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ORIGINAL PAPER

Cataract surgery in patients with glaucoma drainage implants: the hooked tube technique

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Abstract
Purpose Cataract surgery has been reported to adversely affect the IOP control in eyes with the glaucoma drainage implant (GDI). One reason might be the flow of lens debris/viscoelastic material through the GDI tube into the bleb. This pilot study was conducted to determine the clinical results of a novel technique for temporary occlusion of the GDI tube with an iris retractor hook during phacoemulsification.
Methods Retrospective analysis of 15 patients (control group) who underwent phacoemulsification between January 2005 and December 2010 and 17 patients (treatment group) who underwent phacoemulsification with the hooked tube technique between January 2011 and April 2016 with a minimum 1-year follow-up.
Results The IOP remained within 4 mmHg of the preoperative level in all eyes of the treatment group. Three eyes exhibited IOP spikes ($\geq$ 10 mmHg) among controls. The mean postoperative IOP at 1 month was statistically significantly increased in the control group compared with the treatment group ($P = 0.040$). The number of antiglaucoma medications at 3 and 6 months was significantly increased in the control group (1.4 ± 1.1 vs. 1.7 ± 1.1; $P = 0.041$, 1.4 ± 1.1 vs. 2.3 ± 1.2; $P = 0.017$, respectively). After phacoemulsification, there was a significant increase in the mean number of antiglaucoma medications used at 6 months in the control group compared with the treatment group ($P = 0.049$). In both groups, one eye developed corneal decompensation.
Conclusions The hooked tube technique seems to provide an effective way to reduce the risk of the IOP spikes after cataract surgery in eyes with GDI.

Keywords Cataract surgery · Glaucoma drainage implant · Iris retractor hook · Postoperative IOP spikes

Introduction

Glaucoma drainage implant (GDI) surgery has become a standard procedure in various forms of uncontrolled glaucomas [1]. The development of visually significant cataract is common after GDI surgery and many patients need cataract surgery afterward. Cataract surgery can affect IOP control in

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eyes with the tube [2–4]. Some GDI patients have even exhibited IOP spikes (≥ 10 mmHg increase) postoperatively [2, 4]. One reason might be the flow of lens debris through the GDI tube into the bleb cavity during cataract surgery. Also, intraoperative use of viscoelastic material may lead to GDI obstruction and a clinically unsatisfactory increase in IOP during follow-up [5].

Many glaucoma patients with the GDI are quite sensitive to postoperative IOP spikes. In such cases, postoperative IOP fluctuation could adversely affect visual field and visual function. A novel technique is presented for occluding the GDI tube temporarily with a flexible iris retractor hook during cataract surgery to reduce the risk of postoperative IOP spikes.

Methods

This study includes all 32 patients with GDI who had a phacoemulsification cataract surgery between January 2005 and April 2016 with a minimum 1-year follow-up. All patients were operated at the Päijät-Häme Central Hospital. A total of 15 patients underwent phacoemulsification cataract surgery without an intraoperative occlusion of the GDI tube between January 2005 and December 2010 (control group). Between January 2011 and April 2016, 17 patients underwent phacoemulsification surgery using a novel technique for temporary occlusion of the GDI tube—i.e., the hooked tube technique (treatment group). The same surgeon performed the surgery in the both groups. The technique used for cataract surgery and a viscosurgical device (OVD) (Viscoat, Alcon, Fort Worth, TX, USA) were same in both groups apart from the temporary occlusion of the GDI tube. However, the size of a clear corneal incisions decreased from 2.75 to 2.4 mm since January 2015.

Data such as IOPs, number of antiglaucoma medications and visual acuities were collected before cataract surgery, and postoperatively at 1 day, then after 1, 3, 6, and 12 months. Outcome measures included IOP, visual acuity, number of antiglaucoma medications, any surgical complications. The study met the criteria set by the local ethical review board of the institution. The research was performed according to the Declaration of Helsinki. Data within the group were compared using the paired t test between the eyes before and after cataract surgery. Data between control group and treatment group at each time point were analyzed using the unpaired *t* test. Statistical analyses were performed using SSPS version 21.0 for Windows (IBM, USA).

The hooked tube technique

After administration of multiple drops of tetracaine 0.5%, the eye is prepared and draped in the usual sterile fashion. A lid speculum is used to retract the eyelids. Before beginning the phacoemulsification cataract surgery, the location of the GDI tube is determined. The first step in the procedure involves a 1-mm limbal paracentesis placed about 30 degrees laterally to the anterior chamber part of the tube. The paracentesis incision can be made with any 1 mm wide metal or diamond knife. An iris retractor hook (Flexible Iris Retractor for ophthalmic surgery, Alcon Grieshaber AG, Schaffhausen, Switzerland) is then inserted through the paracentesis.

Holding the outside part of the hook with forceps, the surgeon moves the inside part of the hook through the orifice/mouth of the GDI tube. Once the hook is inside the tube lumen, the surgeon bends the tube with gentle traction toward the anterior chamber angle, avoiding touching the corneal endothelium (Video 1). The tube is bent by gently pulling the retractor hook with forceps and locked into the bent position by sliding a silicone donut down the shaft and against the cornea (Fig. 1). Once the tube has been occluded by

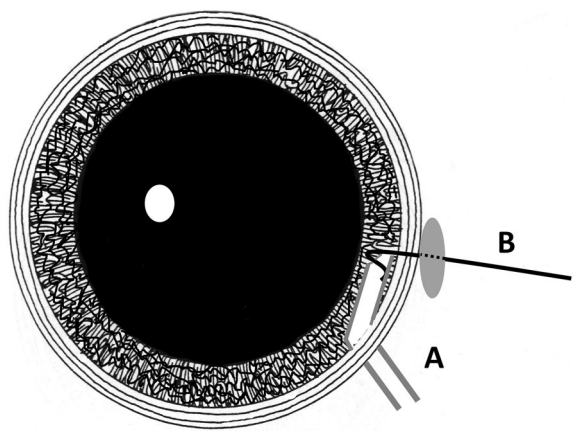

Fig. 1 Glaucoma drainage implant tube (**a**) is occluded with a flexible iris retractor hook (**b**) during phacoemulsification cataract surgery

the hook, intracameral lidocaine is injected followed by the OVD.

Clear corneal phacoemulsification is performed in the usual manner with an intraocular lens insertion into the capsular bag. Following cataract surgery, the OVD is eventually aspirated using an irrigation/aspiration instrument. The tube is then released by sliding the silicone donut away from the cornea, thus unhooking the tube. After carefully pulling the retractor hook out of the eye through the incision, the GDI tube is irrigated using an irrigation–aspiration cannula. The corneal incisions are hydrated with balanced salt solution to create a watertight seal. Postoperatively, topical dexamethasone drops combined with chloramphenicol (Oftan Dexa-Chlora, Santen, Tampere, Finland) were applied for 3 weeks.

Results

Data from 32 patients (32 eyes) performed during two different time periods were reviewed.

Patients' characteristics and preoperative data are summarized in Table 1. The patients in both study groups were comparable with respect to age, IOP, antiglaucoma medication, and visual acuity (Table 1). Table 2 shows the IOP profile after the phacoemulsification surgery as compared between the two study groups. The mean IOP (± SD) in the treatment group was 17.9 ± 4.8 mmHg before phacoemulsification and 16.4 ± 2.8 mmHg at day 1 ($P = 0.09$). Average IOP in the control group was prior 15.9 ± 1.9 mmHg and 17.7 ± 8.1 mmHg on the first postoperative day ($P = 0.377$). There was a statistically significant drop in IOP at 1 month ($P = 0.007$), 3 months ($P = 0.043$), 1 year ($P = 0.035$), but not at the 6-month follow-up ($P = 0.159$) in the treatment group. The decreases from the preoperative IOP at 1, 3, 6, and 12 months postoperatively were not statistically significantly different in the control group ($P = 0.168$, $P = 0.146$, $P = 0.703$, $P = 0.910$, respectively). The mean postoperative IOP at 1 month was statistically significantly increased in the control group compared with the treatment group ($P = 0.040$, Table 2).

The IOP remained within 4 mmHg of the preoperative level in all eyes of the treatment group, but not in the control group during the follow-up visits. Two

Table 1 Demographic and preoperative data of the study groups

Characteristics	Control group	Treatment group	*P*
No. of patients (eyes)	15 (15)	17 (17)	
Male/female	6/9	6/11	
Diagnosis of glaucoma [*n* (%)]			
Pseudoexfoliation	7 (47)	8 (47)	
Primary open angle	5 (33)	4 (23)	
Uveitic	2 (13)	2 (12)	
Neovascular	1 (7)	2 (12)	
Pigmentary	–	1 (6)	
GDI type [*n* (%)]			
Molteno	6 (40)	–	
Molteno3	9 (60)	14 (82)	
Baerveldt	–	2 (12)	
Ahmed	–	1 (6)	
Age (years)			
Mean ± SD	75.2 ± 14.7	73 ± 8.4	0.531
Visual acuity (log MAR)			
Mean ± SD	0.7 ± 0.3	0.8 ± 0.8	0.164
IOP (mmHg)			
Mean ± SD	15.9 ± 1.9	17.9 ± 4.8	0.124
Antiglaucoma medication			
Mean ± SD	1.4 ± 1.1	1.5 ± 1.5	0.778

Treatment the hooked tube technique, *GDI* glaucoma drainage implant, *SD* standard deviation, *IOP* intraocular pressure

Table 2 Postoperative mean intraocular pressure and mean numbers of antiglaucoma medication

Time	IOP (mmHg)			No. of medications		
	Control group	Treatment group	*P*	Control group	Treatment group	*P*
Day 1	17.7 ± 8.1	16.4 ± 2.8	0.551	1.4 ± 1.1	1.4 ± 1.5	0.920
1 month	17.7 ± 4.9	14.4 ± 3.9	0.040	1.5 ± 1.1	1.2 ± 1.3	0.496
3 months	17.7 ± 4.9	15.9 ± 4.1	0.250	1.7 ± 1.1	1.1 ± 1.4	0.560
6 months	16.1 ± 2.6	16.1 ± 4.7	0.957	2.3 ± 1.2	1.4 ± 1.5	0.049
12 months	15.9 ± 2.4	15.8 ± 4.9	0.925	1.7 ± 1.0	1.4 ± 1.2	0.418

Treatment the hooked tube technique, *IOP* intraocular pressure

eyes exhibited IOP spikes of 10 mmHg at 1 month and at 3 month. In addition, IOP was 43 mmHg in one patient on the first postoperative day among controls. In this study, the mean number of preoperative (1.5 ± 1.5) and postoperative antiglaucoma medications (Table 2) was not statistically significantly different in the treatment group at any follow-up. However, the number of antiglaucoma medications at 3 and 6 months was significantly greater than before phacoemulsification in the control group (1.4 ± 1.1 vs. 1.7 ± 1.1; $P = 0.041$, 1.4 ± 1.1 vs. 2.3 ± 1.2; $P = 0.017$, respectively). After cataract surgery, there was a significant increase in the mean number of antiglaucoma medications used at 6 months in the control group compared with the treatment group ($P = 0.049$, Table 2).

The Snellen visual acuity improved in 14 (82%) of 17 eyes of treatment group and in 13 (87%) of 15 eyes in control group. At the last follow-up visit, the mean log MAR visual acuity did not differ statistically significantly between the control group and the treatment group (0.2 ± 0.2 vs. 0.3 ± 0.3; $P = 0.161$). Vision was decreased due to corneal decompensation in one patient in both study groups. The other reason for the decrease in visual acuity was age-related macular degeneration. No intraoperative complications were present in any study eyes.

Conclusions

Cataract progression has been reported to increase after GDI surgery [6]. Although the IOP spike is a rather rare complication after GDI surgery, it is not insignificant especially in the advanced glaucoma eyes. For the historical comparison, three studies were reviewed on phacoemulsification in eyes with GDI [2–4]. Sa and Kee studied the effect of temporal clear corneal phacoemulsification on IOP in 13 eyes with prior Ahmed glaucoma valve insertion [4]. An increase in antiglaucoma medication at the final follow-up was reported in their study. Also, 1 month after cataract surgery, the mean IOP increased by 4 mmHg or more in six patients (46%), one of whom had an IOP spike (10 mmHg increase). The authors concluded that phacoemulsification may adversely affect the capsule bleb of the Ahmed glaucoma valve.

Another study reported outcomes in 23 eyes with functioning Ahmed glaucoma valves which later underwent phacoemulsification [2]. The authors found that four eyes (17%) developed an IOP spike (> 10 mmHg increase) on the first postoperative day. They also found that the average (± SD) IOP increased from 14.5 (± 3.9) preoperatively to 19.2 (± 6.3) mmHg on the first postoperative day, although the mean IOP declined to the same level as preoperatively at 1 month. In a retrospective analysis of nine eyes with functioning Baerveldt implants subsequent to clear corneal phacoemulsification, the authors found no significant change in mean IOP after phacoemulsification [3]. However, IOP increased in two eyes (9%), while one eye (4%) required repeat glaucoma surgery.

According to the present study, the hooked tube technique may reduce the risk of poor IOP control after cataract surgery in eyes with GDI. In contrast to results in the control group and in other studies [2, 4], none in the treatment group developed an IOP spike during the follow-up visits and the IOP remained within 4 mmHg of the preoperative level throughout

the follow-up. Similar to other studies [2, 4], in the control group two eyes had IOP spikes at 1 month and at 3 month after cataract surgery. Also, the number of postoperative antiglaucoma medications increased in the control group but not in the treatment group.

The capsule of the GDI represents the outflow area for aqueous humor. Resistance to fluid flow through the capsule wall determined the postoperative IOP achieved with GDI. One reason why cataract surgery may adversely affect filtration through the bleb capsule wall might be the flow of lens debris through the GDI tube into the bleb cavity during surgery. In theory, this accumulation of debris can cause an inflammatory reaction and/or mechanical obstruction of the capsule wall, which may lead to impaired filtration of aqueous humor through the bleb capsule. However, one can speculate that any inflammatory reaction caused by the debris is short-lived because it appears not to alter long-term IOP control after GDI surgery. Also, the cataract type could influence to the amount of the accumulated debris in the bleb cavity. In case of a hard cataract, very dense nuclei often break into many tiny particles that can get trapped more easily into the bleb cavity. This can be one explanation for the late IOP spikes in two eyes of the control group.

Another explanation for postoperative IOP spikes, especially during the first postoperative days, might be the viscoelastic material used during surgery. This material can become trapped in the GDI and obstruct it, as reported by Ressiniotis and Down [5]. They presented a case of raised IOP (31–58 mmHg despite maximum antiglaucoma treatment) 1 month after penetrating keratoplasty (PKP). In this particular patient, the viscoelastic material was evacuated about 1 month after the PKP procedure from the GDI bleb cavity through a stab incision made in the GDI capsule wall. The authors concluded that the raised IOP was due to accumulation of the viscoelastic material in the bleb cavity over the GDI plate. Degradation of the viscoelastic material retained inside the bleb can be very slow, possibly due to low aqueous humor production [5].

Temporary occlusion of the GDI tube during cataract surgery with a flexible iris retractor hook, i.e., the hooked tube technique, seems to avoid certain risks of earlier postoperative IOP fluctuations. Flexible iris hooks were originally developed to enlarge a small pupil intraoperatively [7]. Nowadays, there are many commercially available disposable and flexible iris retractor hooks which can also be used in the hooked tube technique. In the present study, the GDI tube was occluded with an iris retractor hook before the anterior chamber was filled with viscoelastic material. This is important because otherwise the viscoelastic material may temporarily obstruct the GDI. The internal diameter of the silicone tube is 0.3 mm. After bending the GDI tube with the hook, the lumen of the soft tube is occluded at the site where the tube enters into the anterior chamber. This prevents the debris flow through the tube during the phacoemulsification. In addition, the iris hook itself with diameter of 0.1 mm inside the tube creates a mechanical barrier against to the lens debris during the surgery.

The hooked tube technique seems to be a valuable tool for avoiding postoperative IOP spikes with minimal complications in cataract surgery patients with prior GDIs. Only one patient (6%), aged 86 years, had postoperative visual acuity reduced due to corneal decompensation. This is about the same rate as reported previously with phacoemulsification in GDI eyes without temporary intraoperative occlusion of the tube [2]. The bent tube may also give the cataract surgeon more working space in the anterior chamber in cases where the intracameral part of the GDI tube is quite long.

In conclusion, I have successfully used the hooked tube technique in all patients where phacoemulsification cataract surgery was needed after previous GDI procedure. The limitations of this study are its retrospective design and small number of study patients. However, the hooked tube technique may help facilitate better IOP control, especially in advanced glaucoma patients with a GDI after cataract surgery. These patients are very sensitive to IOP spikes due to large visual field defects. None of the patients with the hooked tube technique required extra antiglaucoma medications or faced IOP spikes during the postoperative period.

Compliance with Ethical Standards

Conflict of interest The author declares that he has no conflict of interest.

Ethical Standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent The study was a purely retrospective analysis and did not require informed consent from the participants. All patient data were deidentified and kept confidential. No identifiable patient data were collected.

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