removal of internal limiting membranes (ILMs) is a potentially useful surgical approach to close an idiopathic macular hole. However, the removal of ILMs is difficult to perform because of poor visibility of the ILMs. We have developed a technique for staining the ILM with a solution of indocyanine green to facilitate the removal of ILMs in eyes with an idiopathic macular hole. Thirteen eyes of 13 patients (8 women and 5 men, aged from 54 to 68 years) with idiopathic macular hole stage 3 or stage 4 that underwent removal of ILMs using this technique had an anatomical closure rate of 92% and an improvement of visual acuity of 89% (≥2 Snellen letter chart lines). The excised specimens were evaluated using transmission electron microscopy. Our results show that this technique is safe and useful in visualizing the ILM, leading to the performance of successful removal of an ILM with least damage to the retina.

Since the initial report of vitreous surgery for an idiopathic macular hole by Kelly and Wendel,1 various surgical techniques and adjuvant therapies have been proposed to increase the success rate of macular hole closure.2,3 Recently, some investigators have reported that the removal of internal limiting membranes (ILMs) is an effective surgical approach to close an idiopathic macular hole, leading to improved closure rate.4-6 In vitreous surgery for an idiopathic macular hole, however, the removal of the ILM is difficult to perform because of poor visibility of the ILMs. Inappropriate removal of the ILM risks damage to the retina, eg, retinal edema or retinal pigment epithelium alterations.7 To obtain better visibility of the ILM, we have developed a technique for staining the ILM using indocyanine green (ICG) that allows safer and easier removal of the ILM.

PATIENTS AND METHODS

From November 1, 1998, through January 1, 1999, we studied a consecutive series of 13 eyes of 13 patients with an idiopathic macular hole, who underwent vitreous surgery and removal of the ILM using a technique for staining the ILM. Of the 13 patients who were studied, 8 were women and 5 were men. The average age of the patient was 61 years, ranging from 54 to 68 years. There were 6 stage 3 idiopathic macular holes and 7 stage 4 idiopathic macular holes. Informed consent was obtained from each patient. The study was approved by the Human Studies Committee and complied with the guidelines of the Declaration of Helsinki. No patient had a history of trauma, surgery, cystoid macular edema, or any other condition known to predispose to macular hole formation. The stage of the macular hole was classified preoperatively according to the scheme proposed by Gass.8 All patients were examined for the best-corrected visual acuity and status of macular closure at 1, 3, and 6 months postoperatively. All the excised specimens from each patient were submitted for transmission electron microscopic processing to verify the presence of the ILM.

SURGICAL TECHNIQUE

Twenty-five milligrams of ICG was dissolved in 10 mL of distilled water, and 0.2 mL of this solution were mixed in 0.6 mL...
of a viscomaterial with a low molecular weight (600,000-1,200,000) using a joint to prevent the formation of air bubbles (Figure 1). An ICG solution of approximately 0.06% was prepared prior to the operation. The osmolarity of the solution was 270 mOsm.

Standard 3-port pars plana vitrectomy was performed, followed by surgical separation of the posterior cortical vitreous from the optic nerve head and posterior retina using a silicone-tapered cannula. A subtotal vitrectomy was then performed. A small amount of viscomaterial containing ICG was placed on the retina around the macular hole for 30 seconds, while the infusion bottle was positioned at the level of the patient’s head. After removal of the viscomaterial containing ICG, the ILMs became clearly visible because they were stained ultramarine green. A small slit was primarily made in the ILM inside the superior arcade and a small stained flap of ILM could be easily raised by a membrane pick. Then the ILM and the epiretinal tissue overlying and surrounding the macular hole were grasped and peeled with vitreous forceps with angled grasping tips (Figure 2). A continuous curvilinear tear was completely created around the macular hole (Figure 3). After a careful search for retinal tears, an air-fluid exchange with an injection of sulfur hexafluoride was performed. The patients were then instructed to assume a prone position for 7 postoperative days.

### RESULTS

The anatomical closure rate was 92%, with 12 of 13 holes closed at the 6-month follow-up examination. Among the 13 eyes, visual acuity at 6 months postoperatively had improved by 2 or more lines on the Snellen letter chart in 11 eyes (84%) and remained unchanged in 2 eyes (16%) (Table). No eyes had a progressive postoperative nuclear cataract during the 6-month follow-up period. Pathologic examination confirmed the presence of the ILM in 9 eyes. Specimens were not processed from the remaining 4 eyes.

### COMMENT

Recently, there had been increasing interest in the removal of the ILM in macular hole surgery. Yoon et al suggested that a macular hole might occur and enlarge because of contraction of perifoveal vitreous and cellular constituents on the surface of the ILM. Their concept of the evolution of macular hole has encouraged vitreous surgeons to perform the removal of the ILM to obtain a better closure rate of macular holes. Some investigators have reported that the removal of the ILM is a promising surgical technique to improve the anatomical success rate of macular hole surgery. However, it is difficult to successfully remove the ILM without injury or harm to the retina because of poor visibility. The retinal pigment epithelium alterations seem to be common after macular hole surgery even if the ILM is not removed. The ILM consists of collagen fibrils, proteoglycans, plasma membrane of the Müller cells, and basement membrane that stains with ICG.

We have developed a technique for staining the ILM using ICG. This technique gives better visualization of the ILM and allows...
surgeons to remove the ILM more safely and effectively, with less risk of retinal damage. Moreover, it becomes possible to confirm areas in which the ILM has been removed, which facilitates quantitative analysis to determine the appropriate size of the area to be removed. Indocyanine green is a non-toxic tricarbocyanine dye and has been used in humans for many years. In ophthalmologic practice, ICG has been used to perform angiograms of the choroid, and has recently been applied to cataract surgery. Moreover, in our preliminary experiments in rabbit eyes, transmission electron microscopic examination revealed that there were no abnormal findings in the retina of eyes in which ICG was injected (data not shown). Indocyanine green, therefore, seems safe for humans eyes.

Our results showed that the closure rate and visual improvement were satisfactory. We did not experience any complications with ILM staining. Our ICG solution, therefore, seems to be acceptable for vitreous surgery for macular hole, but its effect on the ocular structure should be carefully evaluated.

In conclusion, our study suggests that the staining of the ILM using ICG is safe and useful in visualizing the ILM to obtain favorable visual results with satisfactory and atraumatic removal of the ILM for macular hole surgery.

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