ORIGINAL RESEARCH

Efficacy and Safety Outcomes of XEN Implantation and Gonioscopy-assisted Transluminal Trabeculotomy for the Management of Advanced Open-angle Glaucoma

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Abstract

Aim: Minimally invasive glaucoma surgery (MIGS) is not typically used in patients with advanced-stage glaucoma. This study describes the outcomes and complications of patients with advanced open-angle glaucoma (OAG) who underwent XEN implantation with cataract surgery or gonioscopy-assisted transluminal trabeculotomy (GATT) with cataract surgery.

Methods: This retrospective study identified patients who had undergone XEN implantation or GATT for the management of advanced OAG. Outcomes included surgical success, intraocular pressure (IOP) reduction, number of topical IOP-lowering drops, visual field mean deviation (MD), best-corrected visual acuity (BCVA), and complications. Surgical success was defined as an IOP of <14 mm Hg and a 20% reduction at 12 months without topical IOP-lowering drops (complete success) or with topical IOP-lowering drops (qualified success).

Results: Exactly 70 eyes were enrolled in this study, including 35 who had undergone XEN implantation and 35 who had undergone GATT. The overall surgical success rate was 74.3% (26 of 35) for eyes that underwent XEN implantation and 71.4% (25 of 35) for eyes that underwent GATT. Percent IOP reduction from baseline to 12 months postoperatively was 48% in the XEN cohort and 32% in the GATT cohort. Significant reduction in the use of topical IOP-lowering drops was demonstrated for both XEN (3.26 ± 1.15–1.23 ± 1.28) ($p < 0.001$) and GATT (2.46 ± 1.12–0.43 ± 0.78) ($p < 0.001$) cohorts at 12 months postoperatively. The only complication reported was transient hyphema, which occurred in three patients from the XEN group and four from the GATT group, and resolved spontaneously.

Conclusions: Both XEN implantation and GATT may be safe and effective management options when treating patients with advanced OAG. However, larger sample sizes are required to make direct statistical comparisons between these techniques.

Clinical significance: In this study, XEN implantation and GATT combined with cataract surgery were each associated with favorable outcomes in patients with advanced OAG.

Keywords: Glaucoma, Gonioscopy-assisted transluminal trabeculotomy, Minimally invasive glaucoma surgery, Open-angle glaucoma, XEN.

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Introduction

Glaucoma is a group of chronic eye conditions characterized by irreversible optic nerve damage, resulting in severe visual loss and possible blindness.[1] It presents a significant healthcare burden and remains the leading cause of irreversible blindness globally.[2,3] In cases of OAG, failure to control IOP adequately with topical therapy typically indicates IOP-lowering surgery.[4] The traditional gold standard for surgical management of advanced OAG is trabeculectomy.[4] However, this technique can be associated with hypotony, bleb leaks, cataracts, and possible damage to the tenon capsule and conjunctiva, which can lead to complications and limit surgical effectiveness.[5,6] Given this, significant innovations in treatment options have become available for OAG with the use of MIGS.[5,6]

Minimally invasive glaucoma surgeries (MIGS) are considered to include all procedures that improve aqueous humor outflow while offering rapid recovery.[3] They have been shown to be associated with fewer operative and postoperative complications than other more invasive surgical techniques.[7] However, MIGS are typically only recommended in mild-moderate cases of OAG, and the effectiveness of MIGS in advanced OAG is not well understood.[3] Among the most commonly used MIGS are the XEN Gel Stent implant and GATT. Most MIGS enhance the outflow of aqueous humor *via* Schlemm's canal or the suprachoroidal pathway. However, the XEN implant is an exception to this, as it is implanted through a clear corneal incision and facilitates aqueous humor drainage from the anterior chamber into the subconjunctival space.[8] Contrarily, GATT offers a minimally invasive trabeculotomy, which has been shown to be an effective means of reducing IOP and medications used.[9]

Although the literature regarding outcomes of these procedures in advanced OAG is sparse, there have been several

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studies that have demonstrated favorable outcomes with these procedures in patients with advanced disease.[10–12] As such, this study sought to describe the safety and efficacy profiles of XEN and GATT in the context of advanced OAG. To our knowledge, this is the first study evaluating the outcomes of these techniques with the same success criteria in the context of advanced disease. The findings described should provide valuable insight regarding the optimal management of patients with advanced OAG.

Methods

This retrospective study identified patients who had undergone XEN implantation or GATT for the management of advanced OAG. Inclusion criteria restricted recruitment to patients who received either XEN or GATT for management of an above-target IOP on maximal tolerated medical therapy or who were deemed to require immediate surgical intervention due to advanced disease state. All patients had a diagnosis of advanced OAG, defined as a MD of visual field < –12 dB OR vision loss in the central 10°. Patients with mild-moderate staged OAG were excluded from the study. All procedures were routine primary surgeries performed by a single surgeon (NS-H) from 1st January 2018 to 1st September 2021 at Miramichi Regional Hospital in New Brunswick, Canada. All patient data was obtained from a cloud-based electronic medical record, OSCAR. Outcomes included surgical success, reduction in IOP, use of topical IOP-lowering drops, visual field MD, BCVA, and complications postoperatively. Success was defined as IOP of <14 mm Hg and 20% reduction at 12 months without topical IOP-lowering drops (complete success) or with topical IOP-lowering drops (qualified success). All patients requiring further surgical intervention or who experienced a loss of light perception were automatically classified as a failure. This study received full approval from the Institutional Ethics Review Board and was conducted in accordance with the Declaration of Helsinki.

Statistical Analysis

Descriptive statistics were included for patient age, sex, and eye receiving surgery for both XEN and GATT cases. Paired *t*-tests were used for comparison of the number of topical IOP-lowering drops, LogMAR BCVA, and the MD of the visual field before surgical intervention and at 12 months follow-up. Repeated measures analysis of variance (ANOVAs) were used to compare IOP before surgical intervention to IOP at each follow-up interval for both XEN and GATT cases. Statistical significance was defined as $p < 0.05$ for all analyses.

XEN Implantation Surgical Technique

All XEN procedures were performed in combination with phacoemulsification and IOL insertion. Prior to the standard phacoemulsification procedure, mitomycin C (0.2 mL of 0.3 mg/mL) was delivered into the subconjunctival space *via* injection, creating a hydrodissection between the conjunctiva and Tenon's capsule. The patient was then prepped and draped in a sterile fashion. A lid speculum was used to retract the eyelids. Two side port incisions (1.8 and 1 mm) were made using a micro-vitreoretinal blade. Xylocaine 1% was administered intracamerally. Viscoelastic was injected into the anterior chamber. An Osher Posterior Pole Gonio Lens was used to visualize the iridocorneal angle. A Vera hook was used to stabilize the eye. The XEN implant was delivered using the XEN gel injector into the subconjunctival space. Any remaining viscoelastic in the anterior chamber was removed *via* coaxial irrigation and aspiration. A large filtering bleb was noted surrounding the XEN Gel Stent. Miostat was injected to constrict the pupil. Vigamox was injected for infection prophylaxis. Wounds were hydrated to a watertight closure and Tobradex ointment was applied postoperatively.

Gonioscopy-assisted Transluminal Trabeculotomy (GATT) Surgical Technique

All GATT procedures were performed in combination with phacoemulsification and IOL insertion. Following the standard phacoemulsification procedure, a Swan-Jacob Gonioprism was employed to visualize the iridocorneal angle. A 5-0 Prolene suture was then passed through the side-port access. A 25-gauge needle was employed to make a 1 o'clock incision nasally in the trabecular meshwork. Micro-Graspers were used to advance the Prolene suture through the goniotomy and 360° around Schlemm's canal, thus creating the ab interno trabeculotomy. Miostat was injected into the eye to constrict the pupil and Vigamox was injected for infection prophylaxis. Wounds were hydrated and Tobradex ointment was applied postoperatively.

Results

Exactly 70 eyes of 60 patients with advanced OAG were included in this study. Of these, 35 eyes had undergone XEN implantation with cataract surgery and 35 eyes had undergone GATT with cataract surgery in the context of the above-target IOP. Baseline demographics are included in Table 1.

XEN Implantation Efficacy Outcomes

Overall surgical success, defined as IOP < 14 mm Hg and >20% reduction at 12 months postoperatively, was achieved by 74.3% (26 of 35) eyes who underwent XEN implantation. For this cohort, 37% of eyes achieved success without topical IOP-lowering drops (complete success) and 37% of eyes achieved success with topical IOP-lowering drops (qualified success).

For patients who underwent XEN implantation, the mean baseline IOP was 24.6 ± 7.4 mm Hg. Significant IOP reduction from baseline was demonstrated at 1 day ($p < 0.001$), 1 week ($p < 0.001$), 1 month ($p < 0.001$), 3 months ($p < 0.001$), 6 months ($p < 0.001$), and 12 months ($p < 0.001$). For these patients, the percent reduction in IOP from baseline (24.6 ± 7.4 mm Hg) to 12 months follow-up (12.7 ± 4.9 mm Hg) was 48%. IOP plotted at each specified follow-up period is included in Figure 1. A significant reduction in the number of topical IOP-lowering drops required was also demonstrated for patients who received XEN (3.26 ± 1.15–1.23 ± 1.28) ($p < 0.001$) (Fig. 2). A comparison of mean BCVA in the XEN cohort before surgery (0.50 ± 0.75) to 12 months post-XEN (0.43 ± 0.75) demonstrated no significant difference ($p < 0.1$). Similarly, no significant change in MD of the visual field was demonstrated between presurgery (–16.9 ± 8.9 dB) and 12 months follow-up (–18.3 ± 7.6 dB) ($p = 0.27$).

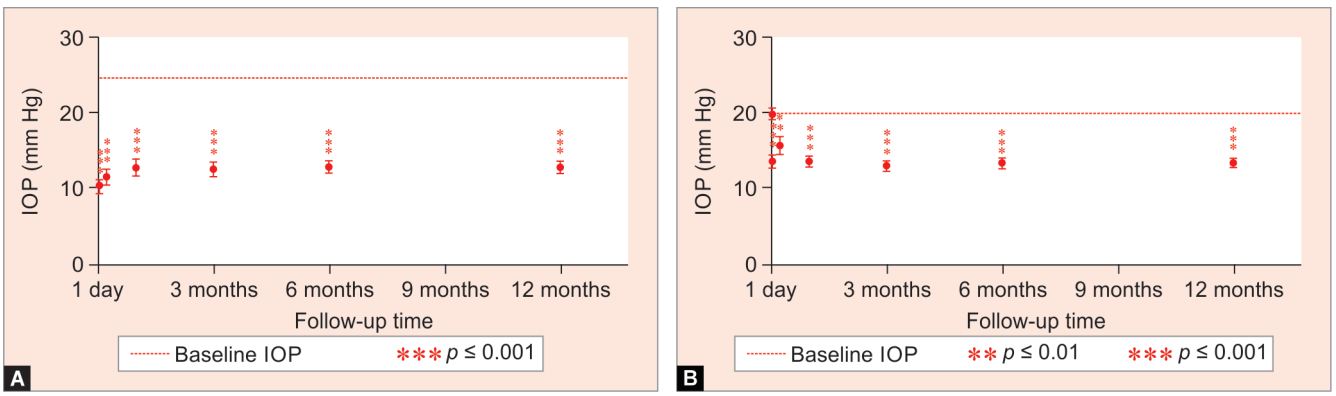
Gonioscopy-assisted Transluminal Trabeculotomy (GATT) Efficacy Outcomes

Surgical success was achieved by 71.4% (25 of 35) of eyes who underwent GATT. A total of 54% of eyes achieved complete success, while 17% achieved qualified success.

The mean baseline (presurgery) IOP of patients who underwent GATT was 19.7 ± 6.1 mm Hg. A significant reduction from preoperative IOP was demonstrated at 1 day ($p < 0.001$), 1 week

Table 1: Baseline demographic characteristics of patients who underwent XEN implantation with cataract surgery or GATT with cataract surgery for the management of advanced OAG

Variable	*XEN Implantation*	*GATT*
Age (years), mean ± standard deviation (SD)	73.9 ± 9.8	71.4 ± 10.6
Sex, *n* (%)		
Female	19 (54.3%)	10 (28.6%)
Eye, *n* (%)		
Right eye	17 (48.6%)	17 (48.6%)
Baseline topical IOP-lowering drops, mean ± SD	3.62 ± 1.15	2.46 ± 1.12
Baseline MD of visual field, mean ± SD	−16.9 ± 8.9	−17.5 ± 4.6
Baseline LogMAR BCVA, mean ± SD	0.5 ± 0.75	0.5 ± 0.48
Baseline IOP (mm Hg), mean ± SD	24.6 ± 7.4	19.7± 6.1



Figs 1A and B: (A) Figure showing the IOP (mean ± standard error of the mean) at various follow-up periods for XEN implantation and (B) GATT cohorts. Significance was determined by comparison of baseline (prerevision) IOP to each follow-up using repeated measures ANOVA with Bonferroni correction

($p < 0.01$), 1 month ($p < 0.001$), 3 months ($p < 0.001$), 6 months ($p < 0.001$), and 12 months ($p < 0.001$). Percent reduction in IOP from baseline (19.7 ± 6.1 mm Hg) to 12 months follow-up (13.4 ± 3.6 mm Hg) was 32% for GATT patients. A significant reduction in required topical IOP-lowering drops was demonstrated for patients who underwent GATT, with the mean number of drops reduced from 2.46 ± 1.12 preoperatively to 0.43 ± 0.78 at 12 months follow-up ($p < 0.001$).

For the GATT patient cohort, a significant improvement in mean LogMAR BCVA was demonstrated from baseline (0.50 ± 0.48) to 12 months follow-up (0.29 ± 0.28) ($p < 0.01$). The MD of the visual field was stable in the GATT cohort when presurgery (−17.5 ± 4.6 dB) and 12 months follow-up (−16.3 ± 7.3 dB) were compared ($p = 0.27$).

XEN and GATT Complications

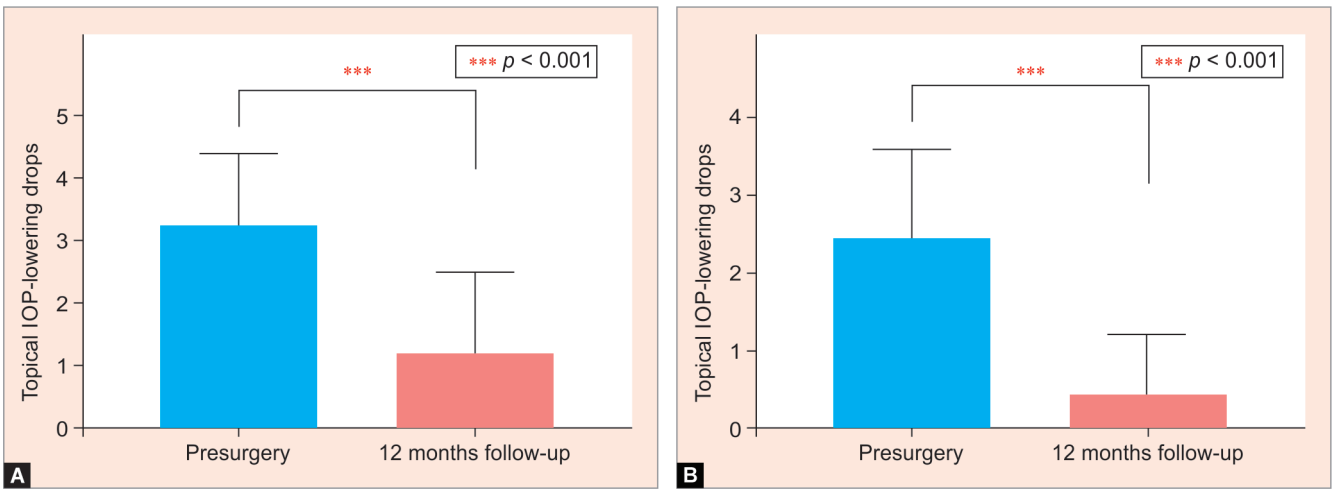
The only complication reported in either group was transient hyphema, which occurred in three patients who underwent XEN and four patients who underwent GATT. All cases of transient hyphema resolved spontaneously within 1 week. Complications and pertinent negatives are included in Table 2.

Discussion

The use of MIGS has become common in the setting of uncontrolled glaucoma.[5–7] Several recent studies have demonstrated favorable outcomes with MIGS in patients with advanced OAG.[10–12] If MIGS are to be used more commonly in patients with advanced disease, it will be important to understand the outcomes and potential complications of various MIGS techniques in this clinical context. To our knowledge, this is the first study seeking to describe the outcomes of both XEN implantation and GATT in patients with advanced OAG.

Success was evaluated using a stringent IOP target of 14 mm Hg and >20% reduction to ensure adequate IOP control for these cases of advanced disease. Our results indicate that both XEN and GATT demonstrated high rates of surgical success at 12-month postoperatively (74.3 and 71.4%, respectively). Significant reduction in IOP from preoperative values was noted at all follow-ups for both XEN and GATT cohorts. XEN implantation was associated with 48% IOP reduction, while GATT was associated with a 32% reduction. However, it is noted that the mean presurgery IOP was lower in the GATT patient cohort and that no formal statistical comparison between the groups was made. Future studies with sufficient sample sizes for such comparisons are warranted to explore this further.

Although the goals of this study were to describe and not compare the outcomes of XEN and GATT in advanced OAG, direct comparisons between these techniques have been made for non-advanced cases. A recent study by Olgun et al. compared success and complications associated with XEN and GATT in all comers with OAG.[13] Their retrospective study reports an IOP reduction of 56.5 and 38.2% for XEN implantation and GATT, respectively, which is similar to the findings described in the present study. Interestingly, they also report a greater proportion of success without topical IOP-lowering drops in the GATT cohort as compared to the XEN cohort, in keeping with our findings.[13]



Figs 2A and B: (A) Reduction in mean topical IOP-lowering drops in patients who underwent XEN implantation with cataract surgery or (B) GATT with cataract surgery

Table 2: Frequency of complications following XEN implantation with cataract surgery vs GATT with cataract surgery for the management of advanced OAG

	XEN Implantation	*GATT*
Transient hyphema (*n*)	3	4
Toxic anterior segment syndrome (*n*)	0	0
Endophthalmitis (*n*)	0	0
Hypertrophic bleb (*n*)	0	0
Hypotony (*n*)	0	0
Suprachoroidal hemorrhage (*n*)	0	0

Several studies have individually examined the outcomes of GATT and XEN in advanced diseases. Aktas et al. in their study of GATT in moderate-advanced POAG reported a 38% IOP reduction at 12 months with the use of combined GATT and cataract surgery.[10] As in our study, the most common complication reported by Aktas et al. was hyphema which was transient and resolved spontaneously.[10] Similarly, a study by Laborda-Guirao et al. has investigated the 12-month outcomes of XEN in advanced disease, reporting a 27.4% IOP reduction at 12 months. Differences in success criteria, operating surgeon, and study population, make it difficult to make comparisons between these studies. Our study contributes to this existing literature by addressing some of these confounding factors.

There are several limitations that are acknowledged in this study. It is important to note that this study seeks to merely describe the outcomes of XEN and GATT in advanced disease without formal statistical comparison. This was due to the retrospective nature and relatively small sample size ($n = 70$) of the study, which limited the conclusions that can be drawn from this study alone. If the sample size were to be increased, it is possible that less frequent complications associated with XEN implantation or GATT could arise. The ability to make direct statistical comparisons between the two surgical groups was also a limitation of sample size and may be an area for future research. Furthermore, this study elected to utilize a 12-month follow-up period due to data availability. Future studies with prospective designs and larger sample sizes are warranted to better understand the use of these techniques in advanced glaucoma.

Conclusion

Our findings suggest that both XEN implantation and GATT, in combination with cataract surgery, may be reasonable management options when treating patients with advanced OAG. Studies with sample sizes large enough to make a direct statistical comparison between these techniques should be done. This will further improve our understanding and guide our treatment for patients with advanced OAG.

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