

Access this article online

Quick Response Code:



Website:

www.e-tjo.org

DOI:

10.4103/tjo.tjo_38_19

Ab-interno trabeculotomy-related glaucoma surgeries

Masaki Tanito, Masato Matsuo

Abstract:

Reductions of intraocular pressure during trabeculotomy result from relieving the resistance to aqueous flow by cleavage of the trabecular meshwork and inner walls of Schlemm's canal at the point of outflow resistance of the aqueous humor. Since trabeculotomy does not result in bleb formation, development of late-onset sight-threatening complications, such as hypotony maculopathy and endophthalmitis, that are associated occasionally with trabeculectomy develop less frequently after trabeculotomy. The *ab-interno* approach is used in several new procedures, including the Trabectome, Kahook Dual Blade, microhook *ab-interno* trabeculotomy, and 360° suture trabeculotomy, instead of the *ab-externo* approach as in conventional trabeculotomy. These newly developed novel, minimally invasive, and trabeculotomy-related glaucoma surgeries can be good options for certain glaucoma cases, including early-stage open-angle glaucoma, developmental glaucoma, and glaucoma in elderly patients.

Keywords:

Ab-externo trabeculotomy, Kahook Dual Blade, microhook *ab-interno* trabeculotomy, minimally invasive glaucoma surgery, suture *ab-interno* trabeculotomy, Trabectome

Introduction

The goal of trabeculotomy is reduction of the intraocular pressure (IOP) in patients with glaucoma.^[1-4] The mechanism by which this is accomplished may be by elimination of the aqueous flow resistance by cleavage of the trabecular meshwork (TM) and inner walls of Schlemm's canal at the point of outflow resistance of the aqueous humor. The *ab-externo* approach that involves incision of the TM after a scleral flap is created has been used traditionally to perform trabeculotomy in combination with metal trabeculotomes.^[1-4] A new technique, i.e., the *ab-interno* approach, for performing trabeculotomy has been reported recently, in which the TM is incised or excised using specialized devices under direct observation of the anterior-chamber angle structure. These novel trabeculotomy approach included the Trabectome procedure during which

the surgeon removes the TM using a small diathermy/irrigation/aspiration handpiece [Figure 1a];^[5] the Kahook Dual Blade is used to excise the TM in a strip using a curette with two blades [Figure 1b];^[6,7] microhook *ab-interno* trabeculotomy, which uses a small metal hook to incise the TM [Figure 1c];^[8-10] and *ab-interno* 360° suture trabeculotomy/gonioscopy-assisted transluminal trabeculotomy, by which the entire TM is incised using a suture after circumferential insertion of the suture into Schlemm's canal [Figure 1d].^[11,12]

Microhook Ab-Interno Trabeculotomy, A Novel Minimally Invasive Glaucoma Surgery

Three different microhooks are used during microhook *ab-interno* trabeculotomy. A straight [M-2215S, Figure 1c] hook is used to incise the nasal angle, and angled-right [M-2215R, Figure 1c] and angled-left [M-2215 L, Figure 1c] hooks

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Tanito M, Matsuo M. *Ab-interno* trabeculotomy-related glaucoma surgeries. Taiwan J Ophthalmol 2019;9:67-71.

Department of
Ophthalmology, Faculty
of Medicine, Shimane
University, Shimane
Prefecture, Japan

Address for correspondence:

Prof. Masaki Tanito,
Department of
Ophthalmology,
Shimane University
Faculty of Medicine,
89-1 Enya, Izumo,
693-8501, Shimane
Prefecture, Japan.
E-mail: tanito-oph@umin.
ac.jp

Submission: 29-03-2019
Accepted: 11-04-2019



Figure 1: Various devices for novel trabeculotomy-related surgeries. (a) The Trabectome provided by Kowa Company Ltd. (<http://www.kowa.co.jp>). (b) The Kahook Dual Blade provided by JFC sale Plan (<http://www.jfcsp.co.jp>). (c) The Tanito *ab interno* Trabeculotomy Microhook provided by Inami and Co., Ltd. (<http://inami.co.jp>). (d) The Chin trabeculotomy suture provided by Handaya Co., Ltd. (<http://www.handaya.co.jp>)

(all from Inami and Co., Ltd.) are used to incise the temporal angle. A Swan Jacob gonioprism lens (Ocular Instruments) is used to observe the angle opposite to the corneal port, and a microhook is inserted into the anterior chamber through the corneal port [Figure 2a and b]. The microhook tip then is inserted into Schlemm’s canal and moved circumferentially to incise the inner wall of the canal and TM over 3 clock hours. Trabeculotomy then is performed in the opposite angle using the same procedure by insertion of the microhook through another corneal port. We recommend perforating the meshwork by gently sliding and not stabbing the tip into the meshwork surface to minimize damage to the outer wall of Schlemm’s canal when inserting the tip of the hook into Schlemm’s canal. After inserted the tip of the hook, the depth of the tip can be visualized thorough the TM. When the tip cannot be visualized through the TM, this usually indicates that the tip is too deep. With adequate direction and depth, only minor resistance is encountered when the tip is moved circumferentially; any resistance usually indicates that the tip is too deep. Avoiding iatrogenic tissue damage around the TM requires careful monitoring of the correct insertion, direction, and depth of the tip of the hook. Intraoperative use of microscope-integrated optical

coherence tomography (OCT) (RESCAN 700, Carl Zeiss Meditec Japan) in combination with a gonioprism^[13] or by anterior-segment OCT (Casia 2, Tomey Corporation) postoperatively can visualize correct opening of the TM [Figure 3a and b].^[9] The surgical video is available at <https://www.youtube.com/watch?v=VPWwhsEsfrn8>.^[14]

An initial case series reported that at the final 6-month examination, microhook *ab-interno* trabeculotomy alone decreased the IOP from 25.9 mmHg preoperatively to 14.7 mmHg postoperatively, a 43% decrease.^[9] Microhook *ab-interno* trabeculotomy combined with cataract surgery decreased the IOP from 16.4 mmHg preoperatively to 11.8 mmHg postoperatively at the final 9.5-month examination, a 28% decrease.^[10] The complications reported included transient IOP spikes, cataract progression, vitreous hemorrhages, and macular edema.^[9,10]

Features of Conventional and Novel Trabeculotomy-Related Surgeries

The features of the new trabeculotomy-related surgeries are shown in Table 1. Since the *ab-interno* approach does not require conjunctival and scleral incisions, the new

Table 1: Comparisons among conventional trabeculotomy and recent trabecular meshwork surgeries

Procedure	Trabeculotomy <i>ab externo</i>	Goniotomy	Trabectome	Kahook Dual Blade	Microhook <i>ab-interno</i> trabeculotomy	360° <i>ab-interno</i> trabeculotomy
Trabeculotomy extent	1/4 circumference	1/4 circumference	1/4 circumference	1/4 circumference	1/2-2/3 circumference	~Entire circumference
Ocular surface invasiveness	++	Minimal	Minimal	Minimal	Minimal	Minimal
Procedural difficulty	Difficult	Difficult	Easy	Moderate	Moderate	Difficult
Reason for difficulty	Require Schlemm's canal identification	Require incision depth control		Large device tip, difficulty in strip excision	Require left-handed procedure	Difficulty in entire circumference suture insertion
Surgical cost	Low	Low	High	Moderate	Low	Low

This table was adopted from my previous publication^[20] with English translation with the permission of the journal

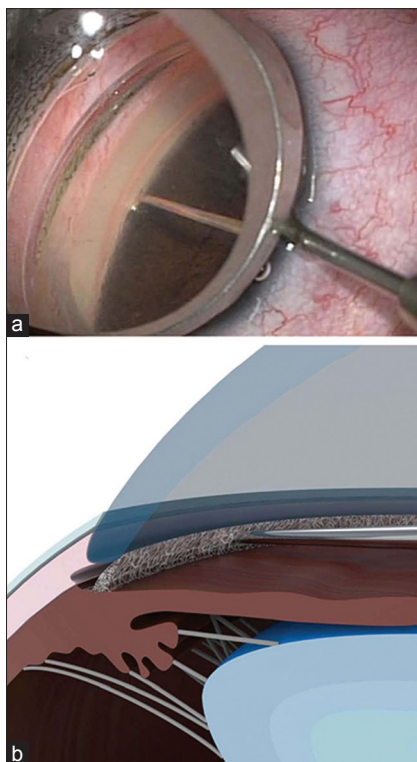


Figure 2: Surgical procedure of microhook *ab-interno* trabeculotomy. (a) Observation of the anterior-chamber angle using a Swan-Jacob gonioprism lens shows the trabecular meshwork and that inner wall of Schlemm's canal is incised circumferentially using the tip of the microhook inserted into the anterior chamber through the small corneal incision. (b) A schematic drawing of the meshwork incision by the tip of the hook. This schema is provided by Inami Co. Ltd

trabeculotomy-related procedures are minimally invasive to the ocular surface, which allows these procedures to be performed safely in the eyes with scleral thinning.^[8] The smaller surgical incisions created in the ocular surface with *ab-interno* trabeculotomy-related procedures cause less induced postoperative astigmatism than astigmatism that develops following trabeculectomy.^[15] Direct visualization of the anterior-chamber angle achieved using a gonioprism lens during *ab-interno* trabeculotomy facilitates easier identification of Schlemm's canal compared with identification of the anterior-chamber

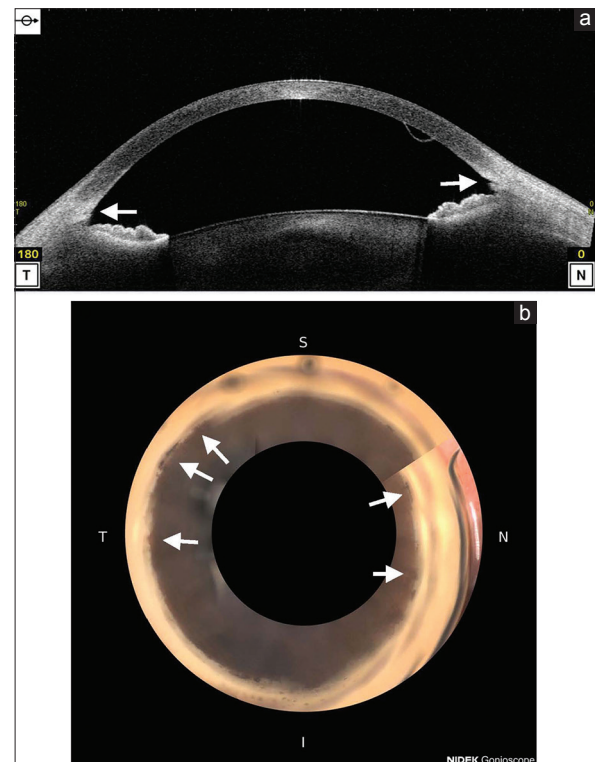


Figure 3: Anterior-chamber angle findings after microhook *ab-interno* trabeculotomy. (a) Observation of the anterior-chamber angle using anterior-segment optical coherence tomography (Casia 2, Tomey). A trabeculotomy cleft is seen in both the temporal and nasal angles (arrows) postoperatively in the right eye. (b) Observation of the entire anterior-chamber angle using a 360° gonioscope (GS-1, Nidek).^[21] Small but interrupted peripheral anterior synechiae (arrows) are seen postoperatively in the right eye

angle under the scleral flap during conventional *ab-externo* trabeculotomy. The extent of the trabeculotomy (90–120°) the conventional *ab-externo* trabeculotomy [Figure 4a], the Trabectome procedure, and the Kahook Dual Blade [Figure 4b] is wider, i.e., 180–240° for microhook *ab-interno* trabeculotomy [Figure 4c] and 360° with suture trabeculotomy when a suture is inserted successfully into the entire circumference of Schlemm's canal [Figure 4d]. In a perfusion study of autopsy eyes, the investigators reported that incisions in the TM

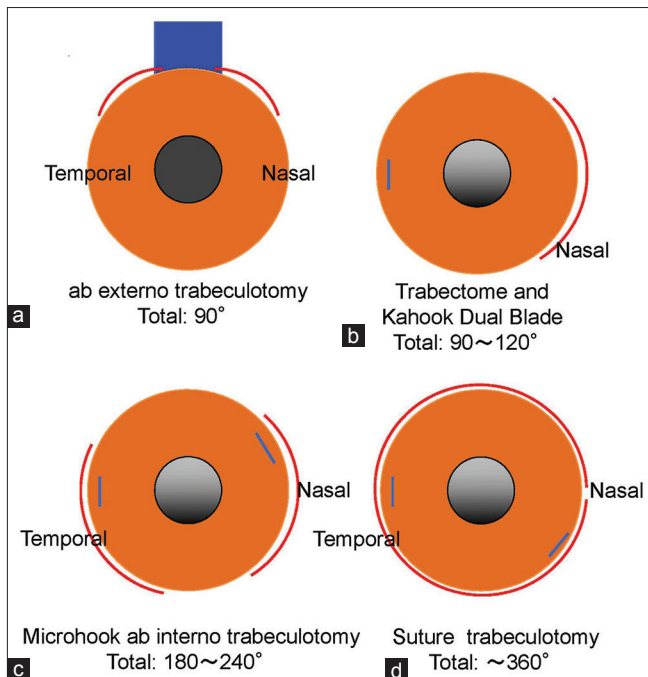


Figure 4: The typical extents of the incisions created in traditional *ab-externo* trabeculotomy and novel trabeculotomy-related glaucoma surgeries. (a) Conventional *ab-externo* trabeculotomy. (b) The Trabectome and Kahook Dual Blade. (c) Microhook *ab-interno* trabeculotomy. (d) Suture *ab-interno* trabeculotomy. The red arcs indicate the extent of the trabeculotomy, the blue lines the corneal side ports, and the blue box the scleral flap. These panels are adopted from our previous publication^[20] with modification with the permission of the journal

that extended for 1, 4, and 12 clock hours eliminated 30%, 44%, and 51%, respectively, of the outflow resistance at 7 mmHg of perfusion pressure and 30%, 56%, and 72%, respectively, of the outflow resistance at 25 mmHg of perfusion pressure.^[16] Those findings indicated that wider trabeculotomies combined with a novel trabeculotomy-related procedure other than conventional *ab-externo* trabeculotomy are advantageous. However, the future comparative studies are needed to corroborate the results. The Kahook Dual Blade requires a single-use handpiece, and the Trabectome procedure requires a single-use handpiece and a surgical machine, all of which increase the surgical costs compared with other procedures.

Indications for *Ab-Interno* Trabeculotomy-Related Surgeries

The indications and contraindications of trabeculotomy-related surgeries are shown in Table 2. Trabeculotomy is the first-choice procedure for most steroid-induced and developmental glaucomas. Early-stage open-angle glaucoma including primary open-angle and exfoliation glaucomas are also candidates for trabeculotomy. Compared with trabeculotomy, trabeculectomy, the gold-standard glaucoma surgery, results in the need for more frequent postoperative

Table 2: Indications for trabeculotomy-related procedures

Indication	
Early-stage open-angle glaucoma (i.e., primary open-angle glaucoma, exfoliation glaucoma, steroid-induced glaucoma)	
Developmental glaucoma without corneal opacity	
Glaucoma accompanying visual disturbance due to cataract (combined cataract and glaucoma surgeries)	
Primary angle-closure glaucoma (combined cataract and glaucoma surgeries)	
Glaucoma in elderly patients (difficulty with frequent hospital access, life expectancy)	
Contraindication	
Ocular inflammation	
Neovascular glaucoma	
Aphakic glaucoma	
Vitreous collapse into the anterior chamber	
Advanced glaucoma	

This table is adopted from my previous publication^[20] with English translation with the permission of the journal

procedures, e.g., laser suture lysis and needling, and possibly is associated with bleb-related complications. The IOP reduction achieved with trabeculotomy might be enhanced by older age and simultaneous cataract surgery.^[3,4,17] Since elderly patients may have difficulties traveling frequently for hospital visits, they can be good candidates for trabeculotomy.^[18] Although the surgical indications for *ab-externo* and *ab-interno* surgeries are the same, the safer profile of the latter, i.e., less invasiveness of the ocular surface, less difficult surgical procedure, and shorter surgical duration, enables surgeons to perform these novel procedures in eyes with an earlier stage of glaucoma than conventional trabeculotomy.

Acknowledgment

This review includes text extracts from reference^[19] and English-translated text extracts from reference^[20] with the permission of the journals.

Financial support and sponsorship

Nil.

Conflicts of interest

The microhooks used were codeveloped by Masaki Tanito, MD, PhD, and Inami and Co., Ltd. (Tokyo, Japan) and provided by Inami and Co., Ltd. Dr. Tanito receives royalties from Inami and Co., Ltd.

References

- Chihara E, Nishida A, Kodo M, Yoshimura N, Matsumura M, Yamamoto M, *et al.* Trabeculotomy *ab externo*: An alternative treatment in adult patients with primary open-angle glaucoma. *Ophthalmic Surg* 1993;24:735-9.
- Tanihara H, Negi A, Akimoto M, Terauchi H, Okudaira A, Kozaki J, *et al.* Surgical effects of trabeculotomy *ab externo* on adult eyes with primary open angle glaucoma and pseudoexfoliation syndrome. *Arch Ophthalmol* 1993;111:1653-61.

3. Tanito M, Ohira A, Chihara E. Surgical outcome of combined trabeculotomy and cataract surgery. *J Glaucoma* 2001;10:302-8.
4. Tanito M, Ohira A, Chihara E. Factors leading to reduced intraocular pressure after combined trabeculotomy and cataract surgery. *J Glaucoma* 2002;11:3-9.
5. Minckler DS, Baerveldt G, Alfaro MR, Francis BA. Clinical results with the trabectome for treatment of open-angle glaucoma. *Ophthalmology* 2005;112:962-7.
6. Seibold LK, Soohoo JR, Ammar DA, Kahook MY. Preclinical investigation of ab interno trabeculectomy using a novel dual-blade device. *Am J Ophthalmol* 2013;155:524-900.
7. Dorairaj SK, Kahook MY, Williamson BK, Seibold LK, ElMallah MK, Singh IP, *et al.* A multicenter retrospective comparison of goniotomy versus trabecular bypass device implantation in glaucoma patients undergoing cataract extraction. *Clin Ophthalmol* 2018;12:791-7.
8. Tanito M, Sano I, Ikeda Y, Fujihara E. Microhook ab interno trabeculotomy, a novel minimally invasive glaucoma surgery, in eyes with open-angle glaucoma with scleral thinning. *Acta Ophthalmol* 2016;94:e371-2.
9. Tanito M, Sano I, Ikeda Y, Fujihara E. Short-term results of microhook ab interno trabeculotomy, a novel minimally invasive glaucoma surgery in Japanese eyes: Initial case series. *Acta Ophthalmol* 2017;95:e354-60.
10. Tanito M, Ikeda Y, Fujihara E. Effectiveness and safety of combined cataract surgery and microhook ab interno trabeculotomy in Japanese eyes with glaucoma: Report of an initial case series. *Jpn J Ophthalmol* 2017;61:457-64.
11. Grover DS, Godfrey DG, Smith O, Feuer WJ, Montes de Oca I, Fellman RL, *et al.* Gonioscopy-assisted transluminal trabeculotomy, ab interno trabeculotomy: Technique report and preliminary results. *Ophthalmology* 2014;121:855-61.
12. Sato T, Hirata A, Mizoguchi T. Prospective, noncomparative, nonrandomized case study of short-term outcomes of 360° suture trabeculotomy ab interno in patients with open-angle glaucoma. *Clin Ophthalmol* 2015;9:63-8.
13. Tanito M. Optical Coherence Tomography Observation of Gonio Structures during Microhook Ab Interno Trabeculotomy. *J Ophthalmol* 2017;2017:6310835.
14. Tanito M. Microhook ab interno trabeculotomy, a novel minimally invasive glaucoma surgery. *Clin Ophthalmol* 2018;12:43-8.
15. Tanito M, Matsuzaki Y, Ikeda Y, Fujihara E. Comparison of surgically induced astigmatism following different glaucoma operations. *Clin Ophthalmol* 2017;11:2113-20.
16. Rosenquist R, Epstein D, Melamed S, Johnson M, Grant WM. Outflow resistance of enucleated human eyes at two different perfusion pressures and different extents of trabeculotomy. *Curr Eye Res* 1989;8:1233-40.
17. Hara K, Takai Y, Tanito M. Outcomes after combined deep sclerectomy and trabeculotomy to treat primary open-angle glaucoma and exfoliation glaucoma. *Shimane J Med Sci* 2019;35:43-52.
18. Tanito M, Sugihara K, Hara K, Takai Y. Different glaucoma types and glaucoma surgeries among different age groups. *Graefes Arch Clin Exp Ophthalmol* 2018;256:2013-4.
19. Tanito M. Novel trabeculotomy-related glaucoma surgeries. *Shimane J Med Sci* 2019;35:31-5.
20. Tanito M. What's the differences among various trabeculotomy-related surgeries [author's translation]. *Jpn J Ophthalmic Surg* 2018;31:98-9.
21. De Giusti A, Pajaro S, Tanito M. Automatic Pigmentation Grading of the Trabecular Meshwork in Gonioscopic Images. *Proceeding Computational Pathology Ophthalmic Medical Image Analysis (COMPAY-OMIA 2018)*; 2018. p. 193-200.