0.12	8.1 ± 3.7	3.2 ± 0.8

A1: Pupillary area before light stimulus, A2: minimum pupillary area caused by stimulus, CR: contraction rate, VC: maximum velocity of contraction, VD: maximum velocity of dilation.
*Significantly different between groups ($P < 0.01$).

Table 4. Presence of Preoperative Posterior Synechia and Postoperative Pupillary Dynamics

Complication	A1 (mm^2)	A2 (mm^2)	CR	VC (mm^2/s)	VD (mm^2/s)
Posterior synechia (+) (n = 6)	13.7 ± 3.3	12.3 ± 3.1	0.10 ± 0.09	7.7 ± 3.7	3.2 ± 0.6
Posterior synechia (−) (n = 6)	16.5 ± 7.7	14.8 ± 8.5	0.14 ± 0.15	6.4 ± 3.9	2.9 ± 1.1

A1: Pupillary area before light stimulus, A2: minimum pupillary area caused by stimulus, CR: contraction rate, VC: maximum velocity of contraction, VD: maximum velocity of dilation.

the light stimulus (mm^2, A1), minimum pupillary area caused by the light stimulus (mm^2, A2), contraction rate (CR) calculated as (A1-A2)/A1, maximum velocity of contraction (VC, mm^2/s), and maximum velocity of dilation (VD, mm^2/s). Data taken at the first postoperative day were compared between the small pupil group and the normal controls. The time course of changes in the above parameters was also assessed up to 3 months postoperatively.

Statistical analysis was performed using Wilcoxon rank-sum test. A P-value of less than 0.05 was considered significant.

Results

Pupillary functions after cataract surgery were compared for the small pupil group and the normal controls. Although pupillary area before the light stimulus (A1) did not differ between groups, minimum pupillary area caused by the light stimulus (A2) was significantly larger in the small pupil group than in the normal controls (Table 1). Contraction rate in the small pupil group was accordingly lower. Maximum velocities of contraction and dilation were also significantly slower in the small pupil group.

Pupillary area before (A1) and after (A2) the light stimulus were significantly larger in patients whose pupil was enlarged to more than 25 mm^2 intraoperatively as compared with the other patients whose pupils were less stretched (Table 2). Similarly, patients who had been on long-term miotic therapy with pilocarpine displayed significantly larger A1 and A2 (Table 3). The presence of posterior synechia did not affect the pupillary dynamics after surgery (Table 4).

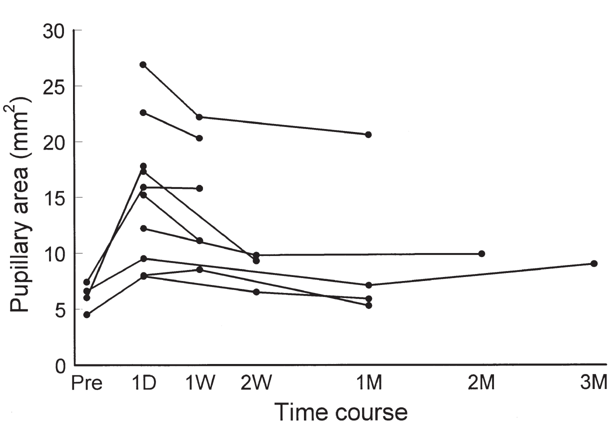

Figure 1. Pupillary area without light stimulus in patients who underwent small pupil cataract surgery with aid of flexible iris retractor. D: day, W: week, M: month.

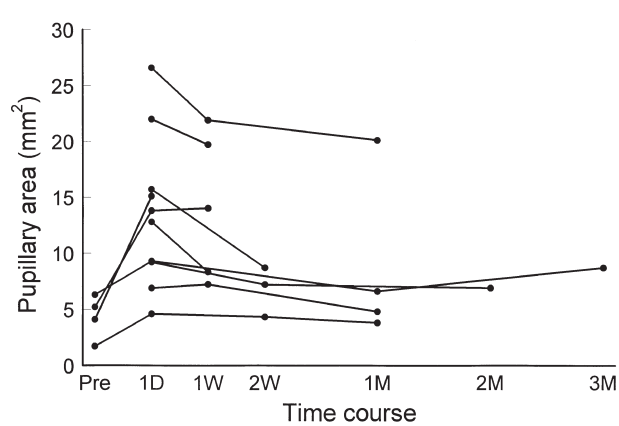

Figure 2. Minimum pupillary area caused by light stimulus in patients after small pupil cataract surgery.

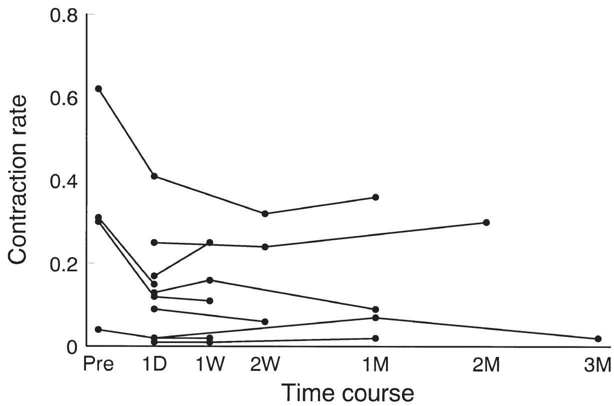

Figure 3. Contraction rate after light stimulus in patients with small pupil cataract surgery.

Time course of changes in pupillary function was assessed in 10 eyes in the small pupil group. Pupillary area before (A1) and after (A2) the light stimulus did not fluctuate significantly after surgery, except for a few eyes that had larger A1 and A2 values on the first postoperative day, followed by slight decreases over time (Figures 1 and 2). The CRs remained quite stable throughout the postoperative period (Figure 3).

Discussion

We quantitatively assessed the pupillary dynamics after small pupil cataract surgery that was performed with the aid of the flexible iris retractor. As shown by the iriscorder data, the pupillary area of the small pupil group before the light stimulus was similar to that of the normal controls (Table 1). However, the pupillary reaction to the light stimulus was significantly poorer in the former group, and thus the minimum pupillary area after the light stimulus remained significantly larger. The pupillary CR was accordingly significantly lower in the small pupil group, and the VC and VD were likewise remarkably slower. Although these comparisons were based on the measurements taken at only 1 day postoperatively, the serial data collected for 1 week to 3 months after surgery indicated that those tendencies did not change significantly (Figures 1–3).

Pupillary functions deteriorated more severely when larger pupillary enlargement was conducted intraoperatively. The patients whose pupils were stretched to larger than 25 mm^2 during surgery had significantly larger pupils postoperatively, with poorer reactions to light (Table 2). On the other hand, if a patient's pupil was enlarged to less than 25 mm^2, the pupillary area before the light stimulus was not significantly different from that of the normal controls, and the light reaction was preserved to a certain extent (Table 2). Similarly, eyes of patients who had been on long-term miotic therapy with pilocarpine displayed significantly larger pupillary area and poorer light reactions (Table 3). It is presumed that excessive intraoperative pupillary dilation led to irregular and permanent damage of the sphincter muscle, causing oversized, nonreacting pupils after surgery. Chronic miotic therapy with pilocarpine could have contributed to this process, because pilocarpine immobilizes the iridial muscles and increases blood–aqueous barrier permeability,[19] which in the long term might result in inflexibility, degeneration, and contracture of the sphincter as well as flaccidity of the dilator muscle. The presence of posterior synechia before cataract surgery did not influence postoperative pupillary dynamics (Table 3). This may be because the development of synechia has no relationship with the status of the iridial muscles per se.

Other possible explanations for the poorer pupillary reaction after small pupil cataract surgery include pre-existing glaucomatous optic nerve damage and more intense postoperative inflammation in these patients. Although not present in the current subjects, eyes with severe optic nerve atrophy would exhibit poorer pupillary light reflex. The markedly deteriorated pupillary function observed herein, however, cannot be attributed to the mild-to-moderate degree of optic nerve damage seen in our patients. As for postoperative inflammation, it may be that eyes with small pupils required more complicated surgical maneuvers, leading to more intense postoperative inflammation and subsequent miosis. The pre-existing damage of the blood–aqueous barrier as mentioned above can enhance this effect.

Enlarging the pupil more than necessary will tear the sphincter, which may induce iris bleeding, alter the blood–aqueous barrier, and cause an atonic, chronically enlarged postoperative pupil.[17] Consequences of the overly stretched and significantly damaged pupil include pupillary capture, chronic inflammation, pigmented and nonpigmented deposits on the intraocular lens, and cystoid macular edema.[17] As shown in the current study, postoperative pupillary damage was less severe when the intraoperative pupillary stretching did not exceed 25 mm^2. This corresponds to a 5.0 × 5.0 mm square pupil, which seems adequate for most situations in cataract surgery. Nevertheless, the pupil still has to be stretched considerably, because a 5.0-mm square has a 7-mm diagonal, which is approximately twice the preopera-

Jpn J Ophthalmol
Vol 43: 20–24, 1999

tive pupillary diameter of the current small pupil patients, 3.4 mm. Therefore, to avoid intraoperative and postoperative pupillary complications, slow and gradual pupillary enlargement is recommended.

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