We have developed a new technique to facilitate internal limiting membrane (ILM) peeling with triamcinolone acetonide during idiopathic macular hole surgery. Twelve eyes of 12 patients with a macular hole, stage 2 to 4 and size 0.12 disc diameters (DD) to 0.39 DD (mean, 0.20 DD), underwent vitrectomy with ILM peeling using triamcinolone. Before ILM peeling, a triamcinolone suspension (8 mg/mL in balanced salt solution) was sprayed around the macular hole, and the triamcinolone in the vitreous cavity was aspirated slowly, making the ILM more visible. Postoperatively, the macular hole was closed in all eyes, and the visual acuity was improved from 20/200 to 20/40 (median, 20/130) to 20/60 to 20/20 (median, 20/40). This technique can facilitate the ILM peeling without any adverse effects in this short-term observation.

Internal limiting membrane peeling during macular hole surgery improves the closure rate and postoperative outcome in some cases, but is sometimes difficult to perform because of poor visibility of the ILM. To solve this problem, indocyanine green (ICG) dye, which is sometimes used for cataract surgery, has been applied during surgery to stain the ILM. In contrast to the safety of the ICG staining technique during cataract surgery, retinal damage and retinal pigment epithelium (RPE) atrophy have been reported in macular hole surgery. Other reports describe a long-term staining by ICG in both the macular area and the disc, suggesting the possibility of retinal or neuronal damage by ICG. Electroretinographic studies in animals have shown that exposure to ICG leads to functional damage, and decreased enzyme activity in cultured RPE cells has been reported.

Because of these observations, it has been recommended that ICG should be used only when there is poor visibility of the retinal surface. Therefore, a safer adjuvant is needed to facilitate ILM peeling.

Recently, triamcinolone acetonide has been used during vitrectomy to make the transparent vitreous more visible because triamcinolone is attached to the surface of the vitreous. Enaida et al reported that the submacular deposition of triamcinolone had no adverse effect for at least 2 weeks after vitrectomy for rhegmatogenous retinal detachment, suggesting no adverse effect to the retina or the RPE. Thus, triamcinolone may be safe for use for ILM peeling in idiopathic macular hole surgery.

We have developed a new technique of the ILM peeling using triamcinolone during macular hole surgery.

**METHODS**

Twelve eyes of 12 patients (5 men and 7 women) with an idiopathic macular hole underwent vitrectomy with removal of the ILM using triamcinolone. Eyes with an older macular hole (more than 12 months), eyes with a large macular hole (larger than 0.5 DD), and eyes with atrophic RPE changes at the hole were excluded. The mean±SD age of the patients was 65.7±4.2 years with a range from 58 to 72 years. There were 2 eyes with stage 2, 9 with stage 3, and 1 with stage 4 macular hole. The mean size of macular hole was 0.20±0.07 DD. The pre-
operative visual acuity ranged from 20/200 to 20/40 with a median of 20/130.

After a complete explanation of the purpose and procedures of this study, informed consent was obtained from all patients before the surgery. The study was performed to conform to the tenets of Declaration of Helsinki, and was approved by the institutional review board.

Visual acuity was measured at each examination during the follow-up period using a standard Japanese acuity chart. The closure of the macular hole was determined by optical coherence tomography (OCT) (Humphrey Instruments, San Leandro, Calif) and ophthalmoscopy. The follow-up period was 15.2±7.1 weeks. Excised specimens from 4 eyes were submitted for transmission electron microscopy to verify the presence of the ILM.

**SURGICAL TECHNIQUE**

An aqueous suspension of triamcinolone (Kenacort-A; Bristol Myers Co Ltd, Tokyo, Japan) was left standing for 30 minutes, and the vehicle of the suspension was discarded as described.15,16 The remaining triamcinolone acetonide (40 mg) was mixed with 5 mL of balanced salt solution and was used as a triamcinolone suspension (8 mg/mL).

After phacoemulcification and intraocular lens implantation, a posterior vitreous detachment was formed with a cutter unless it was already present, and as much of the vitreous as possible was removed. After clamping the infusion canula, the triamcinolone suspension (0.2-0.3 mL) was sprayed onto the macular, and immediately after the spray, the triamcinolone in the vitreous cavity was aspirated slowly using the cutter with the infusion canula. Scattered triamcinolone particles remained on the surface of the retina around the macula hole which provided an excellent view of the ILM (Figure 1). When the ILM was peeled, the ILM with triamcinolone was clearly visible, and the edge of the unpeeled ILM was easily detected, which helped in removing unpeeled ILM. The area free of the ILM was planned to be 1 to 2 DD surrounding the macular hole. Fluid-gas exchange was performed, and the vitreous was replaced by 12% perfluoropropane gas.

Although ICG dye stains the entire ILM,10 triamcinolone does not stain the ILM. Therefore, there are several important points that need to be followed to make the ILM more visible with triamcinolone. First, the trialcinolone suspension must include large particle sizes because only large particles of triamcinolone can make the ILM clearly visible. Thus, the particles in the suspension should be examined before spraying it on the retina. Second, surgeons should try not to completely remove triamcinolone in the vitreous cavity before ILM peeling because the triamcinolone that accumulated on the ILM would be removed. Third, surgeons should repeat the spraying of the triamcinolone solution on the retina until some amount of triamcinolone particles remain on the retina.
RESULTS

The ILM was successfully removed from all eyes, and OCT and fundus examination results showed a complete closure of the macular hole in all eyes. The postoperative visual acuity (20/60 to 20/20; median, 20/40) was better than the preoperative visual acuity (20/200; median, 20/130) by 2 or more lines in all eyes (Table). In 11 of 12 eyes, the ILM with triamcinolone was effective in assisting ILM peeling. In 1 eye (case 9), the visibility of the ILM was not as good as in the other 11 cases because only a small amount of triamcinolone remained on the surface of the ILM (Figure 2). However, the ILM was peeled without difficulty. In all 12 eyes, triamcinolone remained at the hole at the end of the surgery, and disappeared by the next day.

Electron microscopic examination confirmed the presence of the ILM in all the processed specimens from the 4 eyes. Fundus examination results revealed no obvious atrophy of the RPE during the follow-up period. Light microscopic examination revealed that triamcinolone particles were attached to a thin layer of the residual vitreous on the ILM (Figure 3).

COMMENT

Triamcinolone improved the visibility of the ILM, which was successfully removed in all 12 eyes. We had 1 case where triamcinolone was less effective than in the other 11 cases, but fortunately, the view of the ILM was sufficient for its removal. Although ICG stains all layers of the ILM,10 triamcinolone seems to form a thin layer on the surface of the ILM. Therefore, we recommend not aspirating or touching the surface of the ILM intensively after the spray or the layer of triamcinolone may be removed. Triamcinolone not only assisted in the initial picking-up of the ILM but also helped in identifying the margins of the unpeeled ILM, which are sometimes missed during the ILM peeling without triamcinolone or other adjuvants.

Triamcinolone has been used in other procedures to make the transparent vitreous visible during vitrectomy, and it is attached to the surface of the vitreous.15,16,18 Electron microscopy has shown that proliferated cells or collagen fibers present on the surface of the ILM after the vitreous detachment is formed manually.1,19 Therefore, it is likely that the sprayed triamcinolone attaches to such cells, resulting in a thin layer on the ILM. When the ILM is not made clearly visible by triamcinolone, 2 possibilities might exist. One possibility is that few cells or fibers existed on the surface of the ILM, and

Table. Patient Data

<table>
<thead>
<tr>
<th>Case No./Age, y/Sex</th>
<th>Stage of Macular Hole</th>
<th>Visual Acuity, Snellen Units</th>
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<tr>
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<td>Preoperative</td>
<td>Postoperative</td>
<td></td>
</tr>
<tr>
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<td>20/130</td>
<td>20/20</td>
</tr>
<tr>
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<td>3</td>
<td>20/200</td>
<td>20/22</td>
</tr>
<tr>
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<td>4</td>
<td>20/130</td>
<td>20/40</td>
</tr>
<tr>
<td>4/60/F</td>
<td>3</td>
<td>20/100</td>
<td>20/20</td>
</tr>
<tr>
<td>5/68/M</td>
<td>3</td>
<td>20/200</td>
<td>20/30</td>
</tr>
<tr>
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</tr>
<tr>
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<td>20/40</td>
<td>20/25</td>
</tr>
<tr>
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<td>20/50</td>
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<td>20/40</td>
</tr>
<tr>
<td>12/66/F</td>
<td>3</td>
<td>20/130</td>
<td>20/40</td>
</tr>
</tbody>
</table>

Figure 2. An ineffective case of triamcinolone-assisted internal limiting membrane (ILM) peeling. Little triamcinolone remained on the ILM because of the strong aspiration of triamcinolone in the vitreous cavity. The arrowhead shows the peeled ILM, and arrows show the edge of the unpeeled ILM.
another is that the surface was aspirated too intensively. In the former, it may be impossible to visualize the ILM with this technique, and in the latter, repeated spray of triamcinolone will visualize the ILM.

It is well known that triamcinolone has anti-inflammatory and anti-proliferative effects.16,21,22 Because inflammation at the macular hole may be one of the factors for closing the hole,19,23 a question may arise whether triamcinolone decreases the closure rate. Indeed, triamcinolone was found at the end of the surgery not only at the edge of the macular hole but also on the RPE. However, the closure of the macular hole was achieved in all eyes, and the improvement of visual acuity in the present 12 cases (0.55 ± 0.23 logMAR) was consistent with that of our previous case series without adjuvant at 3 months postoperatively (0.59 ± 0.17).24 These data suggest that triamcinolone had no adverse effect on the closure or the functional recovery of the macular hole for a mean follow-up period of 1.5 weeks. In addition, none of the macular holes opened during the follow-up period.

Cataract and intraocular pressure elevation may be possible complications after injection of triamcinolone.25-27 We did not observe cataract formation because we used this technique in eyes with simultaneous phacoemulsiﬁcation and intraocular lens implantation. Four eyes had a mild intraocular pressure rise (less than 30 mm Hg) after surgery, but the pressure was normalized by the medication alone.

In conclusion, our results demonstrate that triamcinolone facilitated ILM peeling during vitrectomy in eyes with an idiopathic macular hole. However, the number of cases was limited and a longer follow-up period is needed to show that this technique has no long-term adverse effects on the closure rate and functional improvements.

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