Gonioscopy-assisted Transluminal Trabeculotomy in Uveitic Glaucoma Secondary to Juvenile Idiopathic Arthritis

Amun Sachdev, BMBSch, MA (Oxon), FRCOphth,* Ashkan Khalili, MD, PhD, FRCOphth,* Jessy Choi, MBChB, FRCOphth,† Richard E. Stead, MBChB, FRCOphth,‡ and Velota C.T. Sung, FRCS(Ed), FRCOphth, MSc(Warwick)*

Abstract: Gonioscopy-assisted transluminal trabeculotomy (GATT) is a minimally invasive ab interno procedure, performed with guidance of an illuminating microcatheter device (iTrack). The pathophysiology of raised intraocular pressure (IOP) in uveitic glaucoma is commonly due to increased resistance at the trabecular meshwork-Schlemm canal. By removing this resistance, GATT can potentially control the IOP. In addition, the ab interno approach avoids violating the conjunctiva and reduces the risk of complications including infection, leak, and hypotony. In this series, we discuss 3 uveitic glaucoma cases secondary to juvenile idiopathic arthritis (JIA) that underwent GATT. Case 1 was a 16-year-old phakic female with a preoperative IOP of 25 to 33 mm Hg had 360-degree GATT; her IOP remained stable at 13 to 15 mm Hg over 21 months. Case 2 was a 23-year-old pseudophakic female with a preoperative IOP of 28 to 34 mm Hg had 180-degree GATT; her IOP remained stable at 6 to 10 mm Hg over 21 months. In our limited case series, GATT is very successful in controlling IOP in young uveitic patients with JIA by surgically targeting the underlying pathophysiology.

Key Words: gonioscopy-assisted transluminal trabeculotomy, GATT, uveitic glaucoma, JIA, trabeculotomy

Secondary glaucoma is a serious sight-threatening complication of uveitis and is particularly common in juvenile idiopathic arthritis (JIA) with prevalence reported as high as 42%, particularly in individuals with persistent low-grade uveitis. Treatment can be difficult and requires aggressive control of both the inflammation and intraocular pressure (IOP). As first-line medical therapy often fails to optimize IOP control, surgical intervention is frequently necessary. This traditionally involves filtering surgery with either trabeculectomy or glaucoma drainage device implantation. However, these procedures carry risks such as endophthalmitis, significant hypotony, and bleb-related complications including blebitis, bleb leak or dysaesthesia; manipulation of the conjunctiva also results in scarring. Therefore, other approaches have been developed with success rates of 86% with goniotomy and 81.8% with trabeculotomy.

Gonioscopy-assisted transluminal trabeculotomy (GATT) is a minimally invasive ab interno procedure, that has evolved from traditional trabeculotomy techniques and is performed with the guidance of an illuminating micro-catheter device (iTrack; Ellex Medical Pty Ltd, Adelaide, Australia). GATT is believed to reduce IOP by fracturing the trabecular meshwork and removing the resistance to aqueous outflow. The ab interno approach avoids the need for conjunctival manipulation or implantation of devices and reduces the risk of complications including infection, wound leak and hypotony. Compared with other minimally invasive glaucoma surgeries such as the iStent or trabectome, GATT also allows up to 360 degrees of the angle to be treated.

The GATT procedure has reported success in open angle glaucoma and congenital glaucoma. At the time of writing, there are no published cases reporting the use of GATT in uveitic glaucoma secondary to JIA. This series presents 3 patients with JIA-associated uveitic glaucoma treated successfully with GATT. Before each case underwent the GATT procedure, their uveitis was well-controlled and stable with either absent or only low-grade inflammation. Consent was gained from all patients to publish their findings and clinical images.

CASE REPORTS

Case 1
A 16-year-old Pakistani phakic female was referred to the glaucoma clinic at a tertiary referral center due to uncontrolled IOP in her left eye over 5 months while on latanoprost 0.005%, brinzolamide 1% and apraclonidine 0.5%. She was also being treated with methotrexate, having been diagnosed with JIA uveitis at age 6. Notably, her right eye previously had uncontrolled IOP that she underwent a trabeculectomy at age 8, followed by Baerveldt tube implantation at age 14. She required removal of the supramid stent suture 10 months later due to an increasing IOP. This resulted in hypotony, which required 5 intracameral viscoelastic injections over a period of 4 months. The supramid was then reinserted via the anterior chamber and the intracameral portion of the tube was tied.
The IOP in her right eye has since been controlled on preservative-free latanoprost 0.005% and brinzolamide 1%/timolol 0.5%.

On examination, the best-corrected visual acuity (BCVA) was 6/6 in her left eye. The IOP was fluctuating between 25 and 33 mm Hg. The cup-to-disc ratio (CDR) was 0.30.

Because of her persistently elevated IOP in her right eye, and considering the unstable IOP in her right eye after tube implantation, she underwent GATT over 360 degrees in her left eye as previously described by Grover et al9 (Video 1, Supplemental Digital Content 1, http://links.lww.com/IJG/A437) demonstrates the GATT procedure, performed by one of our authors (V.C.T.S.), with the fibreoptic iTrack microcatheter (Ellex Medical Pty Ltd). There were no intraoperative complications; orbital floor triamcinolone 4%/bupivacaine 0.25% was also given at the time of surgery. All her glaucoma medications were stopped.

At postoperative day 1, her IOP was 9 mm Hg. BCVA was 6/36 and she had 1.5 mm of hyphaema. By postoperative week 3, her BCVA had stabilised to 6/7.5 and her hyphaema had completely resolved. She continued to do well over 14 months postoperatively with her IOP remaining at 6 to 10 mm Hg while off all glaucoma medications and her uveitis remaining well-controlled throughout. Although she was phakic at the time of her procedure, there was no evidence of any cataract progression during the postoperative period.

**Case 2**

A 23-year-old White pseudophakic female was referred to the glaucoma clinic at a tertiary referral center due to uncontrolled IOP in her right eye over 9 months while on latanoprost 0.005%, dorzolamide 2%/timolol 0.5% and apraclonidine 0.5%. She had undergone previous surgery in this right eye—a trabeculectomy at age 5 and subsequent Baerveldt tube implantation at age 13. She had previously been treated with etanercept for her JIA, having developed anterior uveitis at age 7. Notably, in her left eye, she had previously undergone a trabeculectomy at age 7 and subsequent Baerveldt tube implantation at age 11. Postoperatively, to eventually achieve a stable IOP in the left eye, she had to undergo multiple revision surgeries including removal/reinsertion of the supramid suture and tying/untying of the intracameral portion of the tube.

On examination, the BCVA was 6/6 in her right eye. The IOP was fluctuating between 28 and 34 mm Hg. The CDR was 0.75. She also had punctate epithelial erosions over her cornea.

Because of her elevated IOP, she underwent GATT over 180 degrees in her right eye. The microcatheter could only be passed through 180 degrees of inferior and temporal Schlemm canal. The microcatheter encountered resistance at the superior Schlemm canal likely due to a second obstruction from previous glaucoma surgeries. The microcatheter was manipulated centripetally with intraocular forces to fracture at least 180 degrees of the trabecular meshwork. There was minimal hyphaema and the procedure was concluded with an orbital floor triamcinolone 4%/bupivacaine 0.25% injection. The patient was instructed to continue on latanoprost 0.005% and dorzolamide 2%/timolol 0.5%.

At postoperative day 1, her IOP was 22 mm Hg. BCVA was 6/9 and she had a microphic hyphaema. By postoperative day 8, her BCVA had stabilised to 6/5 and her hyphaema had completely resolved. Her uveitis remained controlled throughout her postoperative period. At her most recent visit, 10 months postoperatively, her IOP was 8 mm Hg while on latanoprost 0.005% and dorzolamide 2%/timolol 0.5% with an improvement in the status of her ocular surface. Figure 1 demonstrates the appearance of the angle with the exposed Schlemm canal postoperatively.

**Case 3**

An 8-year-old White aphakic male was referred to the glaucoma clinic at a tertiary referral center due to uncontrolled IOP in his right eye over 5 months while on latanoprost 0.005%/timolol 0.5%, brinzolamide 1%, pilocarpine 2% and trials of oral acetazolamide. He was also being treated with mofetilxate and adalimumab, having been diagnosed with persistent anterior uveitis at age 4 and JIA at age 7.

On examination, the BCVA was 6/15 in his right eye, due to pre-existing amblyopia. The IOP was fluctuating between 21 and 32 mm Hg. The CDR was 0.75. He had previously undergone a right lensectomy with goniosynechialysis and anterior vitrectomy at age 7, after which he remained aphakic.

Because of his elevated IOP, he underwent GATT over 360 degrees in his right eye. There were no intraoperative complications; orbital floor triamcinolone 4%/bupivacaine 0.25% was also given at the time of surgery. All his glaucoma medications were stopped.

At postoperative day 1, his IOP was 10 mm Hg. BCVA was perception of light and he had <1 mm of hyphaema. At postoperative day 8, he was noted to have vitreous hemorrhage with microphic hyphaema and BCVA of counting fingers. Over the subsequent months, his IOP remained stable at 14 to 15 mm Hg. Although his vitreous hemorrhage eventually cleared, he developed persistent anterior chamber and vitreous cells which remained unresponsive to topical, oral and intravenous steroids; he ultimately underwent anterior chamber washout and vitrectomy. Since this additional procedure, occasional ghost cells continued to persist in his anterior chamber and vitreous cavity; his uveitis remained controlled with no active inflammatory cells. In addition, as a consequence of the vitreous hemorrhage, his vision reduced to 6/30. Patching was attempted in case of worsening amblyopia but this did not improve his vision. At his most recent visit, 21 months postoperatively, his IOP was 13 mm Hg while off all glaucoma medications.

**DISCUSSION**

In uveitis, there are a number of proposed mechanisms for the increased resistance to aqueous outflow that is believed to result in elevated IOP and secondary glaucoma. These include mechanical obstruction of the trabecular meshwork by inflammatory debris, constriction of the trabecular endothelium due to mediators such as Rho kinase, chronic scarring of the meshwork and outflow channels and the use of steroids in treating uveitis, which can cause accumulation of extracellular matrix proteins and glycosaminoglycans in the meshwork.1 Glaucoma is a particularly common complication of JIA.1

Trabeculectomy with mitomycin C augmentation has shown variable rates of long-term successful IOP control in uveitic glaucoma, ranging from 67.0 % to 89.5% at 1 year and falling to 38.0 % to 61.7% at 5 years.8,9 In comparison, primary glaucoma drainage device implantation has relatively greater rates of success, ranging from 89 % to 91% at 1 year and falling to 75% at 5 years.8,10 In addition, Figure 1. The appearance of the angle postoperatively for case 2.
trabeculectomy has been associated with higher rates of early and late postoperative complications such as hypotony and bleb-related complications.\footnote{8} As such, the evidence-based approach for surgical success has generally been in favor of primary implantation of glaucoma drainage devices over trabeculectomy, albeit at the expense of tube-related complications.\footnote{8} Surgery targeting the drainage angle has been a more recent development in pediatric uveitic glaucoma; reported success rates have been 81.8% after 1 or 2 ab externo trabeculotomy procedures using the Harm trabecutome\footnote{8} and 86% after 1 or 2 goniotomy procedures.\footnote{3} However, these reported success rates were achieved with > 1 procedure being necessary in a significant proportion of patients. Ab externo trabeculotomy also requires conjunctival and scleral excision and manipulation which can contribute to greater difficulty in performing future filtration surgery and a subsequent higher risk of failure.

This article describes 3 cases of secondary glaucoma related to JIA-associated uveitis and highlights that the GATT procedure performed using an fibroptic microcatheter can have favorable results on IOP control. The illuminated fibroptic catheter allows accurate cannulation of the Schlemm canal avoiding false passage and reducing the risk of complications. In all of the patients, GATT was effective in reducing IOP by 40% to 66%. Preoperatively, the patients had been using 3 to 4 glaucoma medications; postoperatively, 2 of the 3 patients maintained good IOP control while completely drop-free, with this effect maintained over 12 months. Case 2 also achieved good postoperative IOP control although she continued to require topical antihypertensives; however, as she required fewer medications postoperatively, this has had beneficial effects on her ocular surface.

Case 2 has also had a more complicated ocular history with previous multiple glaucoma surgeries that caused significant subconjunctival scarring and obstruction of the Schlemm canal superiorly; as such, the GATT procedure could only be completed through 180 degrees of the Schlemm canal. The less effective IOP reduction and continued need for antihypertensive drops in this case may therefore suggest a positive dose-response relationship in the GATT procedure. Indeed, studies in other subtypes of pediatric glaucoma such as primary congenital glaucoma, juvenile open angle glaucoma and glaucoma secondary to cataract surgery, have shown greater success rates and postoperative IOP reductions in 360 degrees trabeculotomy compared with <180 degrees trabeculotomy, although <180 degrees trabeculotomy was performed with the Harm trabecutome rather than the microcatheter used in our case.\footnote{10,11} This is in contrast to adult eyes, in which the degree of trabeculotomy has no apparent effect upon IOP reduction.\footnote{12}

GATT has had reported success in pediatric patients with primary congenital glaucoma and juvenile open angle glaucoma.\footnote{7} Although our findings are reflected in patients with JIA-associated uveitic glaucoma, they have provided further evidence that GATT can be effective in younger patients. By maintaining the integrity of the conjunctiva, GATT increases the future surgical treatment options for this group of patients with very complex needs.

It is notable that GATT has had reported success in steroid-induced glaucoma.\footnote{13} As steroids are the mainstay of treatment for uveitis, they may also be one of the potential mechanisms behind the raised IOP in these patients. This may therefore suggest that GATT could be an effective procedure for patients with a mixed mechanism of uveitic glaucoma and steroid-induced glaucoma.

Hypotony is a common complication of filtering surgery in patients with uveitic glaucoma. Indeed, hypotony maculopathy after Baervaldt tube surgery is particularly common in patients with JIA-associated uveitic glaucoma.\footnote{14} Cases 1 and 2 had undergone Baervaldt tube implantation in their fellow eyes and subsequently required multiple revision surgeries due to labile postoperative IOP. The success of GATT in these patients highlights its relatively good safety profile and predictable postoperative IOP reduction.

The most common complication of GATT is hyphaema which typically resolves within a few weeks and is seen in 30% of patients.\footnote{3} Case 3 was aphakic and developed a postoperative vitreous hemorrhage with a subsequent persistence of ghost cells in the vitreous and anterior chamber. Vitreous hemorrhage may result in the prolonged obstruction of the visual axis and consequently increase the risk of developing amblyopia in younger patients. The appearance of ghost cells can make assessment of the extent of postoperative inflammation and uveitis more difficult; this therefore increases the risk of over-treatment with steroids and/or surgery. Therefore, in addition to the contraindications listed in Grover recent paper,\footnote{15} the authors propose that a relative contraindication for GATT may be aphakia.

Our article presents 3 young patients in whom GATT was successfully performed for JIA-associated uveitic glaucoma, with substantial and sustained reductions in IOP and reduced dependence upon glaucoma medications. To the best of our knowledge, this is the first reported series of secondary uveitic glaucoma effectively treated with GATT in young patients. Although further study is certainly required into the longer-term effects of GATT in this patient population, the success of this procedure in our case series suggests that it may be an effective surgical option for younger patients with JIA-associated uveitic glaucoma.

**REFERENCES**

1. Kalogeropoulos D, Sung VC. Pathogenesis of uveitic glaucoma. *J Clin Ophthalmol* 2012:1–125–138.
2. Kalogeropoulos D, Kalogeropoulos C, Moschos MM, et al. The management of uveitic glaucoma in children. * Turk J Ophthalmol* 2019;49:283–293.
3. Bohnsack BL, Freedman SF. Surgical outcomes in childhood uveitic glaucoma. *Am J Ophthalmol* 2013;155:134–142.
4. Wang Q, Wang J, Fortin E, et al. Trabeculotomy in the treatment of pediatric uveitic glaucoma. *J Glaucoma* 2016;25:744–749.
5. Grover DS, Godfrey DG, Smith O, et al. Gonioscopy-assisted transluminal trabeculotomy, ab interno trabeculotomy: technique report and preliminary results. *Ophthalmology*. 2014;121:855–861.
6. Rahmatnejad K, Pruzan NL, Amanullah S, et al. Surgical outcomes of Gonioscopy-assisted Transluminal Trabeculotomy (GATT) in patients with open-angle glaucoma. *J Glaucoma*. 2017;26:1137–1143.
7. Grover DS, Smith O, Fellman RL, et al. Gonioscopy assisted transluminal trabeculotomy: an ab interno circumferential trabeculotomy for the treatment of primary congenital glaucoma and juvenile open angle glaucoma. *Br J Ophthalmol*. 2015;99:1092–1096.
8. Iverson SM, Bhardwaj N, Shi W, et al. Surgical outcomes of inflammatory glaucoma: a comparison of trabeculectomy and glaucoma-drainage-device implantation. *Jpn J Ophthalmol*. 2015;59:179–186.
9. Iwao K, Inatani M, Seto T, et al. Long-term outcomes and prognostic factors for trabeculotomy with mitomycin C in eyes.
10. Lim ME, Neely DE, Wang J, et al. Comparison of 360-degree versus traditional trabeculotomy in pediatric glaucoma. *J AAPOS*. 2015;19:145–149.

11. Rojas C, Bohnsack BL. Rate of complete catheterization of Schlemm’s canal and trabeculotomy success in primary and secondary childhood glaucomas. *Am J Ophthalmol*. 2020;212:69–78.

12. Manabe SI, Sawaguchi S, Hayashi K. The effect of the extent of the incision in the Schlemm canal on the surgical outcomes of suture trabeculotomy for open-angle glaucoma. *Jpn J Ophthalmol*. 2017;61:99–104.

13. Boese EA, Shah M. Gonioscopy-assisted Transluminal Trabeculotomy (GATT) is an effective procedure for steroid-induced glaucoma. *J Glaucoma*. 2019;28:803–807.

14. Tan AN, Cornelissen MF, Webers CAB, et al. Outcomes of severe uveitic glaucoma treated with Baerveldt implant: can blindness be prevented? *Acta Ophthalmol*. 2018;96:24–30.

15. Grover DS, Smith O, Fellman RL, et al. Gonioscopy-assisted transluminal trabeculotomy: an ab Interno circumferential trabeculotomy: 24 months follow-up. *J Glaucoma*. 2018;27:393–401.