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Indocyanine green aided Schlemm's canal identification during gonioscopic assisted transluminal trabeculotomy

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Abstract

Performing procedures like gonioscopic assisted transluminal trabeculotomy (GATT) in eyes with congenital glaucoma may be difficult many a times due to difficult visualisation of angle structures. Inaccurate identification of angle landmark may lead to various inadvertent surgical complications. Hence, there is a need for techniques to improve visualisation of surgical landmarks during these procedures. In this study, 0.2% indocyanine green (ICG) was used to stain the TM before the surgeon proceeded with GATT. It yielded excellent differentiation of the trabecular meshwork by imparting a bright green hue. This led to successful identification of the site of incision and subsequent 360° cannulation of Schlemm's canal (SC) in 5/5 cases. ICG aided SC identification is helpful in children with congenital glaucoma undergoing angle surgeries, especially in eyes with poor structure differentiation.

Introduction:

Angle surgeries are traditionally considered the first surgical modality for treatment of primary congenital glaucoma (PCG), if the corneal clarity permits gonioscopic angle visualisation. In classical ab-externo trabeculotomy, identification of the Schlemm's canal (SC) is necessary, to ensure proper cannulation and avoid unnecessary complications. The radial incision here is made in the scleral bed after raising a partial thickness scleral flap at the junction of grey and blue zone, ensuring proper placement of the Harm's trabeculotome. On the contrary, in ab-interno angle surgeries, including goniotomy and gonioscopy assisted transluminal trabeculotomy (GATT), the incision is made to deroof trabecular meshwork (TM) at the anterior border of non-pigmented TM, enabling subsequent direct exposure to the SC. Improper placement of the incision may lead to various intra and post-operative complications like iridodialysis, cyclodialysis, anterior chamber (AC) collapse, cannulation

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into the suprachoroidal space or inadequate postoperative lowering of intraocular pressure (IOP).¹

These complications are easier to avoid in adults due to enhanced visibility of the TM, owing to its pigmentation. However, utmost caution is warranted in paediatric subjects, as the TM may not be adequately visible leading to an increased risk of complications. This poor visibility may be the consequence of combination of various factors like poor visibility through hazy corneas secondary to corneal edema or Haab's striae, lack of TM pigmentation, minimal blood reflux into the TM, translucent uveal meshwork, high insertion of iris, altered infantile anatomy in greatly stretched eyes, and presence of a primordial membrane over the TM (Figure 1 A, B). These difficulties, coupled with the risk of perioperative complications and the need for repeat general anaesthesia in children, impair proper identification of the TM and SC in paediatric population. To bypass these problems, some surgeons have even suggested performing GATT in children in a two-step fashion due to difficulty in localising the TM in young eyes.² This is done by performing a nasal goniotomy initially to lower IOP followed by full 360-degree GATT later, when TM is more easily identifiable.

Hence, there is a need for techniques that augment identification of surgical landmarks for ab-interno glaucoma surgeries in children. Herein, we describe a technique to enhance visualisation of the TM using indocyanine green (ICG) dye enabling precise incision placement.

Materials and Methods:

PCG patients requiring surgical intervention to control IOP with cornea clear enough to permit intraoperative gonioscopy manoeuvres were selected for the study. Institutional Ethics committee approval was obtained, and the study was conducted in accordance with the tenets of the Helsinki Declaration. Non-consenting patients, and those with significant corneal clouding precluding the visualisation of TM, were excluded from the study.

Pharmaceutical-grade ICG (Aurogreen, ICG 25 mg, AuroLab India), thoroughly dissolved to 0.2% by adding 0.7 ml of the manufacturer provided sterile solvent followed by 11.2ml of sterile balanced salt solution (BSS), was prepared before starting the surgery. After general anesthesia was provided, aqueous paracentesis was performed followed by ICG dye instillation intracamerally through a standard 1 mm side-port incision, and kept there for 1 minute followed by a thorough AC wash.

Intraoperative gonioscopy following dye instillation revealed band-like staining of both the anterior and the posterior TM with forest green color typical of ICG. It provided the surgeon with a landmark to incise at the junction of the anterior-most layer of the stained zone and the non-stained zone. (Figure 2 A–D).

Results:

Five patients of PCG, with mean age 10.8 months (range: 5 – 18 months, SD: 4.8 months), were recruited in the prospective study. The mean baseline IOP was 30.8mmHg (range:

26– 34 mmHg, SD: 3.63 mmHg). Successful identification of site of goniotomy incision could be done in all the patients, although patchy TM pigmentation was noted in two cases (Figure 2 C–D). All the cases were uneventful, with subsequent successful circumferential cannulation of the SC with a 6–0 polypropylene suture. AC was well formed on the first postoperative day with presence of blood streaking along the treated angle over the iris in two cases, and the cornea did not show any evidence of residual ICG staining. Mild hyphema was seen in two patients on the first postoperative day, which resolved spontaneously by the end of first week. Average IOP at the end of first month was found to be 16.8mmHg (range: 12– 22 mmHg, SD: 4.15 mmHg) with an average IOP reduction of 46.6% from the baseline, which was deemed successful in all the patients, with three patients maintaining a normal IOP off medications, and the final two patients on a single anti-glaucoma medication.

Discussion:

Precise placement of goniotomy incision is paramount not only in achieving optimal IOP reduction but also, in achieving success while performing SC cannulation like during GATT surgeries, where wrong identification of landmark can lead to procedure abortion/failure. Though some reports have suggested manoeuvres to enhance visibility during ab externo glaucoma procedures,^{1,3} there are limited reports for visibility augmentation during ab-interno procedures or the failure rates of TM cannulation. Endoscopes have been used to visualise the SC during GATT.² However they are useful only after successful initial cannulation, providing no benefit in identification of the exact landmark for TM incision at the beginning. As a result, dye enhanced techniques have been tried in the past for enhancing the visibility of TM during endoluminal procedures, however their use still remains limited. Trypan Blue (TB; 0.06%) has been used to stain the TM during microinvasive glaucoma surgery (MIGS), e.g. during iStent implantation.⁴ However, TB gives a dark blue hue, which sometimes makes it difficult to differentiate the stained TM from the darker structures in the angle like the high inserted iris, iris processes, pigments or the goniosynechia. Further, the duration of instillation has also not been standardised to minimise endothelial toxicity. Perhaps due to these reasons, TB aided TM identification, has not been universally adapted by the paediatric glaucoma surgeons as described. On the contrary, the forest green hue of ICG is easily identified in eyes with pigmented or non-pigmented TM alike.

The use of ICG to stain intraocular tissues has been traditionally limited to staining the internal limiting membrane (ILM) during macular hole surgery, and sometimes for capsular staining during phacoemulsification,⁵ and has been found to be non-toxic at concentrations of 0.05 to 0.25%.⁶ 0.5% ICG is equivalent to 0.1% TB with respect to safety and efficacy,⁷ although a lower dose of the former (0.25%) can stain the capsule with similar effectiveness⁸. Capsular staining with ICG has the added advantage of fluorescing in the red part of the visible spectrum, thereby improving the capsular visibility under the red glow with low illumination⁹. It seems that ICG, even if toxic, has effects subtle enough not to produce any significant visual disability. The concentration and duration of ICG used in this study appears to be safe and was selected on the basis of prior published evidence for its safe use for capsular staining during cataract surgery and during aqueous angiography experiments in human eyes undergoing cataract surgery.^{10,11} The characteristic

staining pattern could be the result of TM staining, subsequent to ICG infused aqueous exodus through the active areas. We also noticed asymmetric staining of the TM in some eyes, possibly due to localised TM dysfunction corresponding to unstained areas.¹² The uptake of ICG by the functional TM cells has not been proven yet, and further clinical and histological studies are needed to demonstrate the same. Nevertheless, ICG aided SC identification seems to be especially useful in eyes with congenital glaucoma with difficult angle structure identification, undergoing ab interno surgeries.

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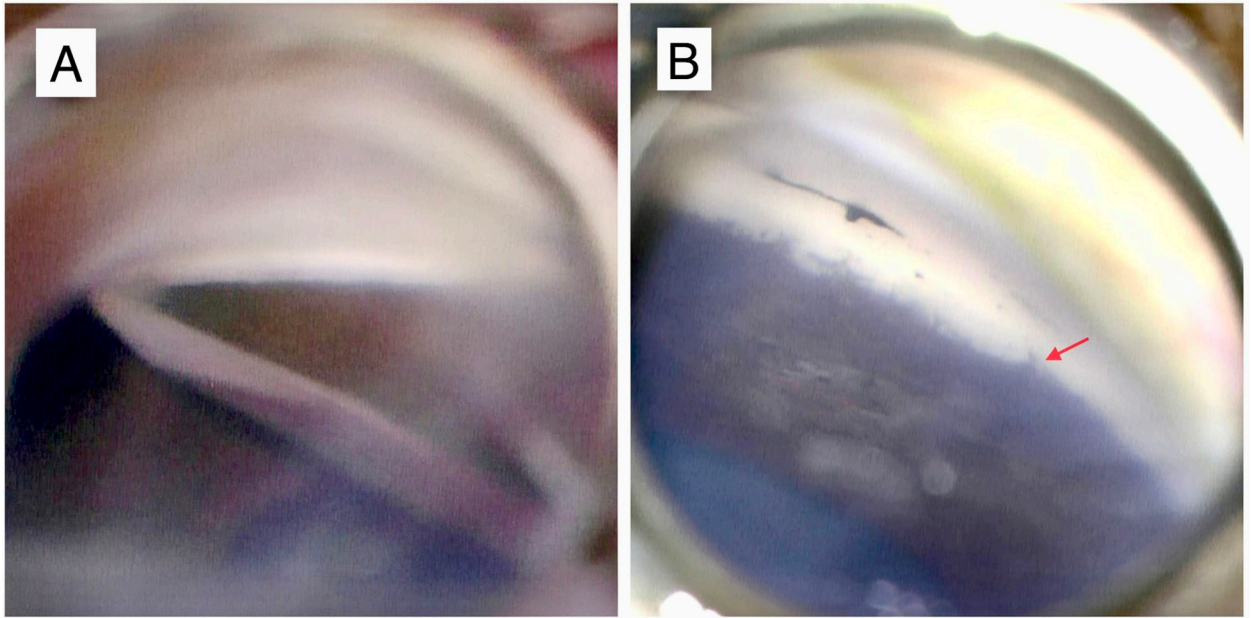


Figure 1:

A: Goniotomy being done in a child with featureless angle making it difficult to identify correct landmark; B: a case of ARS with high iris insertion and large peripheral anterior synechiae (red arrow), making it difficult to identify the correct location.

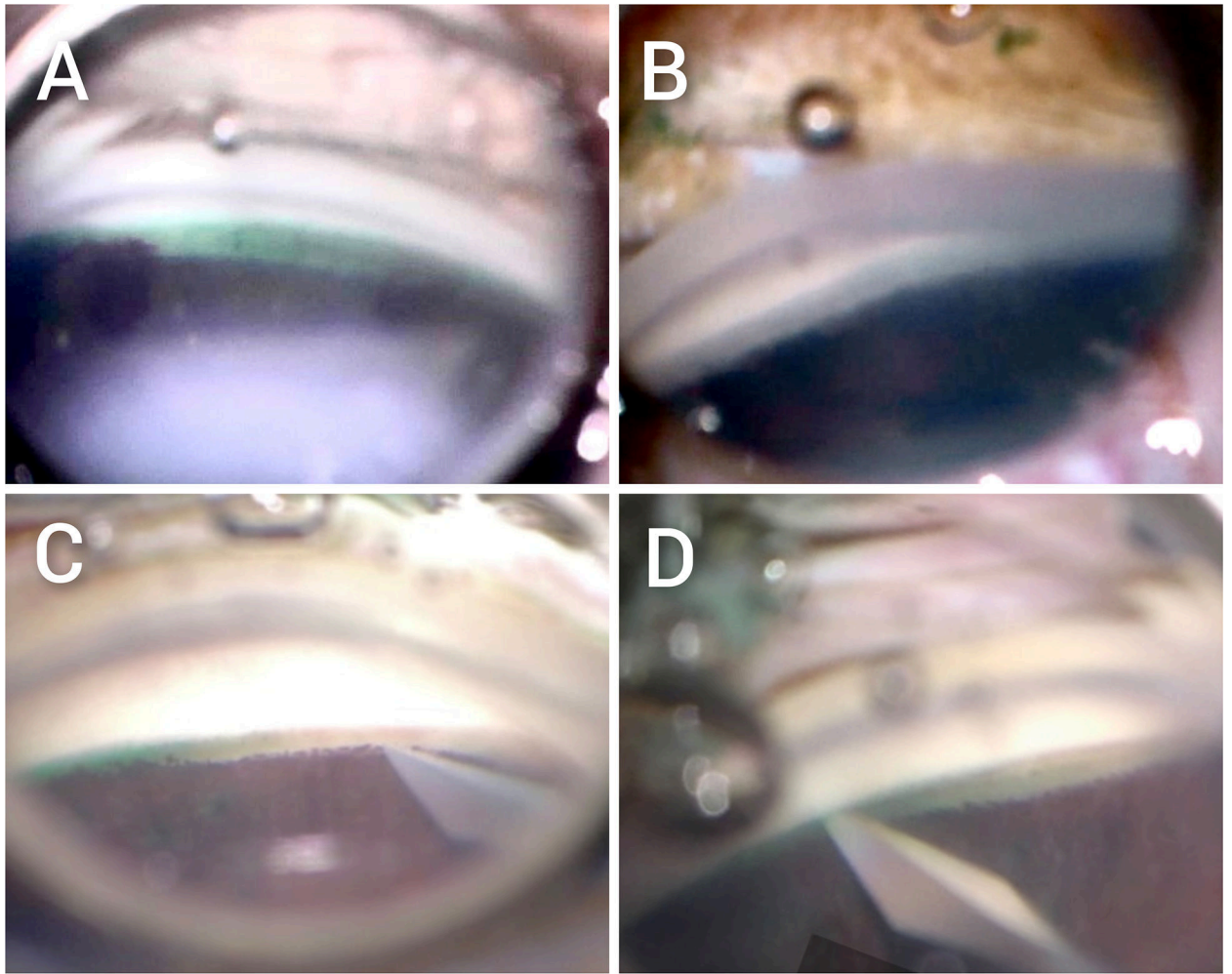


Figure 2:

Gonio-photograph of a 5-month-old child with PCG and central corneal opacity undergoing goniotomy; greenish pigmentation of the TM is visible post staining with ICG (A, white arrow). In another child of PCG with featureless angle and difficult identification of structures, ICG helped us select the correct site for surgical incision at the anterior most part of the pigmented zone (B, black arrow). The TM may be asymmetrically stained, as seen here in an 8-month-old child with PCG undergoing goniotomy (C). Site of goniotomy is just anterior to the stained zone (D). Note that the stained area is well appreciated despite the presence of significant TM pigmentation.