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# Novel Trabeculotomy-related Glaucoma Surgeries

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Trabeculotomy reduces intraocular pressure by relieving the resistance to aqueous flow via cleavage of the trabecular meshwork and inner walls of Schlemm's canal at the point of outflow resistance of the aqueous humor. Because of the absence of a bleb, late-onset sight-threatening complications, such as hypotony maculopathy and endophthalmitis, that are associated occasionally with trabeculectomy develop less often after trabeculotomy. Several recently reported procedures, including the Trabectome, Kahook Dual Blade, microhook ab interno trabeculotomy, and 360° suture trabeculotomy, use the ab interno approach, instead of the ab externo approach that use in conventional trabeculotomy. These novel, minimally invasive, trabeculotomy-related glaucoma surgeries can be good options for certain glaucoma scenarios including early-stage open-angle glaucoma, developmental glaucoma, and glaucoma in elderly patients.

Key words: ab externo trabeculotomy, trabectome, Kahook dual blade, microhook ab interno trabeculotomy, suture ab interno trabeculotomy, minimally invasive glaucoma surgery（MIGS）.

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**Emergence of novel trabeculotomy-related surgeries**

Trabeculotomy is performed to reduce the intraocular pressure（IOP）in patients with glaucoma［1-4］. The mechanism of IOP reduction by trabeculotomy is believed to be elimination of 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.

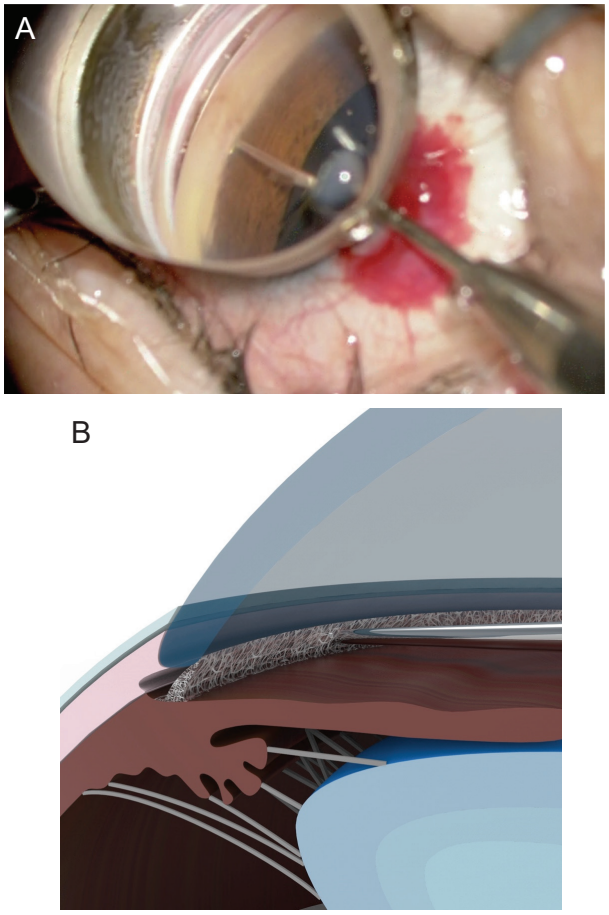


Fig. 1. Surgical procedure of microhook ab interno trabeculotomy. A: Observation of anterior chamber angle using a Swan-Jacob gonioprism lens shows the trabecular meshwork and inner wall of Schlemm's canal is incised circumferentially using the tip of the microhook inserted into the anterior chamber 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.

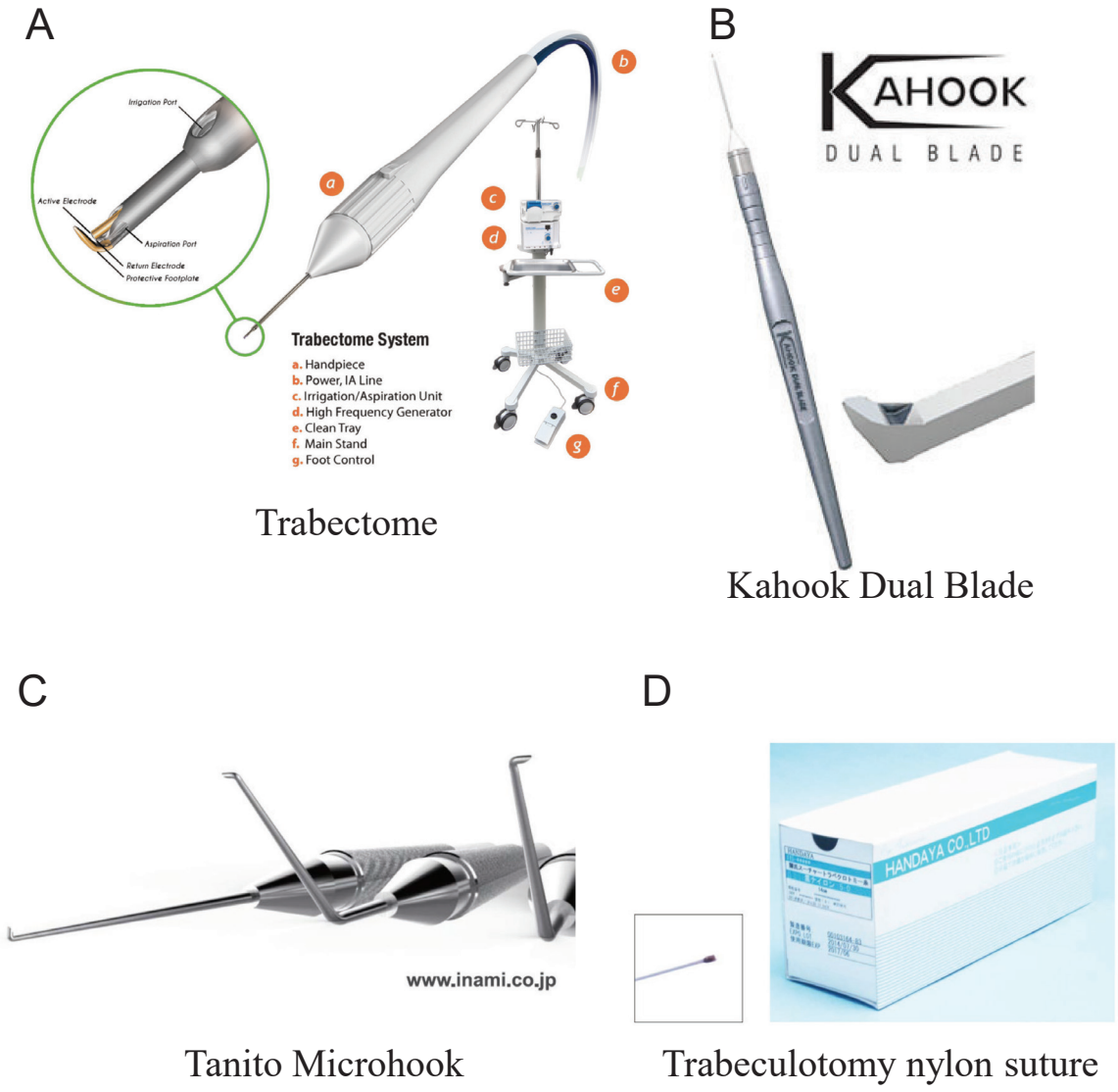


Fig. 2. Various devices for novel trabeculotomy-related surgeries. A: The Trabectome provided by Kowa Company Ltd. (http://www.kowa.co.jp). B: The Kahook Dual Blade provided by JFC sale Plan (http://www.jfcsp.co.jp). C: The Tanito ab interno Trabeculotomy Microhook provided by Inami & Co., Ltd. (http://inami.co.jp). D: The Chin trabeculotomy suture provided by Handaya Co., Ltd. (http://www.handaya.co.jp)

Traditionally, the ab externo approach, i.e., incision of the trabecular meshwork after creation of a scleral flap, has been used to perform trabeculotomy in combination with metal trabeculotomes [1-4]. Recently, the ab interno approach for performing trabeculotomy that incises/excises the trabecular meshwork tissues using specialized devices under direct observation of the anterior chamber angle structure has been reported (Fig. 1A and 1B). This novel trabeculotomy approach includes the Trabectome procedure, during which the trabecular meshwork is removed using a small diathermy/irrigation/aspiration handpiece (Fig. 2A) [5]; the Kahook Dual Blade, which is used to excise the trabecular meshwork in a strip using a curette with two blades (Fig. 2B) [6, 7]; microhook ab interno trabeculotomy, during which the trabecular meshwork is incised using a small metal hook (Fig. 2C) [8-10]; and ab interno 360° suture trabeculotomy/gonioscopy-assisted transluminal trabeculotomy, during which the entire trabecular meshwork is incised using a suture after circumferential insertion of the suture into Schlemm's

canal (Fig. 2D) [11, 12].

**Features of conventional and novel trabeculotomy-related surgeries**

Table 1 shows the features of the recently developed trabeculotomy-related surgeries. Because the ab interno approach negates the need for conjunctival and scleral incisions, recently reported trabeculotomy-related procedures have the advantages of being minimally invasive to the ocular surface. Therefore, these procedures can be performed safely in eyes with scleral thinning [8]. Direct observation of the anterior chamber angle using a gonioprism lens during ab interno trabeculotomy enables easier identification of Schlemm's canal than the identification of it under the scleral flap during conventional ab externo trabeculotomy. The extent of trabeculotomy, i.e., 90°to 120° for conventional ab externo trabeculotomy (Fig. 3A), the Trabectome procedure, and with use of the Kahook Dual Blade (Fig. 3B) is wider, i.e., 180° to 240° for microhook ab interno trabeculotomy (Fig. 3C) and 360° with suture trabeculotomy when a suture is inserted successfully into the entire circumference of Schlemm's canal (Fig. 3D). A perfusion study of autopsy eyes reported that incisions in the trabecular meshwork extending for 1, 4, and 12 clock hours eliminated 30%, 44%, and 51%, respectively, of the outflow resistance at the perfusion pressure of 7 mmHg and 30%, 56%, and 72%, respectively, of the outflow resistance at the perfusion pressure of 25 mmHg [13]. Those results indicated that wider trabeculotomies combined with some novel trabeculotomy-related procedures other than conventional ab externo trabeculotomy can be advantageous. However, this must be tested in future comparative studies. The Kahook Dual Blade requires a single-use handpiece, and the Trabectome procedure requires a single-use handpiece and a surgical machine, which increase the surgical costs compared with other procedures.

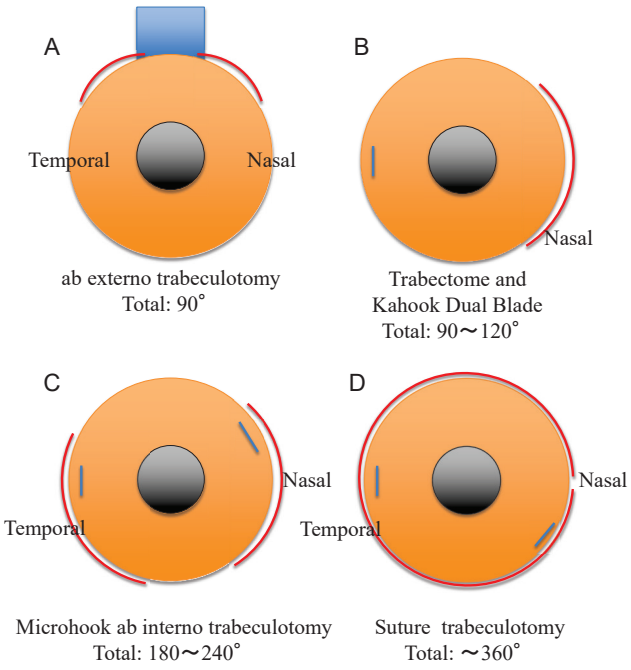


Fig. 3. The typical extents of the incisions created in traditional ab externo trabeculotomy and novel trabeculotomy-related glaucoma surgeries. A: Conventional ab externo trabeculotomy. B: Trabectome and Kahook Dual Blade. C: Microhook ab interno trabeculotomy. D: Suture ab interno trabeculotomy. The red arcs indicate the extent of the trabeculotomy, the blue lines the corneal side ports, and blue box the scleral flap. These panels are adopted from my previous publication15 with modification with the permission of the journal.

**Indications for trabeculotomy-related surgeries**

Table 2 shows the indications and contraindications of trabeculotomy-related surgeries. Trabeculotomy is the first choice for most steroid-induced and developmental glaucomas. Early-stage open-angle glaucoma including primary open-angle and exfoliation glaucomas are other candidates for trabeculotomy. Compared to trabeculotomy, trabeculectomy, the gold standard glaucoma surgery, requires more frequent postoperative procedures such as laser suturelysis and needling and may be associated with bleb-related complications. Higher age and simultaneous cataract surgery might enhance the IOP reduction achieved with trabeculotomy [3, 4]. Frequent travel to hospitals can be difficult for elderly patients. Accordingly, elderly patients can be good candidates for trabeculotomy [14]. In an initial case series, microhook ab interno trabeculotomy alone decreased the IOP from the preoperative level of 25.9 mmHg to 14.7 mmHg, a 43% decrease at the final 6-month evaluation [9], and microhook ab interno trabeculotomy combined with cataract surgery decreased the IOP from the preoperative level of 16.4 mmHg to 11.8 mmHg, a 28% decrease at the final 9.5-month evaluation [10]. Although the ab externo and ab interno surgeries share the same surgical indications,

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

| Procedure | Trabeculotomy ab externo | Goniotomy | Trabectome | Kahook Dual Blade | Microhook ab interno trabeculotomy | 360° ab interno 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[15] with English translation with the permission of the journal.

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 anterior chamber
  - ✓ Advanced glaucoma

This table is adopted from my previous publication[15] with English translation with the permission of the journal.

the safer profile of the ab interno procedure, i.e., less invasiveness of the ocular surface, easier surgical procedure, and shorter surgical time, enables surgeons to perform these novel procedures in eyes with an earlier stage of glaucoma than conventional trabeculotomy.

## *ACKNOWLEDGEMENT*

This review includes English-translated text extracts from reference 15 with permission from the journal.

## *CONFLICT OF INTEREST*

The microhooks used were co-developed by Masaki Tanito, MD, Ph.D, and Inami & Co., Ltd. (Tokyo, Japan) and provided by Inami & Co., Ltd. Dr. Tanito receives royalties from Inami & Co., Ltd.

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