REVIEW

Anterior and Posterior Capsule Staining in Pediatric Cataract Surgery: *Surgical Techniques, Guidelines and Recommendations*

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During the past few years there has been enormous interest in the use of vital dyes to enhance visualization during various steps of ophthalmic surgeries. In this article, we present applications of the two most commonly used dyes, trypan blue and indocyanine green (ICG), for anterior and posterior capsulorhexis in pediatric cataract surgery. We have also provided guidelines and recommendations for ophthalmic surgeons, based on the published experimental and clinical studies.[1-9]

Use of 0.5% indocyanine green and 0.1% trypan blue dye for anterior capsule staining was reported by Horiguchi and Melles.[1,2] A clinical study comparing both dyes was first reported by Chang.[3] Pandey and associates[4-7] extensively studied 3 different types of capsular dyes –2% fluorescein sodium, 0.5% ICG and 0.1% trypan blue for anterior and posterior capsule staining in adult and pediatric cataract surgery. These experimental studies demonstrated that 0.5% indocyanine green and 0.1% trypan blue dyes can be successfully used to stain the posterior lens capsule to enhance visualization while learning and performing posterior capsulorhexis, a technically challenging procedure (Figures 1, 2).[5-7] According to recently published clinical reports, ophthalmic dyes are increasingly being used to facilitate anterior and posterior capsulorhexis during pediatric cataract surgery.[8-10] Staining of the lens epithelial cell using trypan blue dye, to facilitate intraoperative removal during pediatric cataract surgery had also been recently suggested.[11]

Experimental studies using 0.5% indocyanine green and 0.1% trypan blue for staining the posterior capsule, while performing posterior continuous curvilinear capsulorhexis (PCCC) in pediatric eyes, demonstrated that dye-enhanced visualization may help make this difficult maneuver safer (Figures 2).[5] Posterior capsule staining also helps identify presence of posterior capsule tear as shown in Figure 2C.

Availability, Preparation and Cost of the Dyes

Both ICG and trypan blue are not approved by United States Food and Drug Administration for capsular staining. ICG dye is available in USA, being approved for choroidal angiography. However, its labeling issues avert packaging the ICG dye in a smaller, more cost-effective quantity. A 0.1% solution of trypan blue is commercially available in the trade name of VisionBlue® (Dutch Ophthalmic Research Company, Netherlands). The 0.1% Vision Blue® solution is ready for injection requiring no dilution. Preparation of the ICG for capsule staining can be accomplished at the beginning of the surgical day. ICG can be prepared as described by Horiguchi and associates.[1] In brief, one half (0.5cc) milliliters of the provided diluent are mixed with the dry ICG powder. Four and one half (4.5cc) milliliters of balanced salt solution are then added to this and the solution is mixed together. This can be used for multiple cases throughout the surgical day.

Surgical Technique

A 0.5% solution of ICG and 0.1% solution of trypan blue is commonly used to stain anterior or posterior lens capsules. For anterior capsulorhexis, ICG or trypan blue may be used under an air bubble. The posterior capsule staining can be done by instilling 1 microdrop of the dye solution into the capsular bag, after cortical clean up. After waiting 60-90 seconds, the excessive dye was washed out from the capsular bag. After filling the capsular bag with viscoelastics (Healon®, Pfizer, New York, NY), PCCC can be initiated by using a 26-gauge needle cystitome. The PCCC can be completed using a Utrata's forceps. Optic capture of a posterior chamber intraocular lens (PC-IOL), as well as anterior vitrectomy, can also be performed, if required.

Our experimental studies revealed that posterior capsule staining using ICG or trypan blue is very helpful when performing the PCCC procedure in children.[5] Recent clinical re-

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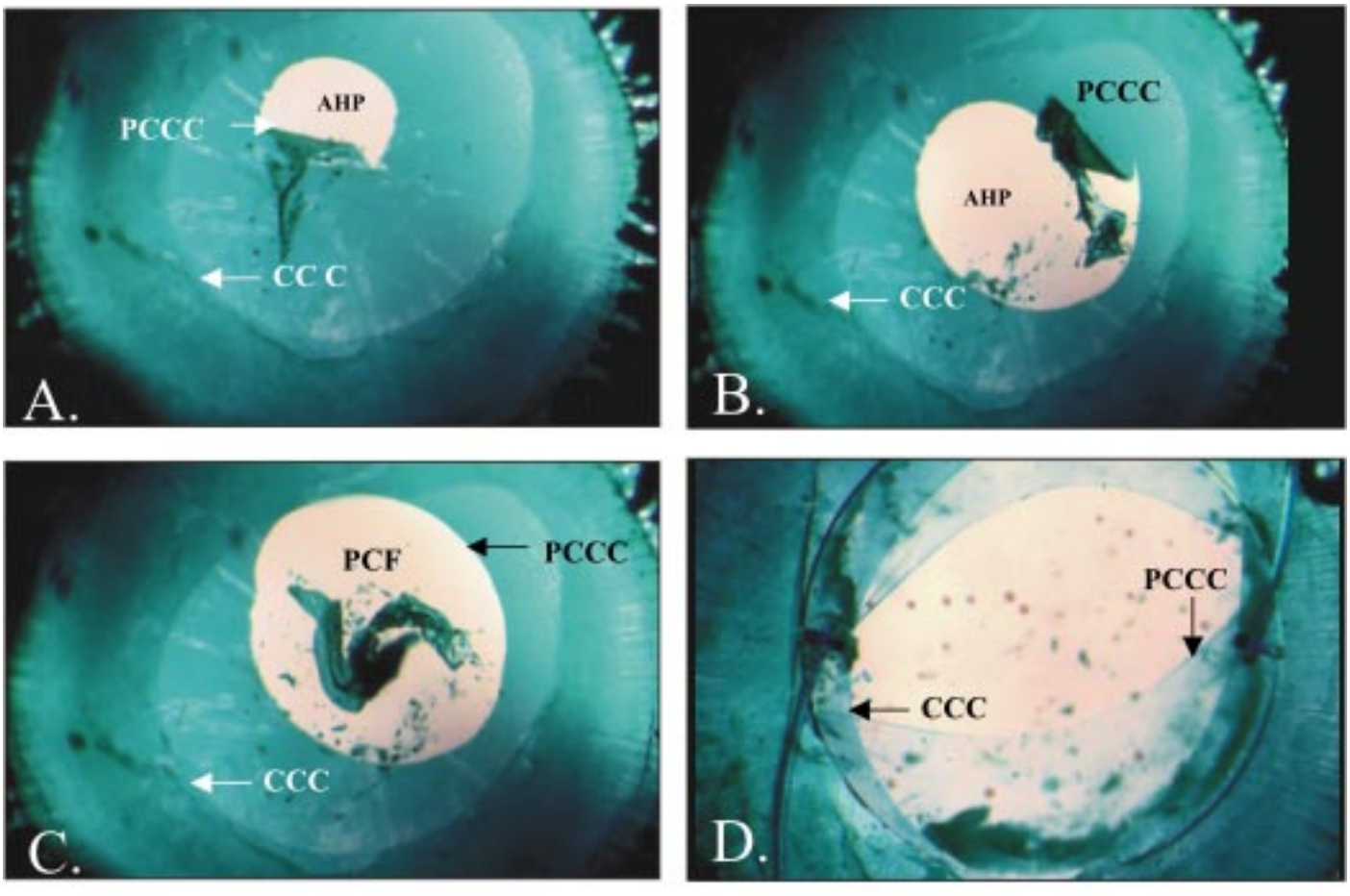

Fig. 1. Gross photographs of a human eye obtained post-mortem showing posterior continuous curvilinear capsulorhexis (PCCC) after staining of the capsular bag with indocyanine green (ICG). Cornea and iris were excised to allow better visualization.

Fig. A: Anterior (surgeon's) view of the cleaned and stained capsular bag showing initiation of the PCCC. Note that it is easier to visualize the stained posterior capsule flap (PCF) against transparent (non-stained) anterior hyaloid phase (AHP) of the vitreous.

Fig. B: The PCCC is in progress.

Fig. C: The PCCC is completed. Note the stained PCCC margin; PCF: posterior capsule flap.

Fig. D: The posterior capture of the intraocular lens (IOL) optic. Both intraocular lens haptics are present in the capsular bag and the IOL optic is captured behind the posterior capsule.

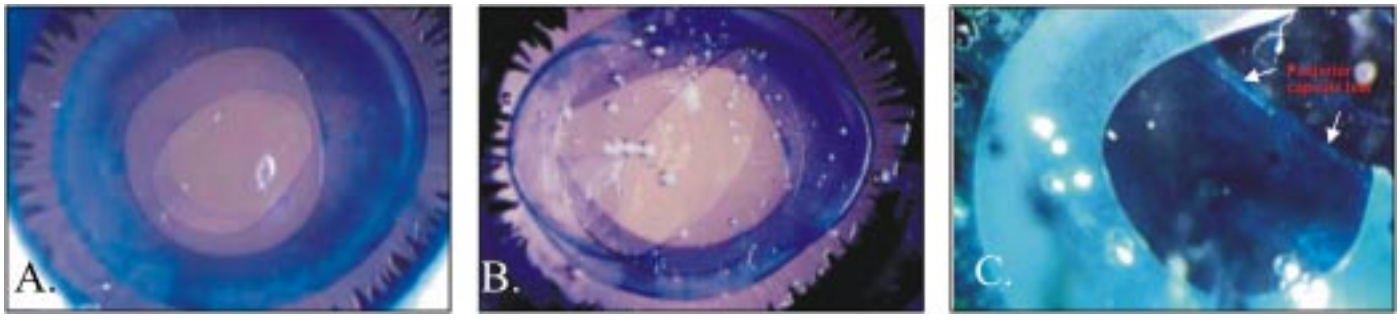

Fig. 2. Dye-enhanced pediatric cataract surgery. Photographs of a pediatric eye obtained post-mortem, taken from anterior (surgeon's view) illustrating the use of the capsular dye to enhance visualization during various steps of the pediatric cataract surgery.

Fig. A: Posterior capsulorhexis after the staining of the capsular bag with trypan blue.

Fig. B: Posterior capsulorhexis and optic capture of a foldable IOL after the staining of the capsular bag with trypan blue.

Fig. C: Visualization of a posterior capsule tear after staining of the capsular bag with ICG (arrows).

ports from other center confirmed the experimental finding using these dyes to stain the posterior capsule when performing PCCC.[8,9] Wakabayashi and Yamamoto[8] reported ICG staining used for anterior and posterior capsulorhexis in congenital cataract combined with anterior vitrectomy. The visibility of both anterior and posterior capsule was poor without staining because of associated corneal opacity in 6-

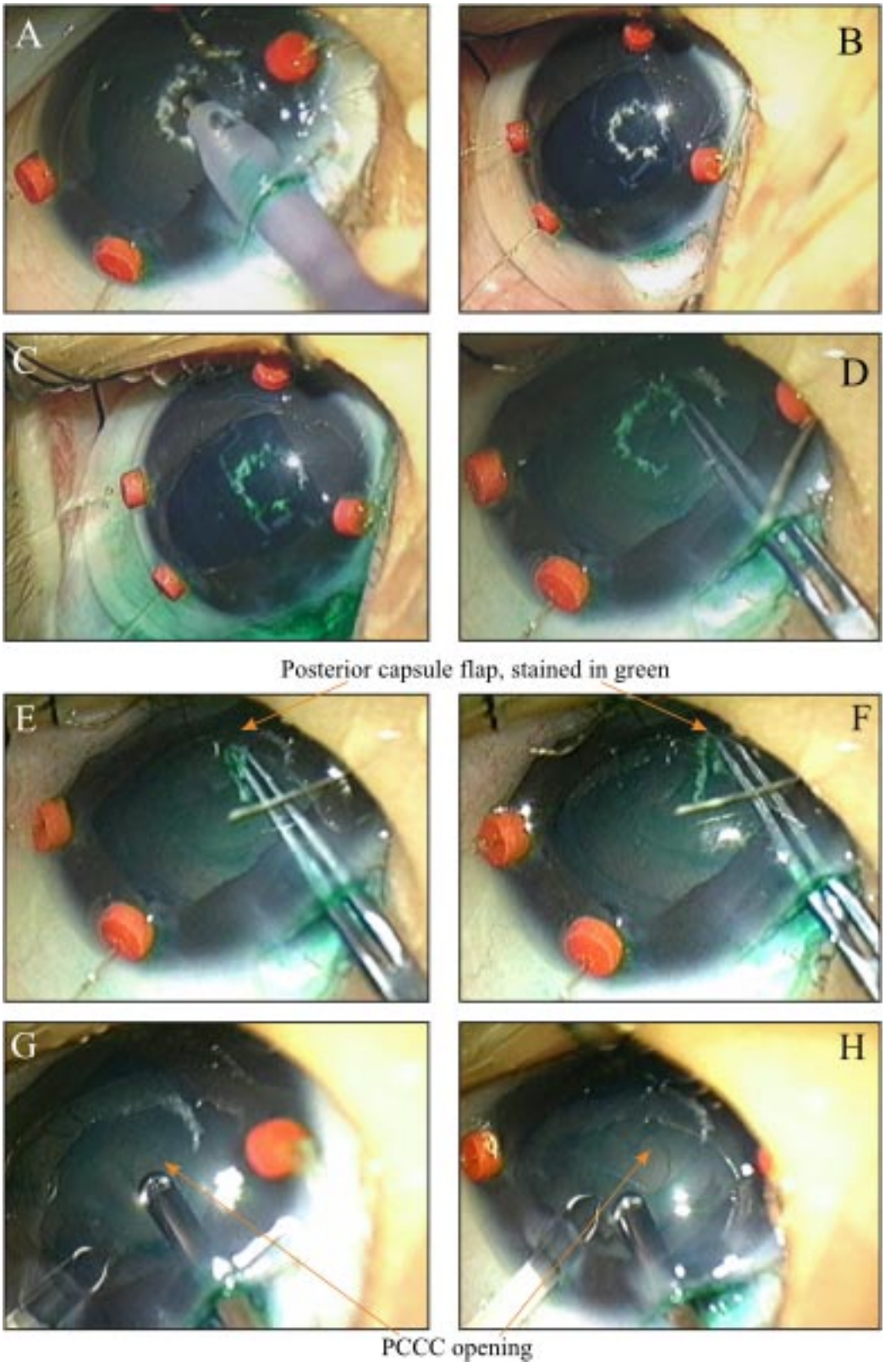

Fig. 3: (A-H). Indocyanine green (ICG) enhanced posterior continuous curvilinear capsulorhexis (PCCC) in congenital cataract combined with anterior vitrectomy. The visibility of the posterior capsule was poor without staining in this 6-month-old child with nuclear cataract, because of corneal opacity. After the extraction of the cataract, a PCCC was performed after ICG staining of the posterior capsule. Note the PCCC was successfully completed because of better visualization of the stained posterior capsule flap against the transparent anterior hyaloid face of the vitreous.

month old congenital cataract. After cataract removal, ICG staining of the capsular bag was to better visualize the posterior capsule. The PCCC was successfully completed because of better visualization of the stained posterior capsule flap against the transparent anterior hyaloid face of the vitreous as shown in Figure 3. Clear visual axes have been maintained postoperatively.

Learning, perfecting the anterior and posterior capsulorhexis procedure during pediatric cataract surgery can be difficult for the beginning surgeon, due to the thin and transparent nature of the capsule. In addition, achieving a consistent size of the anterior and posterior capsule opening for performing the IOL optic capture can be challenging. A thin sclera, highly elastic anterior and posterior capsules and a positive vitreous pressure, make ACCC/PCCC even more difficult than in older children/adults.

Posterior capsule staining facilitates PCCC with or without IOL optic capture during cataract surgery in infants and children (Figure 2).[5] Vitreous loss can also be identified by the formation of colored localized clumps, depending on the type of dye used. Even when utilizing the vitrector to open the posterior capsule, visualization of the capsulotomy edge can be difficult and would be enhanced by use of a dye. Also, IOL insertion into a soft pediatric eye after CCC and PCCC can be very difficult.

Adequate visualization of the remaining capsule and of the capsulotomy edges is paramount to avoid inadvertent sulcus placement, asymmetric bag-sulcus fixation or dislocation of the IOL through the PCCC.

Safety and Efficacy

Several laboratory, animal and clinical studies have evaluated capsular dyes and capsule staining techniques for safety and efficacy during adult cataract surgery. Horiguchi et al.,[1] reported the technique of staining the anterior capsule using a 2% solution of ICG in patients with mature cataracts. They compared the results of phacoemulsification and IOL implantation in 2 groups of 10 eyes. In the first group, the anterior capsule was stained with ICG before CCC, and in the second, no dye was used. There was no statistically significant difference reported in their study between both groups concerning specular-microscopy endothelial cell counting, and laser flare-cell photometry, thus the staining procedure was considered to be safe.

Clinical experience with ICG and trypan blue for anterior capsule staining in mature white or brunescent cataracts was first reported by David Chang[3] in two consecutive, non-randomized series of mature or brunescents cataracts. The technique of dye injection under an air bubble was utilized. ICG dye was used in the first series, and trypan blue in the subsequent series. According to the author, both dyes provided consistently excellent visualization and clinical results without any adverse effects. However, trypan blue created a more intense and persistent staining and provided superior visualization when compared with ICG, according to this first clinical study (Chang DF, MD. Compare two dyes. Eye Net 2000; 4:22).

We would like to emphasize care when performing anterior capsule staining in vitrectomized patients during pediatric cataract surgery. Inadvertent staining of the posterior lens capsule may occur secondary to diffusion of dye into the vitreous cavity, thereby obscuring the red reflex.[12] However, the trypan blue molecule is large and under normal circumstances does not appear to cross the intact zonula ciliaris (cilary zonules). It is likely that an intact anterior hyaloid face would prevent bulk flow of dye into the vitreous cavity. The surgeon should avoid using any ophthalmic dyes in pediatric cataract surgery combined with implantation of hydrophilic acrylic lenses having a high water content (>70%), as this can lead to permanent staining (discoloration) of the IOL by some ophthalmic dyes.[13] This discoloration may become associated with a decrease or alteration in the best-corrected visual acuity, and eventually require IOL explantation/exchange.[13]

In an ongoing study, Tehrani and associates found that the stained anterior lens capsule using trypan blue was actually weaker, and less force was required to begin the tear at the capsule edge (Mana Tehrani, MD, Personal communication, November 2003). These authors performed special elasticity tests using fresh lens capsules, which were removed, during routine cataract surgery in human eyes. One half of the excised capsule was dyed with VisionBlueÒ the other half (non-stained) was used as a control. Analysis of 15 capsules suggested that the capsules that stayed in contact with the trypan blue was actually weaker, in terms that only a half of strength was necessary to tear up the capsule. The precise mechanism is not clear at present, and requires further investigations. However, this phenomenon seems to be due to the presence of preservative in the trypan blue solution.

Guidelines and Recommendation for Surgeons

We would like to provide some recommendations and guidelines for ophthalmic surgeons regarding suitable ophthalmic dyes and the anterior and posterior capsule staining technique in pediatric cataract surgery. These are based on our experience in postmortem human eyes, use on patients from our institution, as well as published clinical reports from several other surgeons. Both ICG and trypan blue are currently preferred over fluorescein sodium dye, due to better staining of the anterior capsule and the absence of vitreous leakage (due to high molecular weight).[5] Both of these dyes provide excellent visualization of the anterior capsule flap during CCC, without causing any toxic effects to the corneal endothelium. Trypan blue has the advantage of being less costly when compared to the cost of ICG, and to the best of our knowledge, the cost of a 0.5-ml ampule of VisionBlueÒ is $5.0, compared to the $90.00 cost of 1 ampule of 25 mg ICG powder. Currently, 0.1% trypan blue is the concentration used by most surgeons. Further studies may be helpful to determine the least concentration of the trypan-blue dye (e.g., 0.05%, 0.025%, 0.01%, etc.) that can be used to stain the anterior lens capsule in order to perform CCC during pediatric cataract surgery.

Staining under the air bubble technique is safer and therefore recommended for cataract patients presenting with high intralenticular pressure and a fragile anterior lens capsule (e.g. pediatric traumatic cataract). When injecting under air, the dye should be injected after the paracentesis but prior to creating the main incision to help with anterior chamber stability. Viscoelastic solutions can be used to visco-seal the incision site in order to avoid escape of the air bubble, and to minimize any anterior chamber fluctuations. Alternatively, mixing the dye with a viscoelastic solution may also be used for better anterior capsule staining, and for

limiting the contact with adjacent ocular tissues.

Use of non-toxic ophthalmic dyes for anterior capsule staining in advanced, white pediatric cataracts allows performance of a safe and successful CCC.[10] The dyes can also be helpful when training residents in the techniques of CCC, and when performing CCC in cases presenting with nebular and/or macular corneal opacity. Anterior capsule staining can also be useful when converting from a can-opener technique to CCC. Surgeons operating only rarely on children may also find anterior and posterior capsule staining useful as an aid to dealing with the elastic nature of the capsule, and the increased tendency for the run-away rhexis. Even when the cataract is not completely white, the learning curve when beginning CCC in unfamiliar territory (such as infantile cataract cases) can be shortened by enhanced visualization of the capsular edge. These dyes may be useful for operating on adult and pediatric cataract cases with poor or no red reflex, or when the surgeon is learning, or in developing-world settings where inexpensive surgical microscopes with imperfect co-axial light may be a necessity.

In summary, capsular dyes can be successfully used in pediatric cataract surgery for performing anterior and posterior capsulorhexis. Posterior capsulorhexis, a technically challenging procedure, is relatively easy to perform after staining of the otherwise transparent posterior capsule, as demonstrated for the first time, in our experimental study (Figures 1,2)[5] and that was confirmed by clinical studies.[8,9] Posterior capsule staining may be specially useful for posterior capsulorhexis procedure being performed in younger children with poor visualization. In addition to anterior and posterior capsulorhexis, staining of the lens epithelial cell using trypan blue dye, to facilitate intraoperative removal during pediatric cataract surgery had also been recently suggested.[11]

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Monthly Meetings Calendar For The Year 2003-2004

27th July, 2003 (Sunday)
Army Hospital

30th August, 2003 (Saturday)
Sir Ganga Ram Hospital

27th September, 2003 (Saturday)
Hindu Rao Hospital

19 October, 2003 (Sunday)
DOS Midterm Conference

1st November, 2003 (Saturday)
R.P. Centre for Ophthalmic Sciences

29th November, 2003 (Saturday)
Dr. Shroff's Charity Eye Hospital

27th December, 2003 (Saturday)
Venu Eye Hospital & Research Centre

31st January, 2004 (Saturday)
Safdarjung Hospital

28th February, 2004 (Saturday)
M.A.M.C. (GNEC)

27th March, 2004 (Saturday)
Mohan Eye Institute

3-4th April, 2004 (Saturday & Sunday)
Annual DOS Conference