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Short-term results of microhook ab interno trabeculotomy, a novel minimally invasive glaucoma surgery in Japanese eyes: initial case series

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ABSTRACT.

Purpose: **To report the first early postoperative results and safety profile after microhook ab interno trabeculotomy (μLOT).**

Methods: **This initial retrospective observational case series included 24 consecutive glaucomatous eyes of 17 Japanese patients (7 men, 10 women; mean age ± standard deviation, 66.7 ± 17.9 years) who underwent μLOT. The trabeculotomy extent, surgical time, perioperative complications, interventions for complications and additional glaucoma surgeries during the follow-up for more than 3 months were collected by reviewing the medical and surgical records. The intraocular pressure (IOP), numbers of antiglaucoma medications, logarithm of the minimum angle of resolution visual acuity (VA), anterior chamber (AC) flare and corneal endothelial cell density (CECD) were compared preoperatively and postoperatively.**

Results: **The trabecular meshwork was incised for a mean of 3.6 ± 0.5 clock hours temporally, 3.7 ± 0.5 clock hours nasally and total 7.3 ± 0.6 clock hours during the 6.2 ± 1.6-min surgery. The mean preoperative IOP of 25.9 ± 14.3 mmHg and number of antiglaucoma medication of 3.3 ± 1.0 decreased significantly ($p = 0.0002$ and $p = 0.005$, respectively) to 14.7 ± 3.6 mmHg and 2.8 ± 0.8 at the final visit at 188.6 ± 68.8 days postoperatively. Compared with preoperatively, the final VA, AC flare and CECD did not change significantly. Hyphema with niveau formation (nine eyes, 38%) and washout of hyphema (two eyes, 8%) were the most common postoperative complication and intervention, respectively. At the final visit, 19 eyes (79%) achieved successful IOP control of 18 mmHg or less and a 15% reduction or greater.**

Conclusion: **Microhook trabeculotomy normalizes the IOP during the early postoperative period in patients with glaucoma.**

Key words: intraocular pressure – microhook ab interno trabeculotomy – minimally invasive glaucoma surgery – surgical complication

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Introduction

Trabeculotomy reduces the intraocular pressure (IOP) in children and adults with glaucoma by relieving the resistance to aqueous flow by cleavage of the trabecular meshwork and inner walls of Schlemm's canal (Chihara et al. 1993; Tanihara et al. 1993; Tanito et al. 2001, 2002). Because of the bleb-less mechanism of IOP reduction, trabeculotomy is associated with a lower probability of vision-threatening complications such as a flat anterior chamber (AC), bleb leaks, hypotony maculopathy, choroidal detachment and bleb infection that sometimes occurs after trabeculectomy with antifibrotic agents (Chihara et al. 1993; Kashiwagi et al. 2016).

The ab externo approach has been used traditionally to perform trabeculotomy in combination with use of a metal trabeculotome that incise 120 degrees of the meshwork (Chihara et al. 1993; Tanihara et al. 1993; Tanito et al. 2001, 2002) or with use of 5-0 nylon sutures, 6-0 polypropylene sutures and a microcatheter that incise 360 degrees of the meshwork (Beck & Lynch 1995; Chin et al. 2012; Dao et al. 2014). More recently, trabeculotomy techniques that are used with the ab interno approaches also have been reported (Grover et al. 2014; Sato et al. 2014, 2015). Recently, we reported both eyes of one patient with steroid-induced glaucoma who underwent a novel ab interno trabeculotomy that we named microhook trabeculotomy (μLOT) (Tanito et al. 2016). In that case, we performed μLOT because of the presence of scleral thinning after recurrent scleritis, and therefore, it was better to avoid performing glaucoma surgeries that require creation of a scleral flap (Tanito et al. 2016). Because of the marked reduction in

IOP in that case and less invasiveness of the ocular surface, we began to perform μLOT in other cases. In this report, we describe the surgical technique, early postoperative results and safety profile of μLOT in the initial case series.

Subjects and Methods

This observational case series included 24 consecutive glaucomatous eyes of 17 Japanese subjects [7 men, 10 women; mean age ± standard deviation (SD), 66.7 ± 17.9 years] who underwent μLOT without simultaneous cataract surgery at Matsue Red Cross Hospital between June 2015 and December 2015 to control IOP (Table 1). The study adhered to the tenets of the Declaration of Helsinki, and the institutional review board of Matsue Red Cross Hospital reviewed and approved the research. Preoperatively, all subjects provided written informed consent for surgery and use of clinical data regarding the glaucoma treatment obtained during the follow-up periods.

Surgical procedure

One surgeon (MT) performed all surgeries (Video S1). The spatula-shaped microhook that was designed specifically for use in μLOT was created by sharpening the tip of a regular Sinskey hook (M-127S, Inami, Tokyo, Japan) by the manufacturer (Fig. 1). Standard sub-Tenon anaesthesia was induced using 2% lidocaine before the procedure. Viscoelastic material (1% sodium hyaluronate, Opegan Hi, Santen Pharmaceutical, Osaka, Japan) was injected into the AC through the clear corneal ports created using a 20-gauge microvitreoretinal (MVR) knife (Mani, Utsunomiya, Japan) at the 2–3 and 9–10 o'clock positions (Fig. 2A). Using a Swan-Jacob gonioprism lens (Ocular Instruments, Bellevue, WA) to observe the angle opposite from the corneal port, a microhook was inserted into the AC through the corneal port (Fig. 2B). The tip of the microhook then was inserted into Schlemm's canal and moved circumferentially to incise the inner wall of Schlemm's canal and trabecular meshwork over 3 clock hours (Fig. 2C). Using the same procedure, trabeculotomy was performed in the opposite angle using a microhook that was inserted through another corneal port (Fig. 2D). After the viscoelastic material was aspirated bimanually (Fig. 2E), the corneal ports were closed by corneal stromal hydration (Fig. 2F). At the end of surgery, 1.65 mg of dexamethasone sodium phosphate (Decadron, Aspen Japan, Tokyo, Japan) was injected subconjunctivally and 0.3% ofloxacin ointment (Tarivid, Santen Pharmaceutical) was applied. Finally, 1.5% levofloxacin (Nipro, Osaka, Japan) and 0.1% betamethasone (Sanbetason, Santen Pharmaceutical) were applied topically four times daily for 3–4 weeks postoperatively in all cases.

In the initial case report, we used a regular straight Sinskey hook to incise the meshwork (Tanito et al. 2016). Because the tip of a regular Sinskey hook is dull, we created a small goniotomy using an MVR knife before we inserted the tip of the hook into Schlemm's canal. By sharpening the tip into a spatula shape, the microhook used in this study could be inserted directly into Schlemm's canal without the need to create an entry site, which resulted in a simplified surgical technique and shorter surgical time. To minimize damage to the outer wall of Schlemm's canal when inserting the tip of the hook into Schlemm's canal, we recommend perforating the meshwork by gently sliding rather than stabbing the tip into the meshwork surface. After insertion, depth of the tip can be monitored by visualizing the tip through the trabecular meshwork; the inability to visualize the tip through the meshwork usually indicates that the tip was inserted too deeply. With adequate direction and depth, only minor resistance is felt when moving the tip circumferentially; any resistance usually indicates that the tip was inserted too deeply. To avoid unintended tissue damage around the trabecular meshwork, the correct insertion, direction and depth of the tip of the hook should be monitored carefully during the procedure.

Measurements

The clinical parameters, including age, sex, glaucoma type, lens status, ocular surgical history, preoperative and postoperative best-corrected visual acuities (BCVAs), IOP, number of antiglaucoma medications, AC flare measured by the FM-600 laser flare meter (Kowa, Nagoya, Japan), corneal endothelial cell density (CECD) measured using the EM-3000 specular microscope (Tomey, Nagoya, Japan), preoperative visual field (Central 30-2 Program, Humphrey Visual Field Analyzer, Carl Zeiss Meditec, Dublin, CA) and duration of postoperative follow-up, were collected from the medical charts. The Snellen VA was converted into the logarithm of the minimum angle of resolution (logMAR) VA. The IOP was measured by Goldmann applanation tonometry except for that measured on postoperative day 3 by the iCARE rebound tonometer (M.E. Technica, Tokyo, Japan). The extent of the trabeculotomy, surgical time, perioperative complications, interventions for complications and additional glaucoma surgeries performed were recorded by reviewing medical and surgical records.

Statistical analysis

The preoperative and final VAs, IOPs, AC flare and CECD were compared using the paired *t*-test. Successful IOP control, defined as a postoperative IOP of 18 mmHg or less and IOP reduction of 15% of more from the preoperative value, was assessed at the final visit. To adjust for possible biases derived from the inclusion of both eyes of a patient and for difference in follow-up period, the preoperative IOP and IOPs measured at 3 days, 1–2 weeks, 1 month (3–5 weeks), 3 months (2–4 months) and 6 months (5–7 months) postoperatively were compared using a mixed-effects regression model in which each patient's identification number was regarded as a random effect and the time period was regarded as a fixed effect, followed the *t*-test for the post hoc comparison between groups. Postoperative changes in the number of antiglaucoma medication also were assessed using the mixed-effects regression model. All continuous data were expressed as the mean ± SD. All statistical analyses were performed using the JMP version 11.0 statistical software (SAS Institute, Inc., Cary, NC, USA). $p < 0.05$ was considered statistically significant.

Results

The patients in this case series had various types of glaucoma, that is

Table 1. Demographic data of subjects and surgical results.

Case	Age (years)	Sex	Eye	Glaucoma Type	Lens status	Previous surgeries	Preoperative findings: VA (logMAR)	IOP (mmHg)	Drugs	AC flare (pc/mseconds)	CECD (cells/mm^2)	Visual field MD (dB)	Extent of trabeculotomies (clock hours): Temporal	Nasal	Total
1	85	M	L	EXG	Pseudophakia	PEA+IOL, SLT	0.00	22	2	9.7		−4.71	4	4	8
2	82	F	R	POAG	Pseudophakia	PEA+IOL+LOT	−0.08	22	3	17.8	2235	−5.43	4	4	8
			L	POAG	Pseudophakia	PEA+IOL+LOT	−0.08	21	3	13.6	2219	−14.26	4	4	8
3	82	F	L	POAG	Pseudophakia	PEA+IOL+LOT	−0.08	17	1	4.9	2555	−3.5	4	3	7
4	74	F	L	PACG	Pseudophakia	PEA+IOL+GSL	0.05	20	3	19.7	2726	−7.47	4	3	7
			R	PACG	Pseudophakia	PEA+IOL+GSL	0.00	17	3	16.3	2229	−7.7	4	3	7
5	33	M	L	POAG	Phakia		−0.08	14	5	10.8	2678	−16.81	4	4	8
6	44	F	R	Steroid	Phakia		−0.08	46	4	8	2436	−1.74	3	4	7
			L	Steroid	Phakia		−0.08	32	3	6	2873	−1.86	3	4	7
7	49	M	L	POAG	Phakia		−0.08	21	3	8.7	2329	−7.68	4	3	7
8	78	F	R	EXG	Pseudophakia	PEA+IOL, SLT	0.00	17	3	30.5	2294	−4.38	3	4	7
			R	EXG	Pseudophakia	PEA+IOL, SLT	−0.08	18	3	24.5	2596	−2.37	4	4	8
9	84	F	R	Mixed	Pseudophakia	PEA+IOL	0.00	26	4	9.1	2244	−14.45	4	3	7
			L	Mixed	Pseudophakia	PEA+IOL	−0.08	20	2	6.9	2397	−7.3	3	3	6
10	38	M	L	POAG	Phakia		1.00	20	5	6.1	2483	−20.84	3	4	7
11	52	M	R	Steroid	Phakia		0.05	69	4	13.1	2631	−10.06	3	4	7
			L	Steroid	Phakia		−0.08	57	4	10.7	1524	−3.3	4	4	8
12	52	M	L	Pigmentary	Pseudophakia	PEA+IOL	1.52	48	5				3	3	6
13	72	F	R	PACG	Pseudophakia	PEA+IOL+GSL,LGP	−0.08	19	3	22.8	2641	−16.7	3	4	7
14	81	F	L	POAG	Pseudophakia	PEA+IOL	−0.08	20	2	13.8	2131	−5.82	3	4	7
15	84	F	R	EXG	Pseudophakia	PEA+IOL+LOT	−0.08	21	3	9.5	2537	−4.38	4	4	8
16	75	F	L	EXG	Pseudophakia	PEA+IOL	0.05	19	4	7.4	2418	−7.52	4	4	8
			R	EXG	Pseudophakia	PEA+IOL	0.10	17	4	33.3	2180	−21.38	3	4	7
17	68	M	L	POAG	Phakia		−0.08	18	3	5.7	2290	−13.22	4	4	8
Mean	66.7						0.07	25.9	3.3	13.4	2393	−8.82	3.6	3.7	7.3
SD	17.9						0.38	14.3	1.0	8.0	279	6.01	0.5	0.5	0.6
p value*															

Table 1. (Continued)

Case	Surgical time (min)	Postoperative findings at final visit: VA (logMAR)	IOP (mmHg)	Drugs	AC flare (pc/mseconds)	CECD (cells/mm^2)	Surgical success†	Surgical Complications: Intraop blood reflux	Postop hyphema with niveau formation	Transient IOP elevation >30 mmHg	Other	Intervention for complication or additional glaucoma surgery	Follow-up (days)
1	6	0.00	12	2			Success	Yes	Yes	Yes	VH	Hyphema washout (PSD3), PPV for VH (PSM1)	316
2	5	−0.08	19	2	21.1	2175	Failed	Yes	No	No			304
	5	−0.08	11	2	13.3	2322	Success	Yes	No	No			299
3	6	0.15	14	1			Success	Yes	No	No			290
4	6	−0.08	14	3	20.5	2773	Success	Yes	Yes	No			256
	5	0.00	14	3	14.6	2257	Success	Yes	Yes	No			228
5	7	−0.08	11	3	10.1	2679	Success	Yes	Yes	No			211
6	10	−0.08	16	3	6.1	2558	Success	Yes	Yes	No			242
	8	−0.08	15	3	6.6	2773	Success	Yes	No	No			217
7	6	−0.08	17	3	7.5	2470	Success	Yes	No	No			227
8	5	0.15	11	3			Success	Yes	No	No			153
	4	0.15	12	3			Success	Yes	No	No			126
9	6	−0.08	18	2	8.6	2412	Success	Yes	No	No			132
	7	0.10	20	2	8.1	2363	Failed	Yes	No	No			111
10	5	1.22	10	4	4.7	2187	Success	Yes	Yes	No		Hyphema washout	122
11	8	0.52	24	5	14.4	2641	Failed	Yes	No	No	Cataract progression	(PSD3) PEA+IOL+ Ex PRESS shunt (PSM4)	128
	8	0.05	20	4	10.9	2638	Failed	Yes	No	No			199
12	8	0.30	14	3	25.2	2225	Success	Yes	No	No			167
13	7	−0.08	13	3	13.9	2466	Success	Yes	No	No			135
14	8	0.00	12	2	10	2173	Success	Yes	No	No			158
15	5	−0.08	15	3	6.8	2503	Success	Yes	Yes	No			106
16	4	0.15	15	3	11.3	2417	Success	Yes	Yes	No			117
	4	0.10	15	3	9	2173	Failed	Yes	Yes	No	VH		112
17	5	−0.08	10	2	5.3	2388	Success	Yes	No	No			171
Mean	6.2	0.08	14.7	2.8	11.4	2430							188.6
SD	1.6	0.29	3.6	0.8	5.6	200							68.8
p value*		0.794	0.0002	0.005	0.184	0.348							

SD = standard deviation; M = male; F = female; PEA+IOL = phacoemulsification/aspiration and intraocular lens implantation; SLT = selective laser trabeculoplasty; LOT = trabeculotomy ab externo; GSL = goniosynechialysis; LGP = argon laser trabeculoplasty; LogMAR = logarithm of the minimum angle of resolution; IOP = intraocular pressure; drug = number of antiglaucoma medications; AC = anterior chamber; pc = photon count; CECD = corneal endothelial cell density; MD = mean deviation; VH = vitreous haemorrhage; PPV = pars plana vitrectomy; PSD = postoperative days; PSM = postoperative month; EXG = exfoliation glaucoma; POAG = primary open-angle glaucoma; PACG = primary angle-closure glaucoma; L = left; R = right; postop = postoperative; intraop = intraoperative; VA = visual acuity; dB = decibels.

* p Values are calculated by using the paired t-test between preoperative and postoperative findings.

† IOP≤18 mmHg and IOP reduction ≥15%.

primary open-angle glaucoma (POAG; eight eyes), exfoliation glaucoma (six eyes), steroid-induced glaucoma (four eyes), primary angle-closure glaucoma (PACG) (three eyes), mixed-mechanism glaucoma (two eyes) and pigmentary glaucoma (one eye), all of which were treated with μLOT (Table 1). Of the 24 eyes, eight eyes were phakic and 16 eyes were pseudophakic. All eyes with PACG and mixed-mechanism glaucoma were pseudophakic preoperatively. Other than cataract surgeries, the previous ocular surgeries there had been performed were ab externo trabeculotomy (four eyes), goniosynechialysis (three eyes), selective laser trabeculoplasty (three eyes) and laser gonioplasty (one eye).

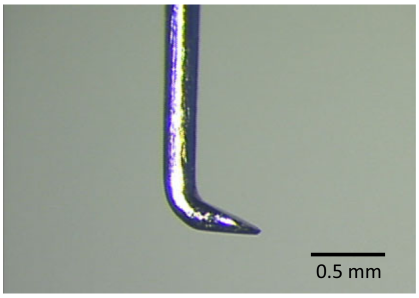

Fig. 1. The tip of the microhook. The spatula-shaped microhook was designed especially for use during ab interno microhook trabeculotomy. It was created by sharpening the tip of a regular Sinskey hook (M-127S, Inami, Tokyo, Japan).

The trabecular meshwork was incised for a mean of 3.6 ± 0.5 clock hours (range, 3–4) temporally and 3.7 ± 0.5 clock hours (range, 3–4) nasally (mean total, 7.3 ± 0.6 clock hours; range, 6–8) during the mean surgical time of 6.2 ± 1.6 min. The preoperative IOP of 25.9 ± 14.3 mmHg (range, 14–69) and number of antiglaucoma medication of 3.3 ± 1.0 (range, 1–5) decreased significantly ($p = 0.0002$ and $p = 0.005$, respectively) to 14.7 ± 3.6 mmHg (range, 10–24) and 2.8 ± 0.8 (range, 1–5) at the final postoperative visit at 188.6 ± 68.8 days (range, 106–316) (Table 1). At the final visit, 19 (79%) eyes achieved successful IOP control of 18 mmHg or less and 15% or more IOP reduction (Table 1). With the mixed-effects regression model, the postoperative decreases in the IOP ($p < 0.0001$ for the model) and the number of antiglaucoma medication ($p < 0.0001$ for the model) were significant (Table 2). Compared with preoperatively, decrease in the IOP was significant at every time-point up to 6 months postoperatively ($p < 0.0001$ for all comparisons). Compared with preoperatively, decrease in the number of antiglaucoma medications was significant for up to 6 months ($p = 0.019$–0.038) except for 1 month postoperatively ($p = 0.056$; Table 2).

Compared with preoperatively, the VA, AC flare and CECD did not change significantly at the final visit ($p = 0.794$, 0.184 and 0.348, respectively); the VA did not decrease in any eye more than 0.3 logMAR unit except for one eye that seen a cataract progression (Table 1, case 11R).

The surgical complications included intraoperative blood reflux from the incised angle into the AC in 24 eyes (100%), postoperative hyphema with niveau formation in nine eyes (38%), vitreous haemorrhage in two eyes (8%), transient IOP spike exceeding 30 mmHg in one eye (4%) and cataract progression in one eye (4%) (Table 1). The interventions required to treat the complications or additional glaucoma surgery included washout of the hyphema at 3 days postoperatively in two eyes, pars plana vitrectomy for a vitreous haemorrhage at 1 month postoperatively in one eye and cataract surgery combined with ExPRESS shunt (Alcon Japan, Tokyo, Japan) at 4 months postoperatively (Table 1). In most cases, mild hyphema observed at 1–3 days postoperatively (Fig. 3A) subsided within 1 week postoperatively (Fig. 3B). Typically, a cleft in the trabecular meshwork was observed in

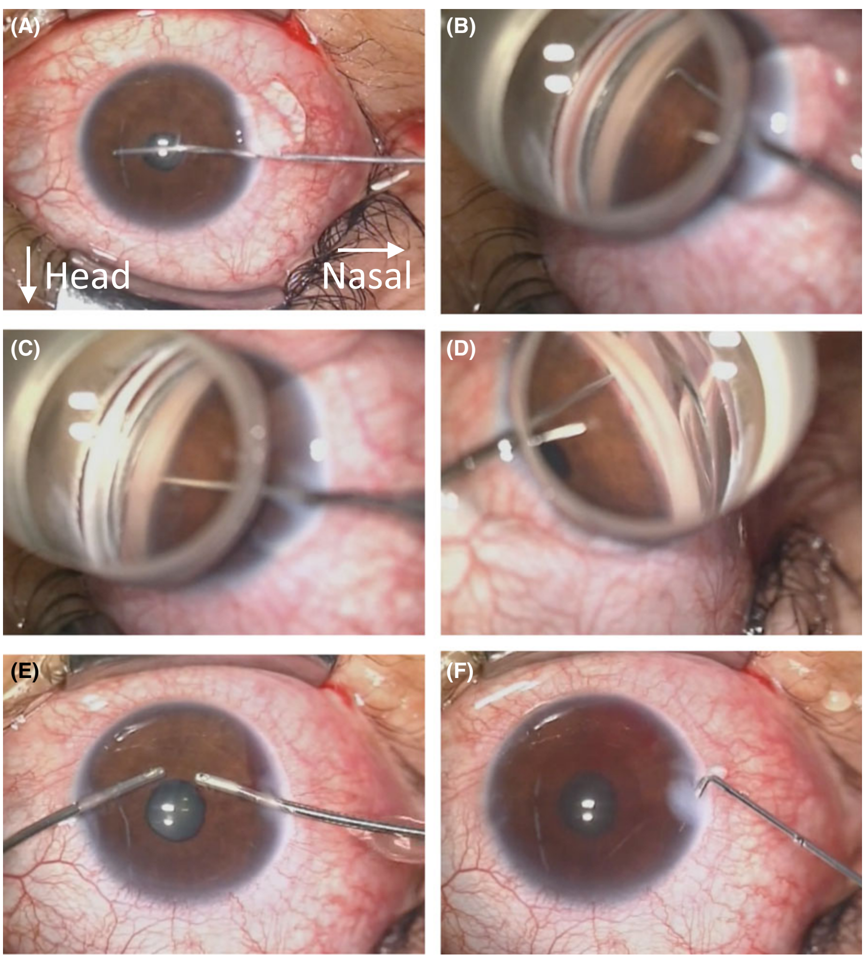

Fig. 2. Intraoperative findings in a 44-year-old woman with steroid-induced glaucoma in the right eye (case 6). (A) Viscoelastic material is injected into the anterior chamber (AC) through the clear corneal ports created using a 20-gauge microvitreoretinal knife at the 2 and 9 o'clock positions. (B) With the temporal angle observed using a Swan-Jacob gonioprism lens, a microhook is inserted into the AC through the corneal port at the 9 o'clock position. (C) The tip of the microhook is inserted directly into Schlemm's canal temporally and moved circumferentially to incise the inner wall of Schlemm's canal and trabecular meshwork. (D) Using the same procedure, trabeculotomy is performed nasally using a microhook inserted from the corneal port at the 2 o'clock position. (E) The viscoelastic material is aspirated by bimanual aspiration (F). The corneal port is closed by corneal stromal hydration.

Table 2. Preoperative and postoperative IOPs and medications.

	No. eyes	IOP (mmHg)	p Value†	Medication (range)	p Value†
Preoperative	24	25.9 ± 14.3 (19.9–31.9)		3.3 ± 1.0 (2.9–3.7)	
3 days	24	12.9 ± 7.0 (9.9–15.9)	<0.0001	2.8 ± 0.7 (2.4–3.1)	0.025
1–2 weeks	24	15.2 ± 4.3 (13.4–17.0)	<0.0001	2.8 ± 0.7 (2.4–3.1)	0.025
1 month	24	16.6 ± 4.7 (14.6–18.6)	<0.0001	2.8 ± 0.9 (2.5–3.2)	0.056
3 months	24	15.0 ± 3.5 (13.5–16.4)	<0.0001	2.8 ± 0.7 (2.5–3.1)	0.038
6 months	13	14.5 ± 2.9 (12.7–16.2)	<0.0001	2.6 ± 0.5 (2.2–3.1)	0.019
		$p < 0.0001$*		$p < 0.0001$*	

IOP = intraocular pressure.
Data are expressed as means ± standard deviations (upper and lower 95% confidence intervals).
* p Values are calculated using the mixed-effects regression model.
† p Values are calculated using the t-test between preoperative and respective time period values.

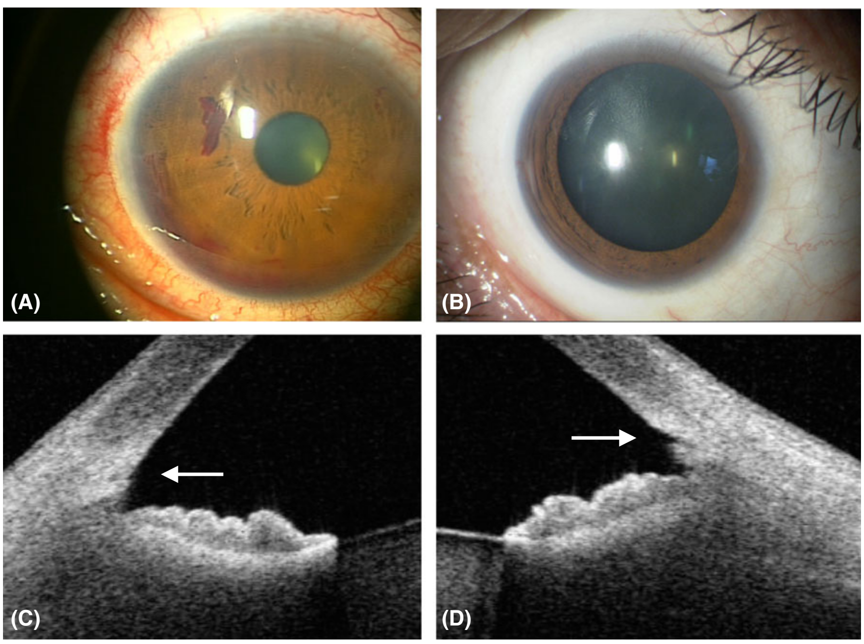

Fig. 3. The postoperative findings in the same case as in Fig. 2. (A) Mild hyphema is seen 2 days postoperatively. (B) The hyphema is resolved completely 2 weeks postoperatively. Three months postoperatively, anterior-segment optical coherence tomography shows a cleft in the trabecular meshwork (arrows) in the temporal (C) and nasal (D) angles of the right eye. The preoperative intraocular pressure of 46 mmHg with four medications has decreased to 16 mmHg with three medications 242 days postoperatively.

the incised angles using anterior-segment optical coherence tomography (Fig. 3C,D).

Discussion

In the current case series, after a trabeculotomy greater than 180 degrees, a marked IOP reduction was achieved during the early postoperative period for up to 6 months in eyes with various types of glaucoma as reported with ab externo 120-degree LOT for POAG (Chihara et al. 1993; Tanihara et al. 1993; Tanito et al. 2001, 2002), exfoliation glaucoma (Tanihara et al. 1993; Honjo et al. 1998), steroid-induced glaucoma (Honjo et al. 2000; Iwao et al. 2011) and PACG (Tanihara et al. 1995). The postoperative IOP reductions of 11.2 mmHg and 43% with 2.8 medications at the final visit achieved by μLOT are comparable to or better than those achieved with ab externo 120-degree LOT (Chihara et al. 1993; Tanihara et al. 1993; Tanito et al. 2001, 2002), but the difference should be clarified in a comparative study. At the final visit, 79% of the current eyes achieved successful IOP control; thus, μLOT seems effective for normalizing the IOP at least during the early postoperative period. In this case series, we treated three PACG eyes and two mixed-mechanism glaucoma eyes because of insufficient IOP reduction after the initial treatment with cataract surgery with or without goniosynechialysis. In such cases, μLOT could perform without any special technique. During the procedure, the depth of incision can be controlled by monitoring the tip of hook through the trabecular meshwork and by feeling the resistance, and these allow surgeons to make a selective incision of trabecular meshwork/inner wall of Schlemm's canal with a minimal damage to the outer wall of Schlemm's canal. Incision of the inner wall without damaging the outer wall of Schlemm's canal is sometimes difficult when using a straight knife (i.e. goniotomy); thus, μLOT seems to be an easier procedure than goniotomy.

In the current case series, trabeculotomy was performed in the temporal and nasal angles, although we currently do not know whether trabeculotomy is required in both angles. In a perfusion study of autopsy eyes, incisions in the trabecular meshwork at the 1, 4 and 12 clock hours eliminated 30%, 44% and 51%, respectively, of outflow resistance, respectively, at the perfusion pressure of 7 mmHg, and 30%, 56% and 72% of outflow resistance at the perfusion pressure of 25 mmHg (Rosenquist et al. 1989), indicating that difference in the extent of trabeculotomy can yield different degrees of IOP reduction. Accordingly, comparisons between IOP reductions with angle incisions on both sides and one side and the correlations between the extent of the incisions and IOP reductions after μLOT should be evaluated in the future.

We observed several complications perioperatively (Table 1), although most subsided spontaneously or were treatable with relatively minor interventions such as washout of the hyphema. One eye required pars plana vitrectomy to recover VA from decreased vision due to vitreous haemorrhage; thus, like other glaucoma surgeries, μLOT also is not a vision-threatening complication-free procedure. Compared to the preoperative values, the VA, CECD and AC flare were unchanged at the final visit. Around 10% loss of CECD was reported 3 and 12 months after the trabeculectomy with Mitomycin C (Storr-Paulsen et al. 2008); thus, no change in CECD after mean follow-up of 6 months can be an advantage of μLOT. Sparing of the conjunctiva and sclera with the ab interno technique, short surgical time, moderate IOP reduction and no bleb-related complications fulfil the conditions of minimally invasive glaucoma surgery (Ahmed 2015; Kahook et al. 2015), as with the recent techniques of ab interno trabeculotomy/trabeculectomy and gonio-bypass surgeries such as the Trabectome (Neomedix Inc., Tustin, CA; Minckler et al. 2005), iStent (Glaukos, Laguna Hills, CA; Malvankar-Mehta et al. 2015), gonioscopy-assisted transluminal trabeculotomy (Grover et al. 2014; Sato et al. 2014, 2015), canaloplasty (Khaimi 2015; Matlach et al. 2015), dual-blade trabeculectomy (New World Medical Inc., Rancho Cucamonga, CA; Seibold et al. 2013; SooHoo et al. 2015) and TRAB360 surgery (Sight Sciences, Menlo Park, CA). The absence of the need for expensive devices seems an advantage of our procedure.

The limitations of the current study included the small sample size, no control group, retrospective study design, short follow-up and inclusion of eyes with various glaucoma types, lens status and previous ocular surgeries. Inclusion of both eyes of a patient is also a factor of possible bias, although we minimized this possibility using a mixed effect regression model. However, we believe that this initial case series indicates that the μLOT is worth further evaluation in a larger and longer longitudinal study or in a study in which it is compared to other surgeries such as ab externo trabeculotomy.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Video S1. Ab interno trabeculotomy using a microhook in the right eye of case 6.