Gonioscopy-assisted transluminal trabeculotomy is an effective surgical treatment for uveitic glaucoma

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ABSTRACT

Background To assess the efficacy and safety of gonioscopy-assisted transluminal trabeculotomy (GATT) in uveitic glaucoma (UG).

Methods A retrospective interventional case series in which 33 eyes of 32 patients with UG underwent GATT with or without concomitant cataract extraction and intraocular lens implantation (CE/IOL) at three Canadian treatment centres from October 2015 to 2020. The main outcome measure was surgical success defined as an intraocular pressure (IOP) ≤18 mm Hg and at least one of the following: IOP within one mm Hg of baseline on fewer glaucoma medications as compared with baseline or a 30% IOP reduction from baseline on the same or fewer medications. Secondary outcome measures were IOP, medication usage and surgical complications.

Results Mean patient age (mean±SD) was 49±16 years (range: 18–79) and 44% were female. GATT was performed as a standalone procedure in 52% of cases and the remainder were combined with CE/IOL. Surgical success was achieved in 71.8% (SE: 8.7%) of cases. Mean preoperative IOP (±SD) was 31.4±10.8 mm Hg on a median of 4 medications. 59% of patients were on oral carbonic anhydrase inhibitors (CAIs) prior to surgery. After 1 year, average IOP was 13.8 mm Hg on a median 1 medication, with 6% of patients being on oral CAIs. No sight threatening complications occurred during surgery or follow-up.

Conclusion GATT is an effective surgical strategy in the management of UG. This microinvasive conjunctival-sparing procedure should be considered early in these patients.

INTRODUCTION

Uveitic glaucoma (UG) refers to glaucomatous nerve damage associated with intraocular inflammation and increased intraocular pressure (IOP). Ocular hypertension (OHT) is common with non-infectious uveitis and the mean annual incidence rate has recently been shown to be 14.4% and 5.1% for IOPs ≥21 mm Hg and ≥30 mm Hg, respectively.[1] Patients with UG have been shown to be at high risk for visual disability.[2] Surgical intervention is frequently indicated in UG cases due to their young age of onset, high IOPs, limited response to topical pressure lowering medications, multiple mechanisms of outflow obstruction, and the need for ongoing topical corticosteroids.[3 4] Topical corticosteroids, invaluable for uveitis control, often raise IOP as well, complicating management further.[5]

Surgical options in UG are like those in other types of glaucoma, however, some differences are noteworthy. Trabeculectomy with antimetabolites has been shown to be as effective in UG as in primary open angle glaucoma (POAG) in some studies,[6] though others have suggested lower efficacy.[7] Young age and inflammation associated fibrosis may be some of the reasons for reduced success in these cases. Glaucoma drainage devices (GDDs) are considered by many to be the first-line surgical treatment for UG. Though good results have been reported with their use, this has been associated with a significant rate of complications such as hypotony.[8] It has been suggested that hypotony occurs more often in patients with UG, and especially in those with juvenile idiopathic arthritis, treated with GDDs as compared with patients with non-UG.[9]

Angle surgery has been known to be effective in the paediatric population for many years, though ab interno trabeculotomy has gained popularity for the treatment of primary and secondary open angle glaucoma in adults only recently.[10–15] The main advantages of the ab interno approach over traditional subconjunctival filtration surgery are its superior short-term and long-term safety, faster recovery, more predictable follow-up, and sparing of conjunctival real estate for traditional filtration surgeries in the future. Swamy *et al* recently reported on the results of ab-interno trabeculotomy using the trabectome in UG with good results.[16] A small case series also described outcomes in UG after Kahook Dual Blade (KDB—12 eyes),[17] and gonioscopy-assisted transluminal trabeculotomy (GATT—3 eyes).[18] The purpose of this study is to report on the results of GATT in UG patients.

METHODS

A retrospective interventional case series of consecutive patients who underwent GATT for the treatment of UG with or without concomitant cataract extraction and intraocular lens implantation was performed by three academic surgeons at the Kensington Eye Institute (Toronto, Canada), Cloudbreak Eye Centre (Calgary, Canada) and Credit Valley Hospital (Mississauga, Canada). Cases were identified by searching each institution's electronic medical record system from 19 October 2015 to 9 October 2020 for the terms 'GATT', 'uveitis', 'uveitic' or 'hypertensive'. Patients of any age with any type of UG were included. Patients were excluded if they had less than 1 month of follow-up available and, if applicable, no further data could be retrieved by contacting their referring physicians.

Data were collected through chart review and correspondences with eye health professionals involved in patient follow-up. Preoperative data included demographics (age, laterality, gender, surgery site and rheumatological status) and ocular information (best-corrected visual acuity, highest IOP measured by Goldmann applanation in the 3 months prior to surgery (baseline IOP), lens status, glaucoma and uveitis diagnoses, cup-to-disk ratio, gonioscopy, previous ocular surgery and/or interventions, glaucoma medications and mean deviation).

The primary outcome was surgical success, defined as an IOP ≤18 mm Hg[19] and one of the following: IOP within one mm Hg of baseline on fewer glaucoma medications as compared with baseline or a 30% IOP reduction from baseline on the same or fewer glaucoma medications. If IOP was above 18 during follow-up, 3 months were allowed for medical control before it was considered a failure. The need for an additional IOP-lowering procedure, including cyclophotocoagulation (CPC), any glaucoma or conjunctival incisional surgery, or revisions of previous surgery requiring an operating room, was considered a failure, as was loss of light perception vision. Secondary outcome measures were medication usage, percentage of patients using oral carbonic anhydrase inhibitors (CAIs) and surgical complications. Postoperative interventions and intraoperative and postoperative complications at any time were recorded. Any blood in the anterior chamber at or after the first postoperative week was defined as a hyphema for the purpose of this study. Postoperative IOP spikes were defined as an increase in IOP of 10 mm Hg from baseline or an IOP of ≥30 mm Hg before three postoperative months.

Proportions were used to describe categorical characteristics and comparisons between treatment groups were made using Fisher's exact tests. Continuous outcomes were reported as means or medians and compared with a two-sided Student's t-test. A two-sided p value of 0.05 or less was considered statistically significant. Snellen visual acuity measurements were converted to logarithm of the medium angle of resolution (logMAR) equivalents for data analysis. The cumulative rates of success according to study group were displayed using Kaplan-Meier curves. All statistical analyses were performed using IBM SPSS.v27 Statistics for Windows (IBM) and Microsoft Excel (Microsoft Corporation, Redmond, Washington).

The details of the surgical procedure for circumferential suture trabeculotomy have been previously described.[20] The surgeons whose patients were included in the study often perform a trabeculotomy of half the chamber angle, that is, hemi-GATT. In this procedure, a 5–0 polypropylene suture is advanced for 180 degrees and then pulled out through the TM to create a trabeculotomy. If the procedure was combined with cataract extraction, the order of the procedures was at the discretion of the surgeon. Postoperative treatment was individualised according to the status of each patient's glaucoma and uveitis. Oral corticosteroids were often used perioperatively, and frequent dosing (eg, every 4 hours) of topical steroids was the norm. Oral corticosteroids or steroid-sparing immunomodulatory medications were used at the discretion of the treating rheumatologist or uveitis specialist.

RESULTS

Thirty-three eyes of 32 patients with UG were included in the analysis. Mean age (mean±SD) was 49±16 years (range: 18–79) and 44% of patients were female (table 1). Non-granulomatous anterior uveitis was the most common type of uveitis (30%) and 24% were unspecified. Approximately one-third of patients had a diagnosis of an extraocular rheumatologic disorder at the time of surgery. The status of intraocular inflammation was available for 23 eyes, 30% of which were active at the time of surgery. Examination findings regarding peripheral anterior synechiae (PAS) were available for 20 eyes, 20% of which had at least one-quarter clock hours of PAS preoperatively. Central corneal thickness measurements were available for 17 patients and the mean was 525±33 µm.

Mean follow-up was 19.0±12.9 months (range: 3.2–46.1) (table 2). Sixty-seven per cent of eyes had reached 12 months of follow-up at the time of writing. Mean IOP decreased from a baseline of 31.4±10.8 mm Hg on a median of four medications to 13.8±8.6 mm Hg on one medication at one postoperative year. At all five postoperative time points (3, 6, 12, 18 and 24 months) the mean IOP was significantly reduced from baseline ($p<0.001$). At final follow-up, mean IOP was 12.5±3.1 mm Hg on a median of two medications.

Figure 1 shows the Kaplan-Meier survival curves for all eyes. After 1 year, the success rate (cumulative survival proportion ±SE) was 0.72±0.09. Success was the same if 21 mm Hg, rather than 18 mm Hg, was used as the upper limit. Eight patients failed, the reasons for which were needing additional IOP-lowering procedures (three patients), IOP above baseline (three patients) and more medications as compared with baseline (two patients) (table 3).

Nineteen patients (59%) were on oral CAIs at baseline compared with five patients (16%) at the 3-month visit. One of these was due to increased IOP in the fellow eye, and the oral CAI was stopped after surgical control of IOP with GATT. In three cases, an oral CAI was started to control early (ie, within two postoperative weeks) IOP spikes. These patients were on zero, one, and four topical medications when the oral medication was started. In two of these the IOP stabilised off the oral CAI on one and two topical medications within five and 8 months. The third patient was advised to discontinue CAI use after IOP stabilised at postoperative month 3.2 but was then lost to follow-up. Oral CAIs were not able to control increased IOP in the fifth patient as they required further surgery for IOP control and was thus considered a failure.

Figure 2 shows scatter plots for eyes at different time points during follow-up. The postoperative IOP improved in all eyes at all follow-up visits after 3 months. Figure 3 shows scatter plots for eyes with preoperative IOPs less than or equal to 18 mm Hg and greater than 18 mm Hg at the final postoperative visit. Figure 4 shows preoperative and postoperative IOPs and medication usage, including CAIs, in all patients in the study.

Table 4 describes intraoperative and postoperative complications. No sight threatening complications occurred in any of the patients in this study. Hyphema and postoperative spikes were the two most common complications. Seventeen hyphemas occurred and all cleared spontaneously by postoperative month three. None of these required surgical interventions or caused persistent corneal issues. Twenty-four postoperative spikes in 17 patients occurred on a median (IQR) of 8.0 (2.5–15.8) postoperative days, all of which resolved by a median of 5.5 (2.0–12.5) postoperative days. A median 2 (0–3) glaucoma medications were added in 17 (71%) of episodes (13 patients) by the time of resolution, which were ultimately discontinued by final follow-up in four patients. Most commonly, a beta-blocker or alpha agonist topical medication was added (each added nine times (20% of all medications added)). An oral CAI was added in eight (33%) episodes, all of which were discontinued by the final follow-up. Nine (38%) patients had an average of 1.5 (max: 4) anterior chamber taps performed, one of which (4%) required CPC for

Table 1 Patient demographics and baseline characteristics

Variables	Standalone (n=17)	Combined (n=16)	Total (n=33)
Age (mean±STD (min, max))	47±17 (18, 79)	51±16 (28, 78)	49±16 (18, 79)
Female (no (%))	7 (41)	8 (50)	15 (44)
Degrees of GATT (mean±STD)*	261±88	193±51	228±80
Diagnosis (no (%))			
NGAU	3 (18)	7 (44)	10 (30)
Intermediate uveitis	1 (6)	2 (13)	3 (9)
Panuveitis	3 (18)	0	3 (9)
UGH	2 (12)	1 (6)	3 (9)
Bechet panuveitis	0	2 (13)	2 (6)
Sarcoid panuveitis	0	2 (13)	2 (6)
CMV anterior uveitis	1 (6)	0	1 (3)
MCP	1 (6)	0	1 (3)
Unspecified	6 (35)	2 (13)	8 (24)
Diagnosed rheumatologic disease (no (%))	3 (18)	8 (50)	11 (33)
Visual acuity			
CDVA (median (Q1, Q3))	20/40 (20/27, 20/50)	20/175 (20/68, HM)	20/60 (20/40, 20/300)
logMAR (mean±STD)†	1.2±1.0	0.4±0.4	0.8±0.9
HVF MD (mean±STD (min, max))	−8.4±5.2 (-18.3, −1.6)	−12.4±8.4 (-28.9, −2.1)	−10.4±7.2 (-28.9, −1.6)
Angle status (no ≤1(%))			
Superior	2 (13)	5 (31)	7 (22)
Nasal	2 (13)	4 (25)	6 (19)
Inferior	2 (13)	4 (25)	6 (19)
Temporal	2 (13)	4 (25)	6 (19)
Lens status (no Phakic:Pseudophakic)	8:9	15:1	23:10
Previous non-CE/IOL surgery (no (%))			
Vitrectomy	2 (12)	0	2 (6)
DALK	1 (6)	0	1 (3)
Prior glaucoma intervention (no (%))			
None	4 (24)	10 (63)	14 (42)
LPI	3 (18)	4 (25)	7 (21)
SLT	1 (6)	1 (6)	2 (6)
MLT	1 (6)	0	1 (3)
CPC	2 (12)	2 (13)	4 (12)

Paired t-tests of unequal variance were calculated for age, GATT degrees, CDVA, logMAR and HVF MD. Unless indicated, corresponding p values for these comparisons were greater than 0.05.
*P=0.012
†p=0.007
CDVA, corrected distance visual acuity; CE/IOL, cataract extraction and intraocular lens implantation; CMV, cytomegalovirus; CPC, cyclophotocoagulation; DALK, deep anterior lamellar keratoplasty; GATT, gonioscopy-assisted transluminal trabeculotomy; LPI, laser peripheral iridotomy; MCP, multifocal choroiditis and panuveitis; HVF MD, Humphrey visual field analyzer mean deviation; MLT, micropulse laser trabeculoplasty; NGAU, non-granulomatous anterior uveitis; SLT, selective laser trabeculoplasty; UGH, uveitis–glaucoma–hyphema syndrome.

IOP control. Two cases of Descemet's membrane detachment resolved without sequelae, and one case of iridodialysis was clinically insignificant and required no further intervention. Two cases of macular oedema were found, both of which took place at postoperative month 12 and resolved spontaneously. Visual acuity before and after surgery are presented in table 5.

DISCUSSION

Glaucoma is the most severe sight-threatening complication of uveitis.[9] UG is notoriously challenging to treat, carries a guarded prognosis, and surgery is often indicated in eyes with this condition.[3 4] Our results show very promising results for the treatment of UG using a microinvasive, ab-interno approach. The preferred surgical approach for the treatment of UG is controversial. Several authors have reported comparable success rates for trabeculectomy in UG as compared with POAG,[6 21–23] though others have found it to be less effective.[24 25] Young age and inflammation have been associated with a higher risk of failure of trabeculectomy,[22] making this surgery a questionable choice for young patients with UG. GDDs have been considered by many authors first-line surgical treatment for UG.[8 9] Though good results have been reported with GDDs in UG, vision-threatening complications, especially hypotony, seem to occur more often in these patients.[8 9] Increased rates of hypotony in these patients could be related to longstanding ciliary body atrophy related to uveitis, or to a shutdown of aqueous production either related to the surgery itself or to postoperative inflammation. Both trabeculectomy and GDDs have the disadvantage of using valuable conjunctival real estate, limiting the options available for further surgical interventions. This is especially important given the young age of many UG patients and the high risk of failure with repeat subconjunctival surgeries. Both of these surgeries also carry lifetime risks

Table 2 Baseline and postoperative data

Variables	Standalone (n=17)	Combined (n=16)	Total (n=33)
Months followed (mean±STD (min, max))	23.3±14.3 (3.2, 46.1)	14.4±9.7 (3.8, 45.4)	19.0±12.6 (3.2, 46.1)
Baseline (no (%))	17 (100)	16 (100)	33 (100)
3	16 (94)	16 (100)	32 (97)
6	15 (88)	13 (81)	28 (85)
12	12 (71)	10 (63)	22 (67)
18	8 (47)	4 (25)	12 (36)
24	7 (41)	1 (6)	8 (24)
IOP (mean±STD) (mo)			
Baseline	33.2±11.5	29.4±10.1	31.4±10.8
3	11.9±3.5	13.8±3.6	12.8±3.6
6	13.4±4.3	12.8±3.7	13.1±4.0
12	11.5±2.7	16.6±12.2	13.8±8.6
18	11.0±2.4	12.5±1.9	11.5±2.3
24	12.6±2.9	14.0*	12.8±2.7
Meds (median (lower-upper quartile, IQR) (mo)			
Baseline	4.0 (3.0–5.0)	4.0 (4.0–5.0)	4.0 (3.0–5.0)
3	2.0 (1.3–3.0)	2.0 (0.0–3.0)	2.0 (0.0–3.0)
6	1.5 (0.0–3.0)	1.0 (0.0–2.0)	1.0 (0.0–2.8)
12	1.0 (0.0–2.8)	1.5 (0.0–2.0)	1.0 (0.0–2.3)
18	2.0 (1.8–3.3)	2.0 (1.5–2.0)	2.0 (2.0–3.0)
24	2.0 (1.5–3.0)	2.0 (2.0–2.0)	2.0 (1.5–3.0)
No patients taking oral CAI (no (%)) (mo)			
Baseline	12 (71)	7 (44)	19 (58)
3	4 (24)	2 (13)	6 (18)
6	2 (12)	0	2 (6)
12	2 (12)	0	2 (6)
18	0	0	0
24	0	0	0

*STD not available as only one value was collected at this time point.
CAI, carbonic anhydrase inhibitor; IOP, intraocular pressure.

of exposure (GDD), leak (trabeculectomy and GDD) and vision-threatening infections (trabeculectomy and GDD). In addition, risk of progressive endothelial cell loss and corneal decompensation over time related to the presence of a tube in the anterior chamber is a concern.

The data regarding ab interno angle surgeries for UG is limited. Freedman *et al* demonstrated good long-term results with goniotomy for childhood UG.[26 27] Swamy *et al* reported on 45 UG eyes that underwent ab interno trabeculotomy with the trabectome.[16] Success criteria in this study were IOP ≤21 mm Hg and a 20% reduction without additional glaucoma surgery, and 91% patients in the study achieved this goal after 1 year. Average IOP was lowered from 29.2mm Hg on 4 medications to 16.7 mm Hg on 2.5 medications after 1 year. Of note, six patients (13.3%) in this study needed further surgeries to control their IOP. For reference, Miller *et al* reported on 16 eyes of 12 patients with UG who underwent goniotomy with the KDB.[17] Average IOP was lowered from 28.1 mm Hg on 3.6 medications to 17.4 mm Hg on 2.1 medications after 9.6 months. Six patients had IOPs above target during follow-up and four patients (five eyes) required additional surgery to control IOP. Sachdev *et al* also reported on three young patients with UG treated with GATT with excellent results after a follow-up of 10–21 months.[18]

Table 3 Description of eight eyes that did not meet the surgical success criteria

Patient no	Reason for failure (Intervention if applicable, postoperative month)
1	Received additional IOP lowering intervention (GSL, 0.5)
2	Received additional IOP lowering intervention (CPC, 0.5)
3	Received additional IOP lowering intervention (Superior GATT, 11.8)
4	IOP above baseline (6.3)
5	IOP above baseline (4.4)
6	IOP above baseline (3.9)
7	More medications as compared with baseline (4.6)
8	More medications as compared with baseline (11.5)

CPC, cyclophotocoagulation; GATT, gonioscopy-assisted transluminal trabeculotomy; GSL, goniosynechialysis; IOP, intraocular pressure.

We found a 72% success rate for GATT in UG. Importantly, out of the eight failures, seven had IOPs equal to or smaller than 18 mm Hg at the end of follow-up. Though these eight patients were analysed as failures due to our stringent success criteria, five were considered clinical success by their treating physician. The reasons for the failures were for requiring additional IOP-lowering interventions (three patients), IOPs above baseline (three patients), and increased medication use as compared with baseline (two patients). The IOP lowering interventions were CPC, goniosynechialysis and hemi-GATT (one case each) performed at 0.5, 0.5, and 12 months after the GATT surgery, respectively. The three patients that failed due to IOPs above baseline all had IOPs of 18 mm Hg or less at time of failure, but this was higher than their baseline IOP. These patients had IOPs in the normal range prior to surgery, which was indicated because of cataract or for reduction of medications, both of which were achieved. The two patients who failed because they required more medication as compared with baseline had baseline IOPs of 35 and 16 mm Hg on two medications, and final follow-up IOPs of 15 and 9 mm Hg on two and four medications, respectively. The former, however, required nearly 6 months of greater than baseline medication use with an oral CAI for stabilisation

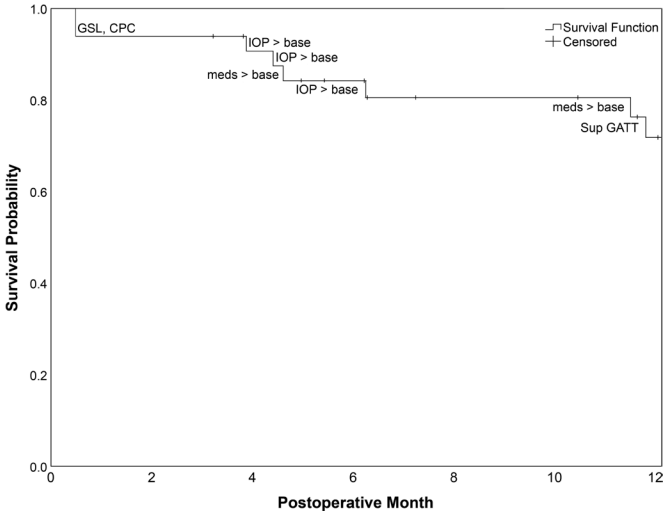

Figure 1 Kaplan-Meir survival curve of 33 eyes over 12 postoperative months (POM) of follow-up. The reason for each failure is annotated as follows. CPC, cyclophotocoagulation therapy; GATT, gonioscopy-assisted transluminal trabeculotomy; GSL, goniosynechialysis; IOP, intraocular pressure; meds>base, medication use that is greater than baseline.

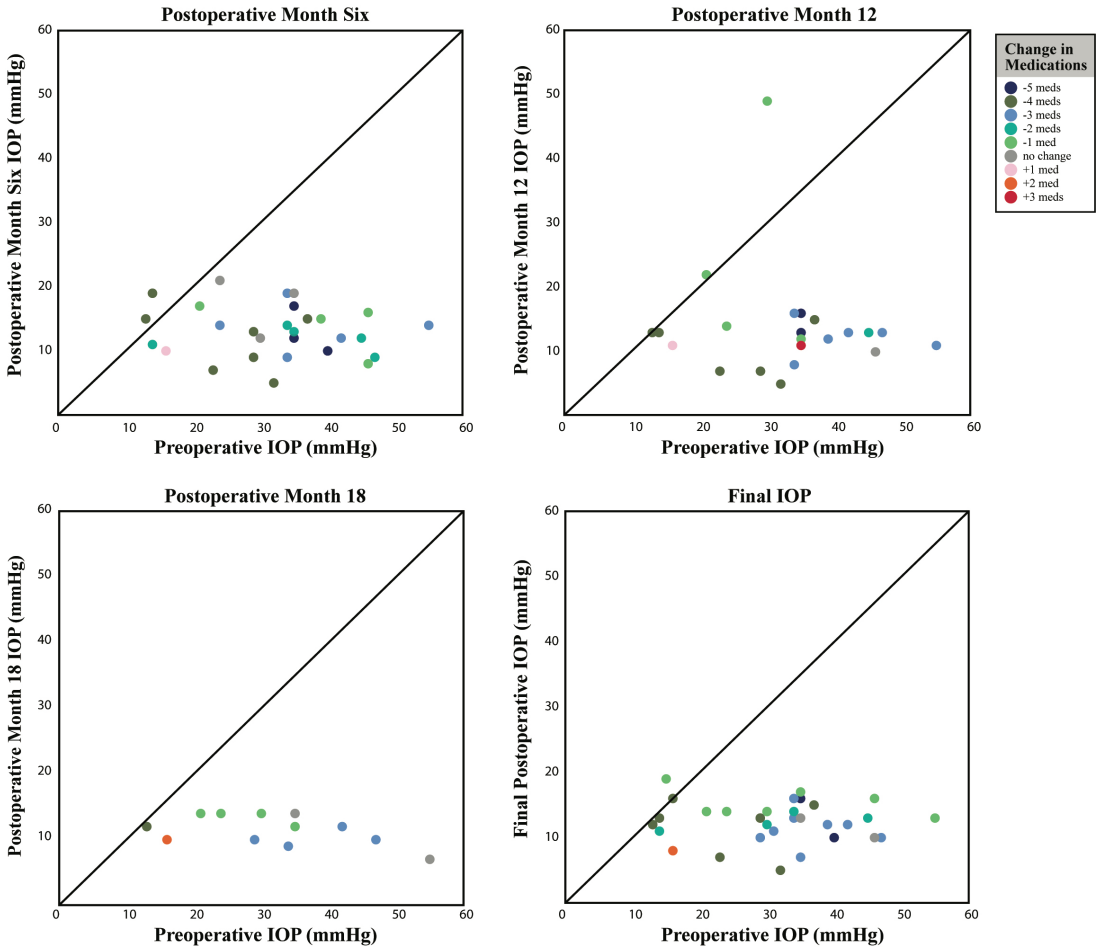

Figure 2 Scatterplots of peak intraocular pressure (IOP, mm Hg) on maximum medical therapy attempted versus postoperative IOP at postoperative month 6 (top left), 12 (top right) and 18 (bottom left) as well as final follow-up (bottom right). The change in medications at each time point from preoperative value is indicated by colour.

following an episode of elevated IOP and was thus considered a failure.

Our results compare favourably with the above studies: average IOP at final follow-up was 12.5±3.1 mm Hg on 1.5±1.3 medications. The lower IOPs and less medication usage in our study as compared with the studies by Swamy *et al* (Trabectome) and Miller *et al* (KDB) could be related to the larger areas of trabeculotomy with GATT (88% of patients in our study had 150° or more of trabeculotomy) as compared with 90–120 degrees. A recent study by Chen *et al* suggested circumferential trabeculotomies may be superior to partial trabeculotomies, supporting this notion.[28] Other reasons for

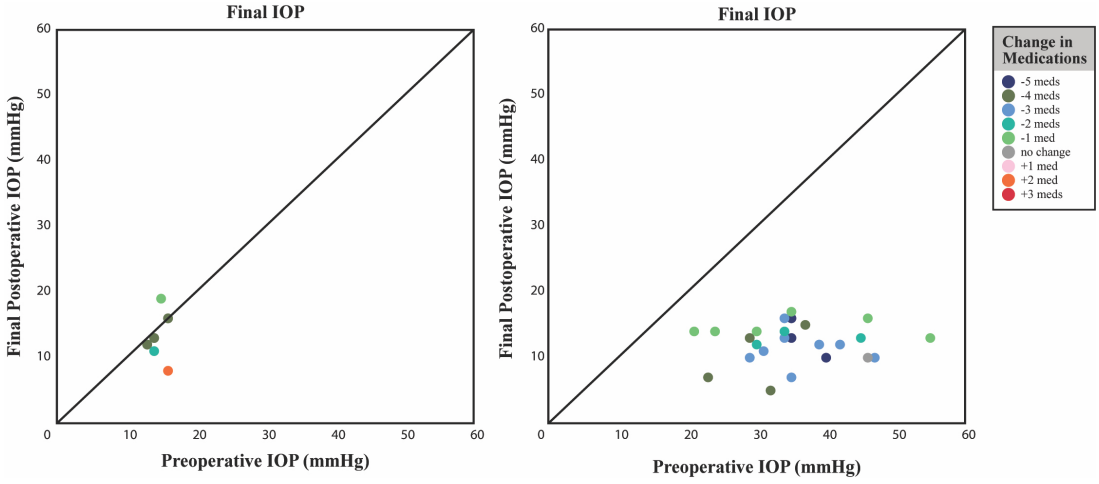

Figure 3 Scatterplots of peak intraocular pressure (IOP, mm Hg) on maximum medical therapy at baseline of less than or equal to 18 mm Hg (left) and greater than 18 mm Hg (right) vs final postoperative IOP. The change in medications from preoperative value is indicated by colour.

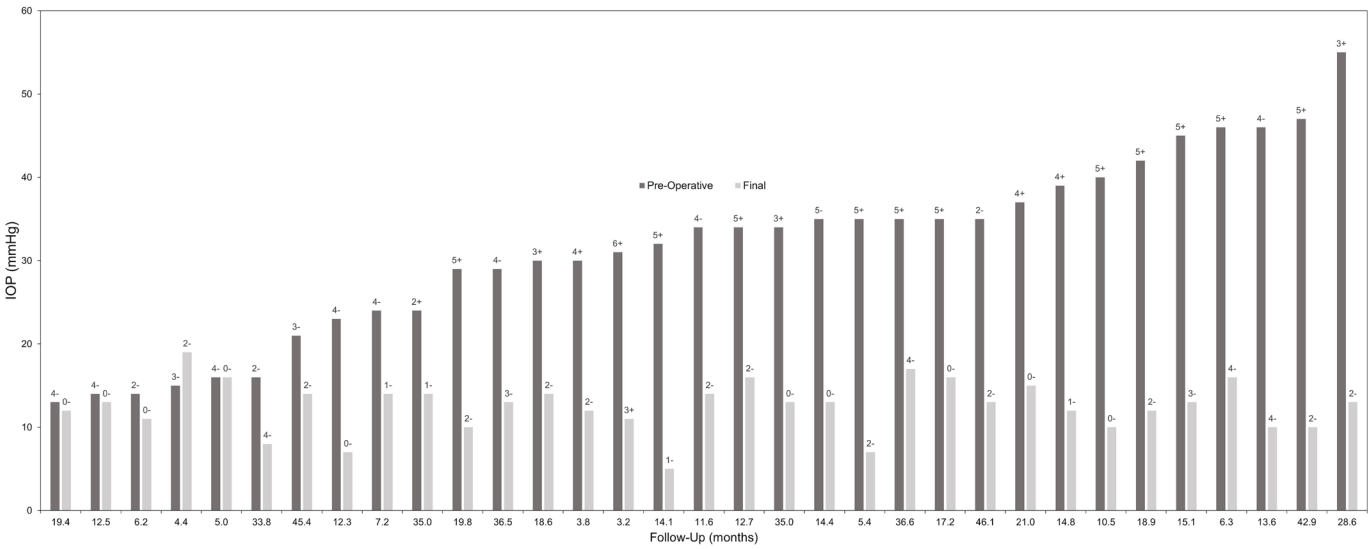

Figure 4 Bar graph representation of IOP at baseline (dark shading) and final follow-up (light shading). All 33 eyes are included. The time of final follow-up (months) is listed below each eye's preoperative and postoperative pair of bars. The number of glaucoma medications (including oral CAIs) at baseline and final follow-up is noted above each respective bar along with whether an oral CAI was used (plus sign) or not used (minus sign). CAIs, carbonic anhydrase inhibitors; IOP, intraocular pressure.

the difference in the results could be intraoperative and post-operative inflammation control, as well as steroid response, which has been suggested to play an important role in angle surgeries.[28]

The fact that more failures were not seen in our study during follow-up is encouraging and suggests that if IOP is stabilised in the early postoperative period, good medium—and perhaps even long-term results can be expected in these patients.

Table 4 Operative and postoperative complications

Variables	Standalone (n=17)	Combined (n=16)	Total (n=33)
Intraoperative complications	None	None	None
Sight threatening complications	None	None	None
Hyphema (no (%))			
POW1	7 (41)	4 (25)	11 (33)
POM1	3 (18)	3 (19)	6 (18)
POM3	0	0	0
IOP spikes (no (%))			
POW1	7 (41)	3 (19)	10 (30)
POM1	8 (47)	5 (31)	13 (39)
POM3	1 (6)	0	1 (3)
Other POM1	1 DM detachment	1 DM detachment	2 DM detachments
Other POM1	1 Iridodialysis		1 Iridodialysis
Other POM3			
Other POM6			
Other POM12	1 CME	1 CME	2 CME
Other POM18			
Other POM24			

NB, cyclophotocoagulation, goniosynechialysis and a superior GATT were required for better IOP control of three patients (see table 3 for more details).
CME, central macular oedema; DM, Descemet's membrane; GATT, gonioscopy-assisted transluminal trabeculotomy; IOP, intraocular pressure; POM, post-operative month.

Two issues regarding our definition of success merit discussion. The first is that two different avenues to success were allowed provided postoperative IOP was 18 mm Hg or less. The first was a 30% reduction in baseline IOP on the same or fewer medications as compared with baseline, and the second was medication reduction without the need for IOP reduction compared with baseline. The reason for the latter is that patients with low baseline IOPs were included in this study. In these patients, success of any IOP lowering procedure would not manifest in significant IOP lowering, but with reduction in medication. For some patients, especially those undergoing cataract removal, the main goal of the GATT surgery may be medication reduction. The second issue is that complete success, that is, achieving IOP targets with no medication, was not set as a primary outcome in this study. The reason for this stems from the difference between GATT and traditional filtration surgeries, and especially trabeculectomy. Contrary to trabeculectomy, where drops are not routinely added in the first months after surgery and rather suture lysis, digital massage, and/or bleb needling are used to modify flow, GATT surgeries often require adding medication in the early post-operative period to gain better IOP control, and these are then continued as needed.

The management of post-operative IOP spikes is controversial. Since the vast majority of these are transient, many surgeons, including the authors, often use 'bridge'

Table 5 Visual outcomes (median CDVA (mean logMAR ±STD))

Time	Standalone (n=17)	Combined (n=16)	Total (n=33)
Baseline	20/40 (0.4±0.4)	20/175 (1.2±1.0)	20/60 (0.8±0.9)
POM3	20/40 (0.3±0.3)	20/49 (0.6±0.7)	20/40 (0.5±0.5)
POM6	20/40 (0.3±0.4)	20/42 (0.5±0.4)	20/41 (0.4±0.4)
POM12	20/31 (0.3±0.3)	20/30 (0.4±0.3)	20/30 (0.3±0.3)
POM18	20/40 (0.3±0.2)	20/36 (0.3±0.2)	20/40 (0.3±0.2)
POM24	20/50 (0.4±0.2)	20/25 (0.1)*	20/40 (0.3±0.2)

*STD not available as only one value was collected at this time point.
CDVA, corrected distance visual acuity.

medications for the first 3 months after surgery with a clear plan of discontinuation when IOP stabilises. This often coincides with the steroid taper which can take longer than usual in UG patients. The two most common bridge medications used by the authors are pilocarpine for its stretching effect on the anterior chamber angle and Diamox for its robust IOP lowering response. In some cases, hypotensive drops which are started early in the postoperative period are left at the discretion of the treating physician. For these reasons, the use of drops after GATT does not constitute failure.

The average IOP reduction from baseline for patients with a baseline IOP of greater than 21 mm Hg was 23.3±8.1 mm Hg (64.1%), with no patient achieving a reduction smaller than 10 mm Hg. One hundred per cent and 85.7% of eyes with baseline IOP of greater than 21 mm Hg and baseline IOP less than or equal to 21 mm Hg had an IOP of 18 mm Hg or less at the final follow-up visit, respectively, and 80.8% and 71.4% had an IOP of 14 mm Hg or less. These numbers are excellent, suggesting UG patients may be particularly good candidates for GATT. Interestingly, the fact that secondary open angle glaucomas possibly do better than POAG with GATT has been suggested by Grover *et al*.[13] The marked reduction in IOP seen in our study is like that seen in a recent study by Sharkawi *et al* which reported on the success of GATT in patients with pseudoexfoliative glaucoma.[29] In uveitis, like pseudoexfoliation, pressure is increased secondary to intraocular processes which block the TM proximally.[30 31] Further studies on patients with primary and secondary glaucomas will likely provide interesting insight as to different areas of blockage in different subtypes of this disease. An important advantage of GATT over other forms of ab interno trabeculotomy is cost. Apart from a multiuse surgical gonioprism, all the equipment needed is either stocked in most operating rooms where anterior segment surgery is routinely performed or is inexpensive (ie, prolene suture).

No sight-threatening complications occurred in this study, and the complications that did occur were self-limited. No cases of hypotony occurred in our series. These results further support the growing body of evidence that GATT is safer than incisional surgery in general, and, in this study, specifically in UG. Apart from the apparent short-term safety benefits, GATT patients do not carry lifetime risks that traditional glaucoma surgeries carry.

There are important limitations to our study, primarily those inherent to retrospective clinical studies, specifically variable and often short follow-up times, and non-standardised preoperative, intraoperative and postoperative inflammation control protocols. Uveitis constitutes an extremely variable group of diseases some of which are quite uncommon, limiting the ability to form large diagnostic-specific groups to study. While this heterogeneity is an inherent limitation of the study, it also strengthens its external generalisability. While underpowered to make broad conclusions, the favourable response of eyes with different types of uveitis to GATT is encouraging.

In summary, our results suggest GATT should be considered early in the treatment paradigm of medically uncontrolled uveitis-related OHT or glaucoma, likely before the current surgical standard of care for this condition. The fact that a microinvasive approach shows promise in the treatment of this aggressive condition is especially encouraging given the current poor prognosis for UG, and that these patients have a significant risk of needing more than one surgical intervention during their lifetime.

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