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Recent Advances in the Surgical Management of Glaucoma in Exfoliation Syndrome

Mohamed S. Sayed, M.D. and Richard K. Lee, M.D., Ph.D.

Bascom Palmer Eye Institute, University of Miami Miller School of Medicine

Abstract

Surgical and laser procedures traditionally employed in the management of exfoliation glaucoma (XFG) include laser trabeculoplasty, trabeculectomy, and glaucoma drainage implant surgery. Having demonstrated similar safety and efficacy in XFG compared to primary open-angle glaucoma, trabeculectomy remains the most commonly performed surgery in XFG. Recent trends in practice patterns in developed nations demonstrate a shift towards glaucoma drainage implant surgery, which is currently the procedure of choice in XFG for many, particularly in developed nations. Additionally, cataract surgery alone may significantly decrease intraocular pressure in patients with XFG, may prevent glaucoma development in patients with exfoliation syndrome, and is recommended to be performed early in the course of the disease. With the relatively recent introduction of non-penetrating glaucoma surgery and the ongoing evolution of minimally invasive glaucoma surgery (MIGS), several other surgical procedures have now become part of the glaucoma surgeon's armamentarium when treating XFG, including the Ex-PRESSTM shunt, deep sclerectomy, viscocanalostomy, trabectome, as well as angle procedures. These techniques have demonstrated promising results in various types of glaucoma. More research is, however, needed to establish the safety and efficacy of these procedures in XFG.

Keywords

Minimally invasive glaucoma surgery (MIGS); glaucoma surgery; exfoliation glaucoma; pseudoexfoliation glaucoma

Exfoliation syndrome (XFS) is the most common identifiable cause of open-angle glaucoma in the world.¹ Exfoliation glaucoma (XFG) generally runs a more rapidly progressive course than does primary open-angle glaucoma (POAG), with more aggressive and severe intraocular pressure (IOP) elevation, IOP fluctuation, visual field constriction, and optic nerve head cupping at the time of diagnosis.^{2–4} Moreover, XFG appears to be more resistant to medical therapy, with a more short-lived response and higher failure rates.^{2, 5–9} A

Corresponding Author: Richard K. Lee, M.D., Ph.D., Walter G. Ross Distinguished Chair in Ophthalmic Research, Associate Professor of Ophthalmology, Cell Biology, and Neuroscience, Bascom Palmer Eye Institute, Department of Ophthalmology, University of Miami Miller School of Medicine, 900 NW 17th Street, Miami, FL 33136, Phone: (305) 326-6400, rlee@med.miami.edu.

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significant proportion of XFG patients, therefore, require surgical intervention to control glaucoma early on in the course of the disease.^{10, 11}

Surgical management of XFG, like that of POAG, has traditionally included laser trabeculoplasty, filtering surgery, and glaucoma drainage implant (GDI) surgery. With the recent advances in minimally invasive glaucoma surgery (MIGS), more surgical options have now become part of the glaucoma surgeon's armamentarium in managing XFG. In this review article, we review the utility, indications, and results of the different surgical techniques in managing XFG, explore the traditional surgical approaches in XFG, but also expand on the relatively newer surgical procedures, including non-penetrating surgery and MIGS, in XFG.

Traditional Surgical Approaches

Laser treatment of the trabecular meshwork with argon laser (argon laser trabeculoplasty; ALT) and, more recently, Nd:YAG laser (selective laser trabeculoplasty; SLT) have gained popularity as adjuncts to medical therapy or as primary treatment for glaucoma. It is not completely understood how laser trabeculoplasty achieves its IOP-lowering effect, but mechanical, biochemical, and cellular modification effects have been theorized to play a role.^{12,13}

Argon laser trabeculoplasty (ALT) has been shown to induce significant initial IOP reduction in patients with XFG that is, however, relatively short-lived, with substantial failure rates on long-term follow up that occur at faster rates than in POAG.^{14–16} Sudden rises in IOP to as high as 40 mmHg after about 2 years from the time of ALT were noted in some patients with XFG and it was hypothesized that continued liberation of pigment and exfoliation material overwhelmed a meshwork now compromised by damage from the ALT. It was found that the use of 2% pilocarpine at bedtime only produced a 3 mm nonreactive pupil for 24 hours, preventing iridolenticular contact and in turn, the sudden late rises in IOP, increasing the duration of success of ALT in eyes with XFG.¹⁴ SLT has largely replaced ALT in many ophthalmic centers, with reported cumulative long-term success rates of 74% and 77% in one prospective, non-randomized study in XFG and POAG, respectively.¹⁷ Another prospective, non-randomized study, however, reported statistically significant differences in success rates between XFG and POAG (27% versus 50%, respectively) after 6 months following 270-degrees SLT. We feel that laser trabeculoplasty can be successfully employed in the management of XFG as a temporizing measure until it fails to adequately control IOP or until definitive glaucoma surgery is undertaken.

Penetrating filtering surgery, i.e., trabeculectomy, is currently the most commonly performed incisional surgical procedure for glaucoma that is uncontrolled on maximal medical treatment, although a shift in practice patterns is currently taking place, with an accelerating trend to utilize tube shunts more often in developed nations.^{18, 19} Although conflicting evidence exists with regards to the response of XFG to trabeculectomy without anti-fibrotic agent augmentation compared with POAG,^{20, 21} XFG was found to have similar long-term IOP lowering effect and complication rates to those of POAG with trabeculectomy augmented by anti-metabolites.^{22–24}

To our knowledge, no studies to date have specifically evaluated the response of XFG to GDI surgery. The Tube Versus Trabeculectomy (TVT) study showed that tube shunt surgery had a higher success rate, lower early postoperative complications, and similar late postoperative complication rates compared with trabeculectomy in the study cohort.²⁵ However, the study included a minority of patients with XFG (4%), and glaucoma type subgroup analysis was not performed. Also, no studies compare valved versus non-valved GDIs in XFG. Two randomized controlled trials, the Ahmed versus Baerveldt (AVB) and the Ahmed-Baerveldt Comparison (ABC) studies, compared Ahmed (valved) and Baerveldt (non-valved) implants in different types of glaucoma. The results of both trials suggest that the Baerveldt implant lowers IOP to a greater degree than does the Ahmed implant, but at the risk of a higher complication rate. The number of XFG cases was not reported in either study, neither was glaucoma type subset analysis included. In the experience of the authors of this review, the Baerveldt implant has commendable success rates in XFG with a good safety profile, and is currently their surgical procedure of choice for patients with XFG.^{26, 27}

Of note, cataract surgery alone has been shown to induce a greater IOP lowering effect in XFG and XFS than in controls with POAG or without glaucoma.²⁸ IOP reduction in exfoliation patients following cataract has been reported to be in the range of 4–5 mmHg.^{29, 30} This may be attributed to anterior chamber (AC) deepening effect of cataract extraction and subsequent widening of the drainage angle. Such effects of cataract surgery may not be applicable to patients with advanced exfoliation or those with uncontrolled IOP falling well outside intraocular (IOP) target range prior to surgery, who may experience very high pressures that are often sustained following cataract surgery. Moreover, cataract surgery may reduce the risk of developing glaucoma in patients with XFS.³¹ The authors of this review therefore recommend that cataract surgery be performed sooner than later in XFS, contrary to the prevailing notion that cataract surgery should be delayed until absolutely necessary. Earlier cataract surgery in XFS eyes may also decrease the risk of complications from zonular weakness and lens prolapse during cataract surgery.

The Ex-PRESS™ Shunt

The Ex-PRESS™ shunt (Alcon Laboratories Inc., Fort Worth, TX) is a miniature, non-valved, biocompatible metallic device implanted *ab externo* to drain aqueous into the subconjunctival space.³² This shunt was designed to provide a safe, minimally invasive alternative to trabeculectomy. The original technique involved inserting the implant at the limbus under the conjunctiva. Due to the complications encountered during the initial experience with this implant, such as extrusion, erosion, and hypotony,^{33–37} this technique was soon altered for the safer implantation under a trabeculectomy-style partial-thickness scleral flap.³⁸ Contrary to trabeculectomy which involves iridectomy and sclerectomy by means of punch or manual corneal or trabecular block excision, no tissue excision is performed as part of the Ex-PRESS™ shunt implantation procedure. The Ex-PRESS™ shunt also provides the theoretical advantage of uniform filtration, given the fixed diameter of the internal lumen of the implant (50 or 200 µm), which may contribute to the consistency and standardization of the procedure. Implantation of the Ex-PRESS™ shunt can be performed with or without simultaneous cataract extraction. Mitomycin-C (MMC) can be

used intraoperatively in the subconjunctival pocket, under the scleral flap, or both at the surgeon's discretion.

The indications of the Ex-PRESS™ shunt are generally similar to those of trabeculectomy, except in cases in which shallow AC depth and filtration angle width do not allow safe implantation of the shunt.

The Ex-PRESS™ shunt was found to have similar IOP-lowering efficacy and fewer complications, including postoperative hypotony, compared with trabeculectomy in different types of glaucoma in numerous studies.^{39–43} The eye is thought to be generally less inflamed following Ex-PRESS™ shunt implantation in comparison with trabeculectomy, putatively due to the lower concentration of transforming growth factors,⁴⁴ lack of iridectomy, and decreased tissue manipulation. This may be relevant in eyes with XFS and XFG, in which more intense and prolonged post-operative inflammation is often a prominent feature.⁴⁵

The Ex-PRESS™ versus trabeculectomy (XVT) study, a multicenter, randomized prospective comparative trial, compared the results of the Ex-PRESS™ shunt (59 eyes) with those of trabeculectomy (61 eyes) over a two-year follow up period.⁴⁶ The study population included patients with POAG, XFG, and pigmentary glaucoma. Mean IOP was significantly lower compared with baseline in both groups ($p < 0.001$). Average IOP and number of medications were similar in both groups during follow-up, with mean intraocular pressure at 2 years after surgery of 14.7 ± 4.6 mmHg and 14.6 ± 7.1 mm Hg in the Ex-PRESS™ and trabeculectomy groups, respectively ($p = 0.927$). The success rate (defined as 5 mmHg IOP ≥ 18 mmHg) was 83% and 79% in the Ex-PRESS™ and trabeculectomy groups, respectively, at 2 years post-operatively ($p = 0.563$). The total number of post-operative complications was higher after trabeculectomy compared with Ex-PRESS™ shunt implantation ($p = 0.013$). The number of eyes with XFG was 5 in the Ex-PRESS™ group and 4 in the trabeculectomy group. Glaucoma type subset analysis was not performed.

The Complications Postoperatively of Ex-PRESS versus Trabeculectomy Study (CPETS) is another recent randomized clinical trial that examines early post-operative complications between trabeculectomy and Ex-PRESS™ implantation in patients with POAG (39 eyes) and XFG (25 eyes).⁴⁷ Frequency of Ex-PRESS™ tube-iris contact was also evaluated. Post-operative AC inflammation and hyphema were significantly more frequent in the trabeculectomy group ($p < 0.05$). The Ex-PRESS™ group had a significantly shorter duration during which the AC remained open during surgery ($p = 0.0002$), which may be responsible, in part, for the lower incidence of early post-operative inflammation and hyphema. Glaucoma type subset analysis was not performed, although iris contact with the Ex-PRESS™ tube occurred more frequently in eyes with POAG and a shallower AC.

The authors of this review feel that although current evidence suggests that the Ex-PRESS™ shunt may have similar efficacy and safety profiles compared with trabeculectomy, the additional cost of the implant may, however, limit its widespread use by glaucoma surgeons. Moreover, the evidence of the utility of the procedure in XFG in particular is lacking, and more high-quality studies are needed to establish its role in XFG.

Deep sclerectomy

Deep sclerectomy is a non-penetrating filtering glaucoma surgery that has become an alternative to trabeculectomy for some glaucoma specialists. The surgical technique involves creating superficial and deep scleral flaps, dissecting the deeper flap, and unroofing Schlemm's canal. The procedure may be combined with laser goniopuncture or an implant laid or sutured onto the scleral bed to enhance efficacy. The procedure had acceptable success rates and commendable safety profile on long-term follow up compared with trabeculectomy in eyes with POAG and other types of glaucoma.^{48–50}

Preliminary safety and efficacy data of deep sclerectomy in XFG are encouraging. Rekonen and colleagues reported no statistically significant difference between deep sclerectomy in 31 eyes with POAG and 38 eyes with XFG on 18-month follow up in a retrospective analysis, with qualified success rates (defined as IOP ≤ 21 mmHg with or without additional topical therapy) of 83.1% and 71.6% in POAG and XFG, respectively.⁵¹ No statistically significant difference in the number of complications or the need for postoperative glaucoma medications was observed. In a prospective study, deep sclerectomy with implant was compared in 27 eyes with advanced POAG and 28 eyes with advanced XFG with regards to complete success (defined as IOP < 19 mmHg on no glaucoma therapy) for a mean follow up of 43 months and 45 months in POAG and XFG, respectively.⁵² At last follow up, 55% of XFG eyes were complete successes compared with 33% of POAG eyes, a difference that was not statistically significant. However, patients with XFG were found to have a higher rate of success over time than POAG patients on statistical survival analysis controlled for covariates ($p=0.014$).

Taken together, data from these studies suggest that deep sclerectomy may be effective and safe in XFG. The authors believe that more studies, including high-quality randomized controlled trials (RCTs), comparing deep sclerectomy to surgical techniques with proven safety and efficacy in XFG, such as trabeculectomy and GDI surgery, are needed to establish the role of the procedure in management of XFG.

Viscocanalostomy

Viscocanalostomy, like deep sclerectomy, is a non-penetrating filtering surgery that was developed in an attempt to avoid complications inherent to trabeculectomy, such as filtering blebs or the use of anti-metabolites. The procedure involves creating a trabecular-Descemet's membrane window to remove the inner wall of Schlemm's canal with the injection of a high viscosity ophthalmic viscoelastic device (OVD) into the canal using a delicate cannula.⁵³ The procedure allows for aqueous egress through the window into the sub-scleral space, in addition to breaking tissue attachments that might be present in the lumen of Schlemm's canal.

Viscocanalostomy demonstrated encouraging long-term IOP reduction and low complication rates in POAG in various reports.^{53–56} Wishart *et al.* compared in a prospective study the results of viscocanalostomy with and without phacoemulsification in 278 eyes with POAG and 36 eyes with XFG with regards to IOP control (complete success defined as IOP ≤ 18

mmHg) and the need for laser goniopuncture (if IOP exceeded 21 mmHg) with a mean follow up of 5 years (range 2–9).⁵⁷ Complete success rates at final follow up and mean IOP reduction rates in all study groups are summarized in Table 1. No significant difference was observed in the outcome of standalone viscocanalostomy compared to viscocanalostomy combined with phacoemulsification in POAG. Success rate of XFG eyes that underwent phacoemulsification combined with viscocanalostomy was 100% at 3 years, although 100% of XFG eyes that underwent viscocanalostomy without cataract surgery failed at 3 years, if YAG goniopuncture was not also performed, suggesting possible postoperative blockage of the outflow window of viscocanalostomy due to the continued production of exfoliation material in the AC in XFG eyes. Laser goniopuncture raised success rates of XFG eyes that underwent viscocanalostomy alone to 92%. The authors concluded that laser goniopuncture was necessary for long-term success of standalone viscocanalostomy in XFG.

In another prospective, non-comparative study, Hassan and Awadalla reported the results of combined phacoemulsification and viscocanalostomy in 30 consecutive eyes of 22 patients with XFG with a mean follow up of 18.6±6.2 months (range 12–36).⁵⁸ A decrease in mean IOP from 25.3±5.2 mmHg preoperatively to 12.3±3.1 mmHg at final follow up was observed ($p<0.05$). Complete success (defined as IOP<21 mmHg without medications) was achieved in 90%, and qualified success (defined as IOP <21 mmHg with or without glaucoma medication) was achieved in 100% of eyes (only three eyes (10%) required a single medication to achieve an IOP of 21 mmHg). Complications included Descemet's membrane micro- and macro-perforations (13.3% and 3.3%, respectively), zonular dehiscence (6.6%), and transient post-operative pressure spikes (3.3%). The authors concluded that phacoemulsification combined with viscocanalostomy achieved excellent IOP control with a low complication rate. The authors compared the results of combined phacoemulsification and viscocanalostomy in XFG to POAG with a mean follow up of 19.7 months (range 12–36) in a subsequent report,⁵⁹ and found greater IOP reduction in eyes with XFG than in those with POAG that was statistically significant at final follow up ($p<0.05$).

The results of viscocanalostomy were compared with those of penetrating filtering surgery in eyes with XFG and other types of glaucoma. In a two-year randomized controlled trial,⁶⁰ Carassa and colleagues compared the results of viscocanalostomy with those of trabeculectomy without anti-metabolites in 50 eyes with uncontrolled XFG or POAG, although post-operative 5-fluorouracil (5-FU) injections and laser suture lysis were allowed in the trabeculectomy group. Success rates (defined as IOP ≤ 21 mmHg with no additional medications and at least a 20% reduction in IOP) were 76% and 80% in the viscocanalostomy and trabeculectomy groups at final follow up, respectively ($P=0.60$). However, only 56% and 72% of eyes had an IOP of ≤ 16 mmHg at final follow up, respectively ($P=0.17$). IOP reduction was similar at final follow up in both groups. No subgroup analysis was done to compare XFG and POAG in this study.

A meta-analysis comparing safety and/or efficacy of viscocanalostomy and trabeculectomy in uncontrolled glaucoma included 10 RCTs with a total of 458 eyes of 397 patients for a follow up period ranging from 6 months to 4 years.⁶¹ Seventy-five eyes (16.4%) had secondary open angle glaucoma, although the number of eyes with XFG was not reported. At all follow up end points, the efficacy of trabeculectomy in lowering IOP consistently

surpassed that of viscocanalostomy in all sub-group analyses with high statistical significance, even in studies that allowed post-viscocanalostomy laser goniopuncture. No glaucoma type subset analysis was performed in this meta-analysis.

A Cochrane review of RCTs and quasi- RCTs comparing nonpenetrating surgery (specifically viscocanalostomy or deep sclerectomy) and trabeculectomy for open-angle glaucoma concluded some evidence exists that IOP control is better with trabeculectomy than with viscocanalostomy.⁶² However, no useful conclusions could be drawn for deep sclerectomy. Such conclusions could reflect the technical difficulties and surgical expertise needed to perform these non-penetrating procedures. Limited data was provided in the review on XFG, and glaucoma type sub-group analysis was not included. The review also determined that the studies were mostly at high risk of bias and lacked methodological quality, and that more RCTs addressing quality of life outcomes need to be undertaken, since better IOP control is unlikely with non-penetrating glaucoma surgery.

Ab interno Trabeculectomy

The Trabectome (Neomedix Corp., Tustin, CA) is a thermal cautery device utilizing focused electrosurgical pulses used to perform a procedure referred to as *ab interno* trabeculectomy, where a segment of the trabecular meshwork and Schlemm's canal is ablated under direct visualization using a gonioscopy lens, with concurrent continuous irrigation to remove debris. The trabectome may be performed simultaneously with cataract extraction. The procedure has demonstrated safety and efficacy in primary and secondary open angle glaucomas.^{63, 64} Jordan *et al.* reported the results of the Trabectome procedure in POAG and XFG in a single center, prospective observational study.⁶⁵ The study included 173 eyes with XFG, with a mean follow up of 200 ± 278 days. Trabectome surgery was performed either alone or combined with cataract surgery. IOP was reduced from 25 ± 5.9 mmHg pre-operatively to 18 ± 8.2 mmHg at final follow up, and medications were reduced from 2.0 ± 1.2 to 1.1 ± 1.1 . Trabectome surgery combined with simultaneous cataract extraction and intraocular lens implantation demonstrated superior IOP lowering effect compared to trabectome surgery alone in either phakic or pseudophakic eyes. This higher IOP-lowering effect of trabectome combined with cataract surgery might in part be attributed to the effect of cataract surgery alone. This is in agreement with results reported by Ting *et al.* in a prospective, non-randomized cohort study to compare the Trabectome procedure either alone or combined with cataract surgery in POAG and XFG.⁶⁶ In the trabectome only group, the mean decrease in IOP was 12.3 ± 8 mmHg in XFG and 7.5 ± 7.4 mmHg in POAG at 1 year ($p < 0.01$). The cumulative probability of success was 79.1% and 62.9%, respectively ($p = .004$). In the combined trabectome and cataract surgery group, the mean decrease in IOP was 7.2 ± 7.7 mmHg in XFG and 4.1 ± 4.6 mmHg in POAG at 1 year ($p < 0.01$). The cumulative probability of success was 86.7% and 91.0% ($p = .73$), respectively. The authors concluded that the Trabectome procedure effectively lowered IOP to the mid-teens, with an overall greater reduction in XFG and improved success when combined with cataract surgery.

Klamann *et al.* compared the IOP-lowering effect of combined Trabectome and cataract extraction (27 eyes) to that of combined trabecular aspiration-cataract extraction (28 eyes)

over a period of 1 year in a retrospective, comparative cohort outcome study.⁶⁷ In both groups, post-operative IOP during the entire follow up period was significantly decreased. A statistically significant lower IOP in the Trabectome group at 1 day ($p=0.019$), 6 months ($p=0.025$), and 1 year ($p=0.019$) after surgery was observed. No statistically significant difference in the number of anti-glaucoma eyedrops between the two groups was observed at any time. Widder *et al.* evaluated the IOP-lowering potential in XFG of a triple procedure consisting of cataract surgery, Trabectome, and trabecular aspiration.⁶⁸ The triple procedure was significantly more effective in lowering IOP compared with combined trabecular aspiration-cataract extraction out to one year post-operatively ($p<0.004$). However, it is highly possible that the IOP-lowering effect of trabecular aspiration may regress after 1 year, and evidence of efficacy of the procedure on long-term follow-up is currently lacking.

Other Minimally Invasive Glaucoma Surgeries (MIGS)

The iStent (Glaukos, Laguna Hills, CA) is a small titanium implant that is placed through the trabecular meshwork to allow aqueous to follow from the anterior chamber into Schlemm's canal. The device is Food and Drug Administration (FDA) approved to be implanted in combination with cataract surgery but may be used off-label in a standalone fashion. The US iStent Study Group reported in a randomized, controlled multicenter trial the results of iStent implantation in combination with cataract surgery (117 treatment eyes) compared with cataract surgery alone (123 control eyes) in mild to moderate open-angle glaucoma.⁶⁹ Only 111 out of the 117 eyes randomized to iStent and cataract surgery underwent iStent implantation, with failure of implantation in the remaining 6 subjects because of complications of cataract surgery (4 eyes), inability to implant a stent (1 eye), or termination from the study before undergoing treatment (1 eye). A total of 14 eyes (6%) of the study population had XFG, although the number of XFG eyes in each group was not reported. Seventy-two percent of treatment eyes versus 50% of control eyes achieved the primary outcome measure of IOP ≤ 21 mmHg with no supplementary glaucoma medications at 1 year ($p<0.001$). Sixty-six percent of treatment eyes versus 48% of control eyes achieved 20% IOP reduction without medication ($p=0.003$). There were no unanticipated adverse device effects due to iStent implantation, and the incidence of adverse events was similar in both groups.

Klamann *et al.* reported in a retrospective cohort study the efficacy and adverse event outcomes of standalone iStent implantation in 35 consecutive patients with different open-angle glaucoma subtypes (POAG $n=17$; XFG $n=15$; pigmentary glaucoma $n=3$). The mean IOP in the XFG group at 6 months was 15.33 ± 1.07 mmHg with an average decrease of 35% from baseline ($p<0.001$). However, IOP was significantly lower in the POAG group compared with the XFG group 3 and 6 months after iStent implantation, even after adjusting for pre-operative IOP ($p<0.05$ and $p<0.05$, respectively). No difference in the number of medications being used was present at any follow-up visit between both groups. The most common complication in the entire cohort was intraoperative blood reflux which resolved, but neither early postoperative hypotony nor IOP spikes were observed in the POAG or the XFG groups. The authors concluded that implantation of the iStent can lower the postoperative IOP significantly in POAG and XFG after a short follow-up of 6 months with a favorable risk profile.

Trabeculotomy by internal approach has also been gaining popularity as a minimally invasive technique in open-angle glaucoma. Ab externo trabeculotomy has traditionally been performed in cases of childhood glaucoma, with higher failure rates reported in adult-onset glaucoma.⁷⁰ The lower long-term success rates in adult-onset glaucomas might be related to the fact that adult angle tissue has thicker trabecular beams with less elastic tissue which may explain why the severed ends of the trabecular meshwork are more likely to fold back into their original position and scar together following angle-based procedures, with subsequent rise in IOP.^{71–73} This in theory can be overcome by more complete removal of the trabecular meshwork or by means of cleaving the trabecular meshwork and opening the Schlemm's canal for the entire 360 degrees.

The Kahook Dual Blade (KDB; New World Medical, Inc., Rancho Cucamonga, CA), gonioscopy-assisted transluminal trabeculotomy (GATT) using either iTrack microcatheter (Ellex Medical Lasers, Adelaide, Australia) or a polypropylene suture, and the TRAB360™ device (Sight Sciences, Menlo Park, CA) are potential procedures that rely on this concept. The inherent characteristics of the new trabecular-based MIGS procedures, particularly the feasibility of combining the procedures with cataract surgery without violating the conjunctiva or sclera, have rendered these procedures popular in today's glaucoma practice. Preliminary data of these procedures show promising results in pre-clinical and clinical results.^{74–76} However, only a small number of XFG patients were included in these initial studies, and more research, including randomized controlled trials, is needed to establish the safety and efficacy of these new procedures in XFG and other forms of glaucoma.

Conclusion

With the tremendous recent advances in glaucoma surgical techniques, more basic research and randomized-controlled clinical trials are necessary to shed light onto the role of different surgical interventions in XFG. It is unclear whether the pathophysiology of XFG and the presence of exfoliation material affect the outcomes of many of these different glaucoma surgical techniques. The continuing refinement of these procedures based on our expanding experience and evidence-based knowledge, as well as the innovation of new surgical procedures, particularly in the MIGS arena, afford XFG patients better opportunities for preserving vision on the long run.

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Table 1

Complete success rates at final follow up and mean IOP reduction rates in standalone viscocanalostomy compared with viscocanalostomy and phacoemulsification in POAG and XFG

Complete success rate at final follow up		
	POAG	XFG
Standalone viscocanalostomy	67%	63%
Viscocanalostomy and Phacoemulsification	76%	95%
Mean IOP reduction		
	POAG	XFG
Standalone viscocanalostomy	40%	51%
Viscocanalostomy and Phacoemulsification	29.9%	42.5%

Abbreviations: POAG: primary open angle glaucoma; XFG: exfoliative glaucoma; IOP: intraocular pressure