We have developed a technique of staining the anterior capsule with a solution of indocyanine green that facilitates performance of the circular continuous capsulorrhexis in eyes with a mature cataract. We compared the results of phacoemulsification and intraocular lens implantation in 10 eyes with the capsule stained with results of 10 eyes having the same procedure with standard circular continuous capsulorrhexis. The results of specular microscopy and laser flare-cell photometry showed no statistically significant differences between the 2 groups. Although the safety of intraocular indocyanine green dye has not yet been definitively established, the findings of this pilot study suggest that it is safe and useful in visualizing the anterior capsule of a mature cataract during cataract surgery.


Clinical evaluations and an experimental study of cataract surgery\(^1\) have shown that continuous circular capsulorrhexis (CCC), a technique introduced by Gimbel and Neuhann,\(^2\) creates an opening in the anterior capsule of the lens that is resistant to tearing during phacoemulsification, cortex removal, and intraocular lens (IOL) implantation. The smooth and round capsular opening allows for secure placement of a posterior-chamber IOL within the capsular bag. The CCC technique also can be used in planned extracapsular cataract extraction.\(^3\) In eyes with a mature cataract and the white lens cortex, however, CCC is often difficult to perform because of poor visibility of the anterior lens capsule. The 2-step CCC method, which involves creating a small CCC followed by a second CCC to enlarge the initial capsular opening, has been developed for those eyes.\(^4\) This technique, however, requires a substantial skill. Unsuccessful CCC increases the risk of posterior capsule rupture, vitreous loss, nucleus drop, and IOL displacement. To obtain better visibility of the capsule, we have developed a capsular-staining technique using indocyanine green (ICG) that facilitates the CCC (CS-CCC). This article describes the method of CS-CCC and discusses its effect on the cornea and postoperative inflammation, factors that must be evaluated before routine use of this technique.

SUBJECTS AND METHODS

In November and December 1996, 20 patients (age range, 45-75; 8 women and 12 men) who had a white cataract were assigned alternately to either the CS-CCC or the CCC group at the time of scheduling phacoemulsification and IOL implantation. None of the patients had evidence of uveitis, glaucoma, or corneal disorders. None of the cataracts had a liquefied cortex. Informed consent was obtained from each patient after the nature of the study was explained, and the tenets of the Declaration of Helsinki (Finland) were followed. The details of these patients are shown in the Table.

SURGICAL TECHNIQUE

Twenty-five milligrams of ICG was dissolved in 0.5 mL of aqueous solvent (provided with the ICG), which was mixed in
4.5 mL of irrigating solution (BSS plus, Alcon, Fort Worth, Tex). The concentration was 0.5%, and the osmolarity was 270 mOsm. After the sclerocorneal or corneal incision was made, air was used to fill the anterior chamber, and a small amount of viscoelastic material was injected around the incision to prevent air leakage. One or 2 drops of the ICG solution were placed on the anterior capsule, and the anterior chamber was re-formed. During the phacoemulsification and IOL placement were then performed with viscoelastic material. After removing the air and redundant ICG, stained anterior capsule became clearly visible and the CCC was easily accomplished (Figure 1). The standard phacoemulsification and IOL placement were then performed. During the phacoemulsification, easy identification of the anterior capsule helped avoid capsular tear in the 2-handed technique of splitting the nucleus.

In this study, we used air in the CS-CCC and performed sclerocorneal incision in all patients. In some of the 20 eyes, a 2-handed aspiration technique was used for complete removal of lens cortex.5

### EVALUATION METHOD

Specular microscopy6-8 and laser flare-cell photometry9-11 were performed preoperatively and postoperatively in all patients. Wide-angle specular microscopy was performed with specular microscopy (CSP-580, Konan, Japan). Using computer-assisted photometric analysis, the average cell count (cells per square millimeter) was measured. The coefficient of variation was calculated by dividing the SD of the cell area by the mean of the cell area, providing a quantitative measurement of polymegathism. Flare was measured with the laser flare-cell photometer (FC-1000, Kowa, Japan). The diffracting light (photon) produced in the anterior chamber by a helium-neon laser beam was detected by a photomultiplier and analyzed with a computer. Flare intensity is proportional to the protein content and size of aqueous humor proteins. Blood-aqueous barrier disruption can be evaluated by counting photons (photons per millisecond).

### RESULTS

The surgical procedure was completed successfully, and visual recovery was excellent in all patients (Table). None of the patients had an elevation of intraocular pressure. Laser flare-cell photometry showed no statistically significant difference between the 2 groups at 1, 3, and 7 days after the surgery (Figure 2). Neither corneal endothelial cell count nor coefficient of variation showed significant differences between the 2 groups before and after surgery (Figure 3, top and bottom).

### COMMENT

Indocyanine green is a nontoxic tri-carbocyanine dye (C₃₈H₅₃N₂NaOs₂) with a molecular weight of 775 d, and has been used in humans since 1956.12 In general medicine, ICG has been used extensively to measure cardiac output and hepatic blood flow.13 In ophthalmologic practice, ICG has been used to perform angiograms of the choroid since 1970.14 Though the fact that ICG has been used medically for many years suggests its safety, the effects of a solution containing ICG on the intraocular structure must be evaluated carefully before it can be used routinely in cataract surgery.

Because the endothelial cell count and coefficient of variation revealed no significant difference between the CS-CCC group and the CCC group, it could suggest that CS-CCC had little effect on postoperative condition of corneal endothelial cells. McEnery and Peyman13 reported use of ICG for staining endothelial cells to count the number of...
the cells for penetrating keratoplasty. Their data in rabbits suggested that ICG is not harmful to corneal endothelial cells and that it selectively stains dead corneal endothelial cells. Because the endothelial cells are alive in human cataract surgery, the ICG neither stains them nor obstructs the surgeon's view. The solution in their experiment, which was prepared with 50 mg of ICG, aqueous solvent, 5% dextrose and saline, was at 1% concentration, and its osmotic pressure was 296 mOsm. Our solution, on the other hand, which was made of 25 mg of ICG, 0.5 mL of aqueous solvent, and 4.5 mL of irrigating solution, was at 0.5% concentration and its osmolarity was 270 mOsm. The normal value of osmotic pressure in plasma ranges from 285 to 290 mOsm in our laboratory, 285 to 290 mOsm in our laboratory, and that of the aqueous is believed to 285 to 290 mOsm in our laboratory. There was no statistically significant difference between 2 groups.

In preliminary experiments in animal eyes, fluorescein sodium, another option for staining the anterior lens capsule, stained the cornea, lens cortex, and nucleus as well as the lens capsule, and migrated into the vitreous cavity, probably because of its smaller molecular weight (376 d) compared with that of ICG (775 d). Further, fluorescein sodium in the vitreous cavity could not be removed by an irrigation-aspiration system. Therefore, we concluded that fluorescein sodium is not suitable for staining the anterior capsule.

Although further study is needed to prove the safety of intracocular ICG, our present study suggests the safety and usefulness of CS-CCC technique, which may improve the result of surgery for white cataract.

**REFERENCES**