Primary congenital glaucoma (PCG) is the most common type of primary pediatric glaucoma. The condition is typically bilateral (65 to 80%) and most of them manifest during first year of life. The incidence varies among different ethnicities. In India the prevalence is estimated to be 1 in 3300 live births and accounts for 4.2% of overall childhood blindness.

The basic abnormality in PCG is isolated trabeculodysgenesis or goniodygenesis - a developmental arrest with failure of the uveal tissue to migrate posteriorly. This uveal tissue blocks the drainage of aqueous through the underlying trabecular meshwork leading to a rise in intraocular pressure. The primary aim of most glaucoma surgeries for PCG is to remove this blockade and create an adequately draining pathway to the aqueous.

Medical management is useful for temporary control of IOP, to reduce corneal edema before surgery and post operatively when surgery fails to control IOP completely. Surgery is the definitive and effective form of treatment in congenital glaucoma. The aim of surgical therapy is to remove this obstruction, restoring the access of aqueous to Schlemm's canal thus maintaining the physiological outflow.

Various surgical options are available in the treatment of PCG. They include angle surgeries like goniotomy, trabeculotomy (manual, 360° suture or microcatheter assisted); filtration surgeries like trabeculectomy, combined trabeculotomy with trabeculectomy with or without anti-metabolites; glaucoma drainage devices, and cyclodestructive procedures. Goniotomy, ab externo trabeculotomy, combined trabeculotomy with trabeculectomy with or without mitomycin - C are the most commonly performed surgeries in the current day glaucoma practice.

Although most surgeons across the country perform combined trabeculectomy – trabeculotomy surgery combined with Mitomycin C, it has been our experience that trabeculectomy hardly works in infants due to excessive fibrosis and we rarely see a well formed bleb in these patients after trabeculectomy. Hence a well done trabeculotomy may be sufficient for children presenting before 2 years of age without the need for adding trabeculectomy and exposing the eye to the toxic effects of mitomycin C. In conventional trabeculotomy we only treat 90-120 degrees of the angle and therefore we started this technique at our centre with the aim of performing a 360 degrees trabeculotomy.

**Principle of common glaucoma surgeries**

Goniotomy involves cleaving the angle under gonioscopic visualization to restore the outflow. However, it requires...
a clear cornea for proper visualization of angle structures. Most of our patients present with corneal changes, also reported to be high (>80%) in a study from our centre. Therefore, goniotomy is often not a feasible option in our scenario.

The goal of trabeculectomy is to increase the outflow by clearing the site of greatest resistance i.e., the inner wall of Schlemm’s canal and adjacent trabecular meshwork. Conventional ab – externo trabeculectomy involves the use of a rigid instrument (Harms trabeculotome) to tear through the trabecular meshwork for approximately 100 to 120 degrees of the angle. Complications reported include hyphema, inadvertent filtering blebs, choroidal detachment, iridodialysis, lens damage, creation of false passage into the anterior chamber or suprachoroidal space.

The technique of 360 degree trabeculectomy using suture material was first described by Smith in 1962 on cadaver eyes. The technique was refined by Beck and Lynch using 6-0 polypropylene and reported a success rate of 87%.

Combined trabeculotomy- trabeculectomy with or without antimetabolites like mitomycin-C (MMC) is considered the standard therapy for treatment of PCG. This procedure is reported to have higher long term success than either procedure separately. Reported complications include those related to the filtering bleb and use of MMC like excessive filtration, failure, leak and bleb related infections.

**Principle of Illuminated microcatheter assisted circumferential trabeculotomy (IMCT)**

To overcome the problems associated with rigid instrumentation, bleb formation and mitomycin use, a new technique of illuminated microcatheter assisted circumferential trabeculotomy has been advocated. It involves the use of an illuminated microcatheter to catheterize the whole circumference of the Schlemm’s canal and 360° trabeculotomy is performed. This flexible microcatheter has a LED source at its atraumatic tip that allows visualization of the catheter through the limbus transsclerally to verify proper placement. This greatly reduces the chances of inadvertent false passages. Currently two illuminated microcatheters are in use i.e., Glaucolight (DORC- Dutch Ophthalmic Research Centre International, The Netherlands) and the iTRACK 250A (iScience Interventional, Menlo Park, CA). These microcatheters were initially introduced for performing canaloplasty, a surgical option in the treatment of primary open angle glaucoma in adults. Glaucolight microcatheter (used by us) is a light fiber based device with an integrated (battery powered) LED source and an atraumatic tip-design for a smooth transfer through the Schlemm’s canal. The bright LED illuminated fiber tip helps to visualize the position of the fiberoptic tip during 360 degree Schlemm’s canal passage. It has a 40G/0, 150 micron diameter for minimally invasive surgery and flexibility for 360 degree catheterization of the Schlemm’s canal.

**Illuminated microcatheter assisted circumferential trabeculotomy - Technique**

The procedure is performed under general anesthesia.

**Steps**

1. A 5mm superonasal conjunctival peritomy is made followed by creation of a superficial scleral flap of 4.0mm x 4.0mm (Figure 2).
2. A deep scleral flap is made to identify and deroof the Schlemm’s canal (Figure 3).
3. The microcatheter is introduced into the Schlemm’s canal (Figure 4) and advanced through the whole...
5. Paracentesis is performed to ensure low IOP before performing trabeculotomy.

6. If a successful complete 360° catheterization is achieved (Figure 7) the two ends of the catheter are pulled in opposite directions like a purse-string, breaking through the trabecular meshwork to perform a 360° trabeculotomy (Figure 8).

7. The closure of the scleral flap is done with 10-0 MFN suture to ensure a water tight seal that would prevent formation of an inadvertent filtering bleb (Figure 9).

8. Peritomy is closed with 8-0 vicryl followed by subconjunctival injection of antibiotic and steroid.

Postoperative management
In the postoperative period, a topical cycloplegic is given along with steroid – antibiotic combination in tapering doses over 6-8 weeks.

Intraoperative problems - What can go wrong and how to manage?
Failure of complete catheterization can occur due to misdirection of the microcatheter into a collector channel (Figure 10), or obstruction within the Schlemm’s canal (Figure 11). In case of misdirection, slight manipulation of the microcatheter can be done to redirect it into the Schlemm’s canal. In case of obstruction, the catheter can be passed from other side of Schlemm’s canal or conjunctiva at the site of obstruction can be incised and a
scleral cut down is made over the tip of microcatheter, the tip is grasped and an attempt is made to recannulate the canal. Viscoelastic can also be used in cases of obstruction to open the canal by injecting the viscoelastic through a special cannula provided for such purpose. Failure to achieve a circumferential (360°) catheterization is dealt by converting the procedure into conventional trabeculotomy using a Harms trabeculotome (Figure 12).

In rare instances, iris prolapse can occur after trabeculotomy which can be managed by gently repositing the iris and tightly suturing the sclera flaps (Figure 13).

**Past studies on IMCT – a review**

Studies in the literature have evaluated the surgical effectiveness of this procedure in treatment of congenital glaucomas; however there are no prospective studies.

Sarkisian\textsuperscript{23} conducted retrospective consecutive case series study in 16 eyes of 10 patients of PCG and found that 75% achieved a complete 360° trabeculotomy using microcatheter; whereas 25% achieved a partial trabeculotomy. The postoperative reduction in IOP from baseline was statistically significant at the 1-, 3-, and 6-month follow-up visits (p≤0.001). At 6 months, IOP was significantly lower in the complete as compared to the partial trabeculotomy cohort (p=0.03) with average of 47% reduction in IOP at 6months. Average medication use was not significantly reduced from baseline at any interval (p=0.37 at 6months). Of the reported complications there were 7 cases (43.8%) of transient hyphema. Secondary surgical procedures for control of IOP were performed in 12.5% eyes. Girkin et al\textsuperscript{24} conducted a retrospective chart study in a heterogenous population of congenital/juvenile glaucoma in 11 eyes of 7 patients using IMCT. Mean IOP
(mm Hg) was reduced from 33.8 ± 6.3 preoperatively to 18.3 ± 3.5 at the final postoperative visit (P-value<0.001). A qualified success was seen in 90.1% of eyes and an unqualified success in 81.8%. Transient hyphema was seen in all cases but no long-term surgical complications were seen. Girkin, Rhodes et al\textsuperscript{25} compared goniotomy with illuminated microcatheter trabeculotomy in 24 eyes of 20 patients. Microcatheter-assisted circumferential trabeculotomy demonstrated a 91.6% qualified and 83.3% unqualified success rate with 12-month follow-up that exceeded the 53.8% qualified and 46.2% unqualified success rate of conventional goniotomy. This procedure has also been evaluated in the initial surgical treatment of medically refractory aphakic glaucoma and juvenile open angle glaucoma with promising results and few complications\textsuperscript{26}.

### IMCT - Merits and demerits – comparison with other conventional surgeries

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<thead>
<tr>
<th>Merits</th>
<th>Demerits</th>
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<tr>
<td>Enables precise localisation of catheter; false passage into subretinal/suprachoroidal space averted (possible with manual or suture trabeculotomy)</td>
<td>Technically demanding; steep learning curve</td>
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<tr>
<td>Treats entire circumference of trabecular meshwork (manual trabeculotomy treats the angle partially)</td>
<td>Incidence of hyphema is more (less with other conventional surgeries)</td>
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<td>No bleb/antimetabolite associated complications (possible risk of trabeculectomy - bleb leak, blebitis, bleb fibrosis etc)</td>
<td>Excessive cost</td>
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<td>Post-operative scarring is less (trabeculectomy has more chances of fibrosis)</td>
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<td>Can also be performed in eyes with failed primary surgery like goniotomy or trabeculectomy</td>
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<td>Can be performed in temporal quadrant sparing the superior site for future filtration surgeries if required</td>
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<tr>
<td>Can be performed in hazy corneas unlike suture trabeculotomy which requires gonioscopic verification</td>
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### Our experience in 20 eyes of primary congenital glaucoma

A prospective interventional study was carried out in 20 eyes of 14 patients with PCG aged ≤ 1 years at the time of surgery. Trabeculotomy was performed via an illuminated microcatheter (Glucolight) with intent to perform complete 360\textdegree catheterization. In cases where complete catheterization of the Schlemm’s canal could not be achieved, ab-externo trabeculotomy was performed using a Harms trabeculotome. All patients were followed up for a period of 12 months with examination under anesthesia at 4 weeks, 12 weeks, 24 weeks and 12 months. At the time of presentation, mean IOP was 21.53 ± 8.65 mmHg (on a single topical anti-glaucoma medication), corneal diameters were 13.23 ± 1.52 mm (horizontal) and 12.68
± 1.31 mm (vertical) and vertical cup to disc ratio was 0.75 ± 0.15. Of the 20 eyes, a complete 360° catheterization and circumferential trabeculotomy was achieved in 16 (80%) eyes and a partial catheterization in 4 (20%) eyes with the need of conversion into usual trabeculotomy. Partial catheterization was due to either misdirection of the probe posteriorly into a collector channel (Fig. 11 and 12) or obstruction within the Schlemm’s canal. Mild transient hyphema was found in all eyes. In one eye there was iris prolapse after performing 360° trabeculotomy. No other intraoperative complications were noted. There was 48.28% decrease in IOP (p = 0.003) and 17.5% reversal of cup to disc ratio (p = 0.01) at the end of 12 months follow-up compared to the preoperative values. No postoperative complications were noted during the entire follow-up. Single topical antiglaucoma medication to control IOP was needed in 2 eyes in which partial trabeculotomy was performed. At the end of 12 months follow-up, an absolute success (defined as an IOP < 15 mm Hg) was seen in 92% of eyes and a qualified success (defined as an IOP < 15 mm Hg with the use of topical anti-glaucoma medications) was seen in 100% of eyes. No patients required a second surgery to control IOP at 12 months follow-up. There was no significant change in corneal diameters throughout the follow-up.

**Conclusion**

Circumferential trabeculotomy performed with an illuminated microcatheter is a safe and effective technique to reduce IOP in PCG and can be advocated as a primary procedure in the treatment of primary congenital glaucoma. Further comparative studies are required to evaluate the long-term success and safety of this procedure and to explore its possible role in the treatment of other developmental glaucomas.

**References**