

# Gonioscopy-assisted Transluminal Trabeculotomy in Post-corneal Transplant Glaucoma: A Case Series

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## ABSTRACT

**Purpose:** Glaucoma following corneal transplant is one of the leading causes of blindness in transplant patients. Post-transplant glaucoma can be managed medically or surgically. While traditional surgical treatments of glaucoma have been associated with superior intraocular pressure (IOP) control, they are also reported to have higher incidence of graft failure among other complications. We hypothesize that minimally invasive glaucoma surgeries such as gonioscopy-assisted transluminal trabeculotomy (GATT) may offer a superior alternative to the traditional surgical methods. **Case Series:** We report on four patients who underwent GATT: Three with post-penetrating keratoplasty glaucoma and one with post-descemet's membrane endothelial keratoplasty glaucoma. Overall, GATT resulted in lowered IOPs, decreased medication use and avoidance of more invasive procedures in two out of four patients. All four patients had no corneal graft rejection. **Discussion:** These cases suggest that GATT may be an appropriate surgical procedure to address post-corneal transplant glaucoma. GATT is minimally invasive which avoids serious complications such as graft failure. Finally, GATT often requires patients to be on less medications and reduces IOP, rendering it a promising therapeutic option compared to other alternative procedures. **Conclusion:** GATT may be an appropriate surgical procedure to address post-corneal transplant glaucoma.

**Key words:** Descemet's membrane endothelial keratoplasty, glaucoma surgery, gonioscopy-assisted transluminal trabeculotomy, penetrating keratoplasty

## INTRODUCTION

Corneal transplant is the most frequently performed tissue transplant worldwide, with over 10 million people currently suffering from bilateral corneal blindness.<sup>[1,2]</sup> A common side effect of corneal transplant is glaucoma, which occurs in 17–35% of patients postoperatively.<sup>[3]</sup> Two common corneal transplant surgeries are penetrating keratoplasty (PKP) and Descemet's membrane endothelial keratoplasty (DMEK). PKP is a full thickness transplant and DMEK is a partial thickness transplant. The main indications for PKP are previous graft failure and keratoconus; whereas, the number one indication for DMEK is Fuchs' dystrophy.<sup>[4]</sup>

Corneal transplant surgery is associated with a number of complications that can arise, including but not limited to graft

failure, induced hyperopia, severe astigmatism, synechiae formation, and glaucoma.<sup>[5,6]</sup> Glaucoma is arguably one of the most dangerous complications due to its permanent nerve damaging effects, risk factor for endothelial cell loss and graft failure.<sup>[7-9]</sup> The pathophysiology of post-corneal transplant glaucoma is still unknown but many mechanisms have been proposed. Some possible mechanisms involve compression of the angle's anatomical elements with the trabecular meshwork's (TM) collapse, incorrect suture of the graft, postoperative inflammation, and prolonged use of corticosteroids in the post-operative treatment.<sup>[10]</sup>

Fortunately, patients who develop post-corneal transplant glaucoma can often be managed medically.<sup>[11]</sup> However, when medical management fails, surgical options are often considered. While traditional surgical interventions

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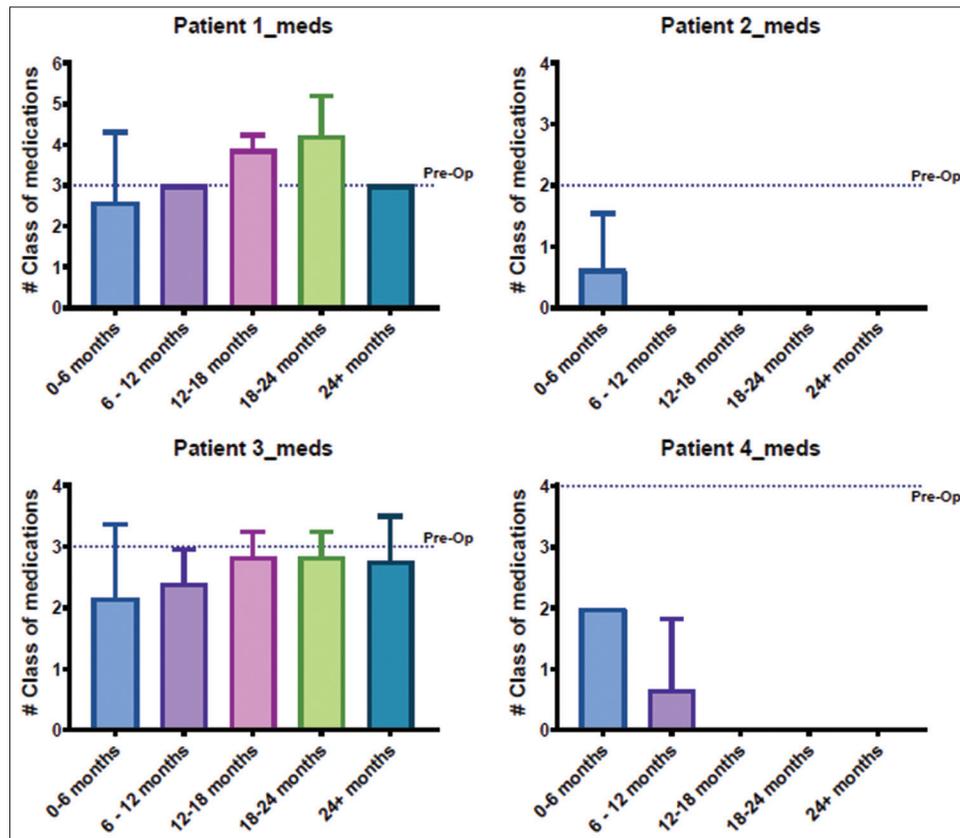
such as trabeculectomy, cyclodestructive procedures, and glaucoma drainage devices (GDD) are usually successful at lowering the intraocular pressure (IOP), they are often associated with high-risk complications including corneal graft failure.<sup>[12-16]</sup>

Recently, several minimally invasive glaucoma surgeries (MIGS) were developed as potential alternatives to the traditional glaucoma surgeries. Gonioscopy-assisted transluminal trabeculotomy (GATT) is a relatively new MIGS which allows for an ab interno approach to the 360 degree suture trabeculotomy and has previously been described by Grover *et al.*<sup>[17]</sup> The GATT procedure has previously been demonstrated to lower IOP in primary open angle glaucoma (POAG) and congenital glaucoma.<sup>[17,18]</sup> However, to the best of our knowledge, the efficacy of GATT in post-penetrating keratoplasty (post-PK) glaucoma has only been explored by a single case report.<sup>[19]</sup> Here, we report a small case series of four patients with post-PK glaucoma treated with GATT. We hypothesized that the GATT procedure would effectively lower pressures in our post-transplant patients while causing minimal damage to the eye without bringing about graft failure.

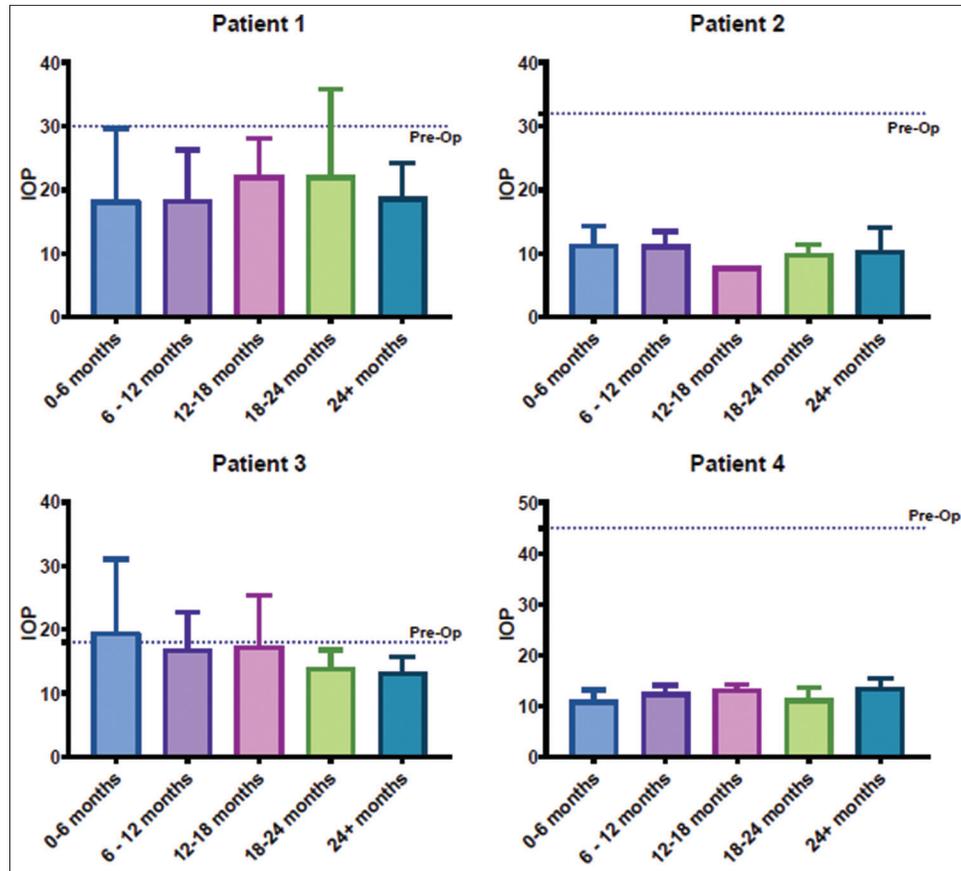
## CASE SERIES

### Patient 1

A 55-year-old male was referred for elevated right eye IOP despite maximal medical glaucoma treatment. The patient had a surgical history of PKP in his right eye, completed 20 years previously because of keratoconus and right eye cataract surgery 15 years prior. The patient was on brimonidine BID OU, travoprost-timolol QHS OU and acetazolamide 125 mg BID for pressure control [Figure 1]. He complained of pressure behind his right eye when leaning forward. On examination, IOP was 30 mm Hg OD and 15 mm Hg OS [Figure 2]. All reported IOPs were completed by a handheld tonometer. Best-corrected visual acuity (BCVA) was 20/150 OD and 20/250 OS. Slit-lamp examination revealed a +2 afferent pupillary defect (APD) OD, a well-placed PKP and a centered PCIOL. Gonioscopy showed open angles and pigment in trabecular meshwork (PTM) of 2 bilaterally. Fundoscopic exam displayed a cup-to-disc ratio of 0.7 bilaterally. A 24-2 Humphrey Visual Field test indicated moderate inferior visual field loss OD. Given that the patient's ODIOP was not under control with medical therapy, the patient underwent a micropulse trans-scleral cyclophotocoagulation (MPCPC); however, 4 months



**Figure 1:** Bar charts of patients 1–4, demonstrating how many classes of glaucoma medications each patient was on over time postoperatively. The dotted lines represent how many classes of glaucoma medications the patients were on before surgery. The error bars represent standard deviation



**Figure 2:** Bar charts of patients 1–4, demonstrating their change in intraocular pressure (IOP) over time postoperatively. The dotted lines represent the pre-operative IOP of each patient. The error bars represent standard deviation

after the laser, the patient had another spike in IOP. GATT surgery was then recommended because of its minimally invasive nature and conjunctiva sparing effects compared to more traditional glaucoma surgeries.<sup>[17]</sup>

The patient underwent a successful 270-degree GATT surgery using a 5–0 polypropylene suture 2 months after our initial surgical recommendation. The technique has previously been described by Grover *et al.*<sup>[17]</sup>

On POD 1, the patient's IOP OD was 10 mm Hg [Table 1], and uncorrected VA (UCVA) was hand motions. After POD 7, the patient was instructed to stop all OD glaucoma medications. On POD 21, the patient's IOP was 15 mm Hg, BCVA and pinhole VA were 20/150 and 20/50, respectively. At 1-month post-operation, the patient had a spike in IOP up to 30 mm Hg. Prednisolone was stopped, but 1 month later, the patient's IOP further deteriorated to 43 mm Hg. Diamox 125 mg QID, brimonidine BID OU, and travoprost-timolol QHS OU were all restarted. On maximum medical treatment, the patient's IOP was still not under control. Over the next year, the patient underwent three MPCPC treatments. One month after their last MPCPC, their IOP was recorded to be 25 mm Hg, BCVA was 20/200, and a GATT revision was recommended. The patient

underwent a successful 360-degree GATT revision 3 weeks later.

On POD 1, the patient's OD IOP was 12 mm Hg and BCVA hand motions. The patient's vision rapidly improved to 20/160 by 1 week post-operation. At 14 months post-operation, the OD IOP was 17 mm Hg and BCVA 20/125. Before the revision, the patient was on four classes of glaucoma medications including 1 oral medication and their pressure was not controlled. 14 months after the revision, the patient was only on three classes of glaucoma medications and their eye pressure had remained in the teens with the exception of one 28 mm Hg measurement.

### Patient 2

A 77-year-old male was referred for elevated OS IOP. In his left eye, the patient had a surgical history of a deep anterior lamellar keratoplasty procedure completed 5 years previous because of keratoconus. The graft failed 2 years later after a cataract removal and intraocular lens (IOL) insertion. A PKP was subsequently completed that same year. Before the initial consult, the patient had superonasal graft edema and was taking prednisolone BID, NaCl hypertonic ophthalmic ointment 5% QID, dorzolamide-timolol BID, and acetazolamide 250 mg

**Table 1:** Pre-operative and post-operative pressures and number of glaucoma medication classes each patient is on

Follow-Up	Patient 1*	Patient 2	Patient 3	Patient 4
Months Followed (mo)	36	52	50	62
IOP mm Hg (mean [SD])				
Pre-operative	30	34	18	46
Months 0–3	19.1 (11.7)	11.9 (2.9)	17.3 (6.1)	10.8 (2.0)
Months 3–6	12 (0)	9 (0.0)	11 (0.0)	13 (0)
Months 6–12	18.5 (7.8)	12.5 (0.7)	17 (7.9)	12.7 (1.5)
Months 12–18	22.3 (5.8)	8.5 (0.7)	14 (2.5)	13.5 (0.7)
Months 18–24	22.2 (13)	11 (0.0)	13.3 (2.8)	11.5 (2.1)
Months 24–36+	18.8 (5.4)	10.5 (3.5)	13.3 (1.3)	13.8 (1.7)
Meds No. (mean [SD])				
Pre-operative	4	2	3	4
Months 0–3	2 (2)	1 (1)	2 (1)	2 (0)
Months 3–6	3 (0)	0	3 (0)	2 (0)
Months 6–12	3 (0)	0	2 (1)	1 (1)
Months 12–18	4 (0)	0	3 (0)	0
Months 18–24	4 (1)	0	2 (0)	0
Months 24–36+	3 (0)	0	3 (1)	0

BID [Figure 1]. The patient complained of blurred vision only in his left eye. On examination, IOP was 12 mm Hg OD and 34 mm Hg OS [Figure 2]. BCVA was 20/30 OD and 20/400 OS. Slit-lamp examination showed no APD, a well-placed PKP, a deep and quiet anterior chamber with a PCIOL centered. Gonioscopy showed open angles and PTM of 1 bilaterally. Fundoscopic examination demonstrated a cup-to-disc ratio of 0.4 OD and 0.7 OS. A24-2-5 Humphrey Visual Field test indicated moderate arcuate visual field loss OS. Given that the patient's OS IOP was not under control with medical therapy, GATT surgery was recommended.

The patient underwent a successful 360-degree GATT surgery 1 day after our initial consult. On POD 1, the patient's OS IOP was 18 mm Hg, and UCVA was 20/80 [Figure 2]. His vision went down to hand motions POD 4, but recovered to 20/300 POD 7 and 20/100 POD 26. After POD 1, the patient was instructed to stop all glaucoma medications. On POD 18, the patient's IOP was 10 mm Hg, BCVA 20/200 and pinhole VA were 20/80. The only eye medications the patient was taking were prednisolone, ketorolac, and lubricating eye drops. At 53 months post-operation, the patient's IOP was 8 mm Hg, BCVA 20/80 and he was only taking prednisolone for his corneal graft. Since his operation, no other glaucoma procedures or medications were needed.

### Patient 3

A 70-year-old male was referred for elevated OS IOP. The patient had a surgical history of a DMEK procedure

completed 1 year previous and a history of chronic uveitis in his left eye. Before the initial consult, the patient had no indications of graft rejection and was taking brimonidine-timolol BID, brinzolamide BID, and acetazolamide 250 mg BID [Figure 1]. On examination, IOP was 21 mm Hg OD and 18 mm Hg OS [Figure 2]. BCVA was 20/50 OD and 20/60 OS. OS Slit-lamp examination showed no APD, a well-placed DMEK, an anterior chamber with 1+ cells and a PCIOL centered. Gonioscopy showed open angles and PTM of 1 bilaterally. Fundoscopic examination demonstrated a cup-to-disc ratio of 0.5 OD and 0.7 OS. A 24-2 Humphrey Visual Field test indicated an advanced inferior arcuate defect OS. Given the patient's significant left eye disease, GATT surgery was recommended.

The patient underwent a successful 180-degree GATT surgery 11 weeks after our initial consult. On POD 1, the patient's IOP OS was 11 mm Hg [Table 1], and UCVA was 20/30. After POD 1, the patient was instructed to stop all glaucoma drops OS and to reduce acetazolamide to 125 mg BID. At 2-weeks post-operation, the patient's IOP was elevated to 26 mm Hg and the glaucoma drops were restarted. Over the next week, the patient's IOP elevated to 32 mm Hg and an emergency surgery was scheduled and a gel eye stent was inserted which failed 1 week later and was removed. Over the next 7 months, the patient needed four MPCPC treatments and two classes of glaucoma medications including one oral before his IOP stabilized. From 14 to 50 months post-operation, the patient's IOP remained in the low teens [Table 1].

#### Patient 4

A 33-year-old man with a history of keratoconus who underwent right eye corneal crosslinking 6 years previously and PKP 2 years previously was seen in the glaucoma clinic because of steroid-induced glaucoma. On presentation, his VA was 20/60 and IOP was 46 mmHg OD on four classes of glaucoma medications including oral acetazolamide [Figures 1 and 2]. He underwent GATT and cataract phacoemulsification. Following 62 months of follow-up, the patient's VA was 20/25 and IOP 12 mmHg [Table 1], off all glaucoma medications. While we have previously reported on this patient in a case report by Nazarali *et al.*,<sup>[19]</sup> we included his follow-up data due to its relevance and the limited number of patients who have undergone both a corneal transplant and GATT procedure.

## DISCUSSION

Traditional glaucoma surgeries are effective at lowering eye pressures in post-corneal transplant patients; however, they pose a high risk to the corneal graft and often result in graft failure and other detrimental eye-related morbidities.<sup>[15]</sup> A meta-analysis of 266 eyes from 13 studies showed that GDD had a mean IOP reduction of 20.2 mm Hg, 16% glaucoma surgery failure rate, and 35% corneal graft failure rate. Trabeculectomy showed a mean IOP reduction of 13.6 mm Hg, 37% glaucoma surgery failure rate, and 24% corneal graft failure rate.<sup>[15]</sup> In addition, CPC had a mean IOP reduction of 20.4 mm Hg, 20.7% glaucoma surgery failure rate, and a 21% graft failure rate. When balancing the need of lowering IOP and preventing graft failure, one can see the difficulty in choosing the best surgical option, especially when the best option with regard to corneal graft failure is still as high as 21%. GATT may offer an option that will lower IOP and have a lower corneal graft failure rate considering the minimally invasive nature of the procedure.

In our retrospective case series of four patients, we defined surgical failure according to Grover *et al.*:<sup>[20]</sup> A post-operative IOP not lowered by at least 20% from pre-operative levels at or after 6 months follow-up, or an IOP > 21 mm Hg at or after 6 months follow-up and finally, a single high IOP measurement refractory to glaucoma medications. From our series, patients 2 and 4 were successful while patients 1 and 3 met the criteria for failure [Table 1]. For the successful patients, their pressures were lowered from the mid-30s and 40s on two to four classes of medications to the low 10s on zero medications for 52 and 62 months, respectively [Figures 1 and 2]. As previously discussed, this is comparable to the pressure lowering effects of trabeculectomy, CPC, and GDD.<sup>[15]</sup> Patient 1 failed the surgery because he had a period of elevated IOP refractory to medication and required an additional GATT revision. Patient three failed the surgery because his pressures were not lowered by 20% of his pre-operative level by the end of 6 months; additionally, he

experienced a spike in IOP refractory to medication. It is important to note that none of the patients experienced any corneal graft failures. Thus, when we compare our patients to Tandon *et al.*'s<sup>[15]</sup> GDD patients, we have a higher surgical failure rate of 50% compared to their 16%; however, our graft failure rate is astoundingly lower at 0% compared to their 35%. Our series, is of course, very limited with only four patients, but these preliminary findings draw an interesting dichotomy between surgical success and graft failure.

To further delineate the similarity between our corneal-transplant GATT patients and non-transplant GATT patients, we can compare them to Grover *et al.*'s<sup>[20]</sup> GATT patients. Grover *et al.*<sup>[20]</sup> separated their patients into six surgical subgroups. Our four patients fell into three of their groups: Group 3– “POAG with prior CE,” receiving only GATT (48% failure rate at 24 months), Group 5– “other glaucoma with no prior CE,” receiving combined GATT and cataract extraction (18% failure rate at 24 months), and Group 6– “other glaucoma with prior CE,” receiving only GATT (27% failure rate at 24 months). Our two successful patients, patients 2 and 4, fell into Groups 6 and 5, respectively.<sup>[20]</sup> Considering that these groups had relatively low failure rates, 18% and 27%, it is not surprising that our patients were surgically successful. Our least successful patient, patient 3, fell into Group 3, which had the highest failure rate of 48%.<sup>[20]</sup> Ultimately, these preliminary comparisons suggest that our corneal-transplant patients have similar success as patients without transplants with the GATT procedure.

The number of patients highlighted in this case series limits our ability to draw strong conclusions. Four patients are a small sample size, and a larger, multicenter retrospective chart review or prospective study would be more appropriate for generating stronger conclusions. Another limitation is the difference in the number of follow-ups among our four patients. Some patients had over 40 follow-up visits while others had just under 20; however, the follow-up length is quite rigorous with the patients still being seen from 39 to 62 months post-operation [Table 1]. Finally, although each of our patients had a corneal-transplant, their ocular histories are much different and with our limited number of patients it is possible that these differences may have substantially affected our results.

## CONCLUSION

In this case series, we report on four patients with post-corneal transplant glaucoma treated with GATT. Our patients had varying degrees of success from the procedure, and this is likely because the post-corneal transplant glaucoma patients represent a heterogeneous population. However, 50% of the cases were successful with long-term follow-up greater than 48 months. We feel that GATT is a reasonable option in treating post-corneal transplant glaucoma, since

it is conjunctival sparring and can be effective against very high pressures. Furthermore, with GATT, the lack of implant makes this procedure compatible with contact lens use, which is important from a quality of life point of view as many post-corneal transplant patients may need rigid gas-permeable or scleral contact lenses. GATT's conjunctiva sparing effects allow for further procedures to be completed in the future. Finally, the lack of implant in the anterior chamber likely lowers the chance of cornea transplant rejection when compared to the more invasive traditional surgical methods. Further prospective studies with larger patient populations are needed before GATT can be definitively recommended for glaucoma treatment in post-corneal transplant patients.

### Declarations

This is to certify that all participants gave written consent for their data to be used for strictly anonymous research purposes. The case series was conducted in agreement with the Declaration of Helsinki and was approved by the Health Research Ethics Board of Alberta (CTC-17-0076).

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