Staining of the Lens Capsule for Circular Continuous Capsulorrhexis in Eyes With White Cataract

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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 have shown that continuous circular capsulorrhexis (CCC), a technique introduced by Gimbel and Neuhann, 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. 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. 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...
was easily accomplished (came clearly visible and the CCC ICG, stained anterior capsule be-
ter removing the air and redundant
placed with viscoelastic material. Af-
rior chamber was re-
was placed on the anterior capsule,
air was used to fill the ante-
molarity was 270 mOsm. After the
concentration was 0.5%, and the os-
plus, Alcon, Fort Worth, Tex). The
4.5 mL of irrigating solution (BSS
plus, Alcon, Fort Worth, Tex). The
centration was 0.5%, and the os-
plus, Alcon, Fort Worth, Tex). The

The surgical procedure was com-
pletely removed lens cortex.5

Table: Patient and Clinical Characteristics

<table>
<thead>
<tr>
<th>Case No./Sex/Age, y</th>
<th>VA† Preop</th>
<th>VA† Postop</th>
<th>IOP‡ mm Hg Preop</th>
<th>IOP‡ mm Hg Postop</th>
</tr>
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<tbody>
<tr>
<td>CS-CCC Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/M/54</td>
<td>0.4</td>
<td>0.8</td>
<td>19</td>
<td>19</td>
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</tr>
<tr>
<td>3/F/74</td>
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<td>1.2</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
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<td>15</td>
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<td>14</td>
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<td>16</td>
<td>18</td>
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<tr>
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<td>1.2</td>
<td>15</td>
<td>10</td>
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<tr>
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<td>0.8</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>10/F/72</td>
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<td>1.0</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>CCC Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/M/59</td>
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<td>18</td>
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<tr>
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<tr>
<td>13/F/69</td>
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<td>1.2</td>
<td>18</td>
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<tr>
<td>14/F/69</td>
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<tr>
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<td>16/F/74</td>
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<td>17/F/80</td>
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<tr>
<td>18/F/69</td>
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<tr>
<td>19/M/67</td>
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<tr>
<td>20/M/74</td>
<td>0.1</td>
<td>1.2</td>
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</tbody>
</table>

*CS-CCC indicates circular continuous capsulorrhexis (CCC) using a capsular staining technique; HM, hand motions.
†Preop VA indicates visual acuity before surgery; postop VA, visual acuity 2 weeks after surgery.
‡Preop IOP indicates intraocular pressure before surgery; postop IOP, intraocular pressure 1 day after surgery.

4.5 mL of irrigating solution (BSS
plus, Alcon, Fort Worth, Tex). The

**RESULTS**

The surgical procedure was com-
pletely removed lens cortex.5

**COMMENT**

Indocyanine green is a nontoxic tri-
carboxyline dye (C₃H₇N₂NaO₆S₂) with a molecular weight of 775 d,
and has been used in humans since
1956.13 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 an-
angiograms of the choroid since 1970.14
Though the fact that ICG has been
used medically for many years sug-
ests its safety, the effects of a solu-
tion containing ICG on the intra-
ocular structure must be evaluated
carefully before it can be used rou-
tinely in cataract surgery.

Because the endothelial cell

count and coefficient of variation re-
vealed no significant difference be-
tween the CS-CCC group and the
CCC group, it could suggest that CS-
CCC had little effect on postopera-
tive condition of corneal endothelial
cells. McEnery and Peyman13 re-
ported use of ICG for staining endo-
theelial cells to count the number of

**EVALUATION METHOD**

Specular microscopy6-8 and laser
flare-cell photometry9-11 were per-
formed preoperatively and postop-
eratively in all patients. Wide-
angle specular microscopy was per-
formed with specular microscopy
(CSP-580, Konan, Japan). Us-
ing computer-assisted photometric
analysis, the average cell count (cells
per square millimeter) was mea-
sured. The coefficient of variation
was calculated by dividing the SD of
the cell area by the mean of the cell
area, providing a quantitative mea-
surement of polymegethism. Flare
was measured with the laser flare-
cell photometer (FC-1000, Kowa, Ja-
pan). The diffracting light (pho-
ton) produced in the anterior
chamber by a helium-neon laser
beam was detected by a photomul-
tiplier and analyzed with a com-
puter. Flare intensity is propor-
tional to the protein content and size
of aqueous humor proteins. Blood-
aqueous barrier disruption can be
evaluated by counting photons (pho-
tons per millisecond).
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, and that of the aqueous is believed to be slightly more hypotonic by 3 to 5 mOsm.[15] Our solution, therefore, is slightly hypo-osmotic to the aqueous; however, this solution was much easier for surgeons to prepare. The photon count of the laser flare-cell photometry also showed no significant difference between the CS-CCC group and CCC group, a finding that indicated that our ICG solution did not increase postoperative inflammation. Hence, based on these 2 factors, inflammation and corneal endothelium, our solution appears to be acceptable for cataract surgery, and excellent visual outcome without a rise in intraocular pressure in the CS-CCC group also suggests its safety.

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 intraocular ICG, our present study suggests the safety and usefulness of CS-CCC technique, which may improve the result of surgery for white cataract.