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Video

# Inverted internal limiting membrane flap combined with subretinal viscoelastic injection for large or chronic macular holes

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A R T I C L E I N F O

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Macular hole
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Inverted internal limiting membrane

A B S T R A C T

*Purpose:* To report two cases with a large or chronic macular hole (MH) that was closed by combining the inverted internal limiting membrane (ILM) flap technique with the injection of ophthalmic viscoelastic device (OVD) into the subretinal space through the MH.

*Observations:* A 76-year-old woman was referred to our clinic for surgery of a MH with a maximum diameter of 1089 μm as determined by optical coherence tomography (OCT). Her visual acuity was 20/50 in the left eye after vitrectomy was performed at a local clinic to remove vitreous opacities. For our surgery, the ILM was peeled and the ILM flap was inverted and placed over the MH. Then, cohesive OVD was injected into the subretinal space through the MH to create a retinal detachment around the MH. The MH was closed by a gas tamponade, and the vision improved to 20/40. The second patient was a 62-year-old man whose vision had been decreasing for 3 years, and he was referred to our clinic. His vision was 20/40 in the left eye and OCT detected a MH with a maximum diameter of 853 μm. After core vitrectomy, the ILM was peeled, inverted, and placed over the MH. Then, dispersive and cohesive OVD was injected through the MH. During this procedure, the MH appeared to enlarge and elevate. Then a yellowish arch-shaped lesion appeared at the temporal edge of the macular detachment. The intraoperative OCT showed that the curled-up retinal pigment epithelium (RPE) within the temporal arch-shaped lesion was adherent to the outer retinal layer. Following gas tamponade, the MH was closed but the patient noticed a paracentric scotoma on the nasal side. The fundus autofluorescence (FAF) images showed a hypo-autofluorescent lesion corresponding to the RPE defect. At postoperative 4 months, his visual acuity had improved to 20/22 and the OCT image showed that the MH was closed with a recovery of the ellipsoid zone of the photoreceptors. The subjective paracentric scotoma disappeared, however the hypo-autofluorescent lesion persisted.

*Conclusions and importance:* A combination of the inverted ILM flap and the subretinal injection of OVD can close a large or chronic MH. An RPE detachment caused by injecting OVD into the subretinal space should be avoided.

## 1. Introduction

A chronic and large macular hole (MH) is known to have lower closure rates and may be refractory to the initial surgery.[1–3] The internal limiting membrane (ILM) peeling and the inverted ILM flap technique has been reported to be helpful for the treatment of refractory MHs. However, the improvement of the macular anatomy and the visual acuity of an eye with a chronic MH by this technique is limited.[4–6] The edge of the retracted retina of eyes with a chronic and refractory MH has a firm adhesion to the adjacent retinal pigment epithelium (RPE), and this adhesion has been considered to be the factor that prevents the closure of the MH.[7]

Based on the idea that releasing the adhesion between the edge of the MH and underlining RPE will be helpful in closing the MH, a technique of injecting fluid into the subretinal space to create an intentional retinal detachment around the MH has been reported as an option for a secondary treatment when the initial vitrectomy with ILM peeling failed to achieve a MH closure.[7–9] This technique uses the injection of balanced salt solution (BSS) into the subretinal space to create a retinal detachment around the MH. In contrast, Kovacs and associates[10] reported on a 'viscostretch' technique in which only the adhesion around the MH was released by injecting a cohesive ophthalmic viscoelastic device (OVD) through the MH to detach the perifoveal retinal tissue around the MH. However, the success rate of this technique has not been confirmed.

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Thus, the purpose of this report is to present our findings in two cases in which OVD was injected through the MH to release adhesions at the retracted edge of the MH to create a retinal detachment around the MH. This was combined with the inverted ILM flap technique during vitrectomy for a successful closure of a large or chronic MH.

## 2. Findings

**Case 1**. A 76-year-old woman was referred to our clinic for surgery for a MH that developed after vitrectomy combined with cataract surgery was performed to remove vitreous opacities at a local clinic 2 months earlier (Fig. 1A–C). Her visual acuity at the initial examination was 20/20 in the right eye and 20/50 in the left eye. The axial length was 21.5 mm in the right eye, and 21.6 mm in the left eye. A MH was found in the left eye with a maximum diameter of 1089 μm measured by the caliper function of the optical coherence tomography (OCT) device.

Then, 27-gauge vitrectomy was performed, and no epiretinal membrane was observed around the MH. Brilliant Blue G (BBG) dye was injected to make the ILM more visible, and it was peeled over a 360-degree area, inverted, and placed over the MH. To release the adhesion of the retinal edge to the RPE, cohesive OVD was injected through the MH to create a retinal detachment around the MH (Fig. 1D). The MH appeared to be enlarged and lifted, and then the inverted ILM flap was readjusted to lie over the MH. The intraoperative OCT images confirmed the presence of a macular detachment around the MH and the inverted ILM flap located over the MH (Fig. 1E). After fluid air exchange, 20 % sulfur hexafluoride gas was injected to tamponade the MH. The patient was instructed to maintain a prone position for 3 days. A closure of the MH was confirmed on postoperative day 15 in the OCT images. The MH remained closed and vision improved to 20/40 at the 3 months postoperative examination (Fig. 1F).

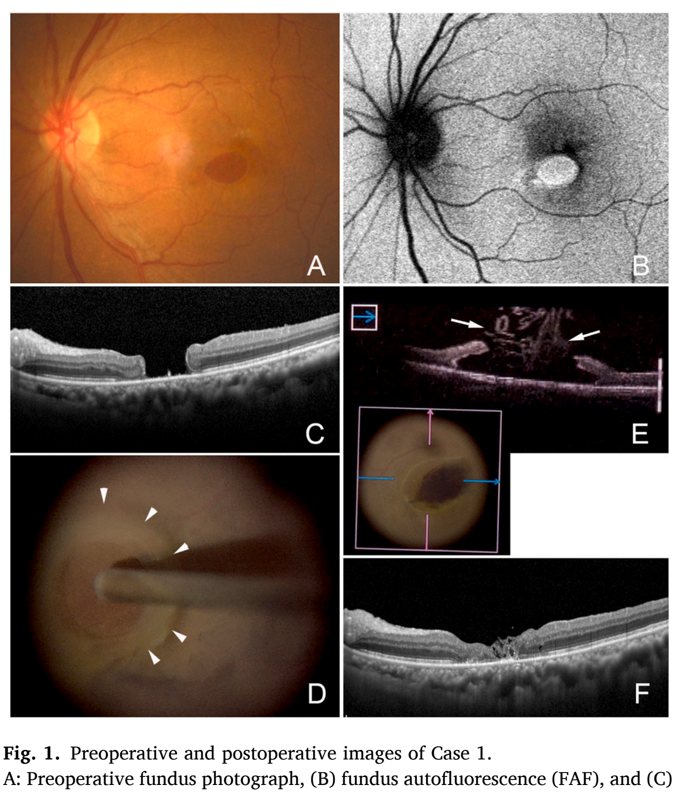


**Fig. 1.** Preoperative and postoperative images of Case 1.
A: Preoperative fundus photograph, (B) fundus autofluorescence (FAF), and (C) optical coherence tomographic (OCT) images show a full-thickness macular hole (MH). D: Intraoperative image shows that a macular detachment (arrowheads) is created by injecting a cohesive ophthalmic viscosurgical device through the MH. E: Intraoperative OCT image shows a macular detachment around the MH and the inverted ILM flap (arrows) is located in the macular hole. F: Postoperative image at 3 months indicates closure of the macular hole with a bridging tissue of the inverted ILM flap.

**Case 2**. A 62-year-old man had been aware of distorted and blurred vision for 3 years but had not undergone any medical examinations. He was referred to our clinic due to a worsening of his vision. His visual acuity at the initial examination was 20/1000 in the right eye due to trauma in childhood and 20/40 in the left eye. The axial length was 27.6 mm in the right eye and 24.0 mm in the left eye. A stage 4 MH with a maximum diameter of 853 μm was detected in the left eye with white deposits at the bottom of the MH suggestive of a long-term patency of the MH (Fig. 2A–C).

To treat the MH, 25-gauge vitrectomy combined with cataract surgery was performed. After core vitrectomy, the ILM was peeled over a 360-degree area and inverted, and the inverted ILM flap was trimmed with a vitreous cutter to a size to cover the MH. To release the adhesion of the detached retina from the RPE, dispersive OVD was injected through the MH from a nasal port, followed by the injection of cohesive OVD to enlarge the focal detachment. During this procedure, the MH appeared to have enlarged and elevated. A yellowish arch-shaped lesion appeared at the temporal edge of the macular detachment (Fig. 2D, video clip). The intraoperative OCT images showed a curled-up RPE edge within the temporal arch-shaped lesion that adhered to the outer retinal layer (Fig. 2E). The absence of the RPE layer suggested its separation from the underlying tissue which indicated an RPE detachment. The temporal edge of the MH appeared to move more in the centrifugal direction compared to the nasal edge. The OVD at the bottom of the MH was washed out by spraying BSS into the MH, and the ILM was inverted again and placed over the MH. After fluid air exchange, 20 % sulfur hexafluoride gas was injected to tamponade the flap over the MH. Postoperatively, the patient was instructed to maintain a prone position for 3 days.

On the next postoperative day, the OCT images in the gas-filled eye indicated that MH was not closed and a small piece of hyperreflective lesion appeared in the subretinal space (Fig. 2F). Beneath the hyperreflective lesion, the choroidal signal was reduced because the signal was blocked by the rolled hyperreflective lesion. There was also hyperpermeability of a choroidal signal at the nasal side of the rolled lesion. The FAF image indicated an arch-shaped hyper-autofluorescent lesion on the temporal side of the MH which corresponded to the curled-up RPE. There was also a hypo-autofluorescent lesion corresponding to the RPE defect. The patient reported a paracentric scotoma on the nasal side even in the gas-filled eye.

MH closure was confirmed in the OCT images at 2 weeks. At postoperative 1 month, the OCT images showed that the MH was closed, the hyperreflective lesion was smaller at the hypertransmission area of the choroidal signal with an absence of the ellipsoid zone (Fig. 2G). The FAF images showed that the arch-shaped hyper-autofluorescent lesion and the hypo-autofluorescent lesion remained. The subjective paracentric scotoma became smaller. At postoperative 4 months, the visual acuity improved to 20/22 and the OCT image showed that the MH was closed with a recovered ellipsoid zone at the decreased hypertransmission area of the choroidal signal (Fig. 2I). Examination of the FAF image showed an arch-shaped hyper-autofluorescent lesion, and the hypo-autofluorescent lesion remained at the temporal side of the closed MH (Fig. 2H). The patient reported that the paracentric scotoma on the nasal side had disappeared and microperimetry did not detect any decrease in the paracentral sensitivity.

An en-face OCTA image of the choriocapillaris (CC) slab on postoperative day 3 showed an arch-shaped hypo-signaling area on the temporal side of the MH which corresponded to the area of curled-up RPE and an enhanced signal area of the CC corresponding to the area of RPE defect (Fig. 2J). On postoperative 1 month, the en-face OCTA image of the CC slab showed that the arch-shaped hypo-signaling area at the temporal side of the MH was still present. However, no other enhanced signaling area of the CC was present (Fig. 2K). The en-face structure OCT image from the outer retina to the CC slab indicated an arch-shaped hyper-signal area at the temporal side of the hypo-signal area at the CC slab because of the signal blockage by the rolled RPE (Fig. 2L).

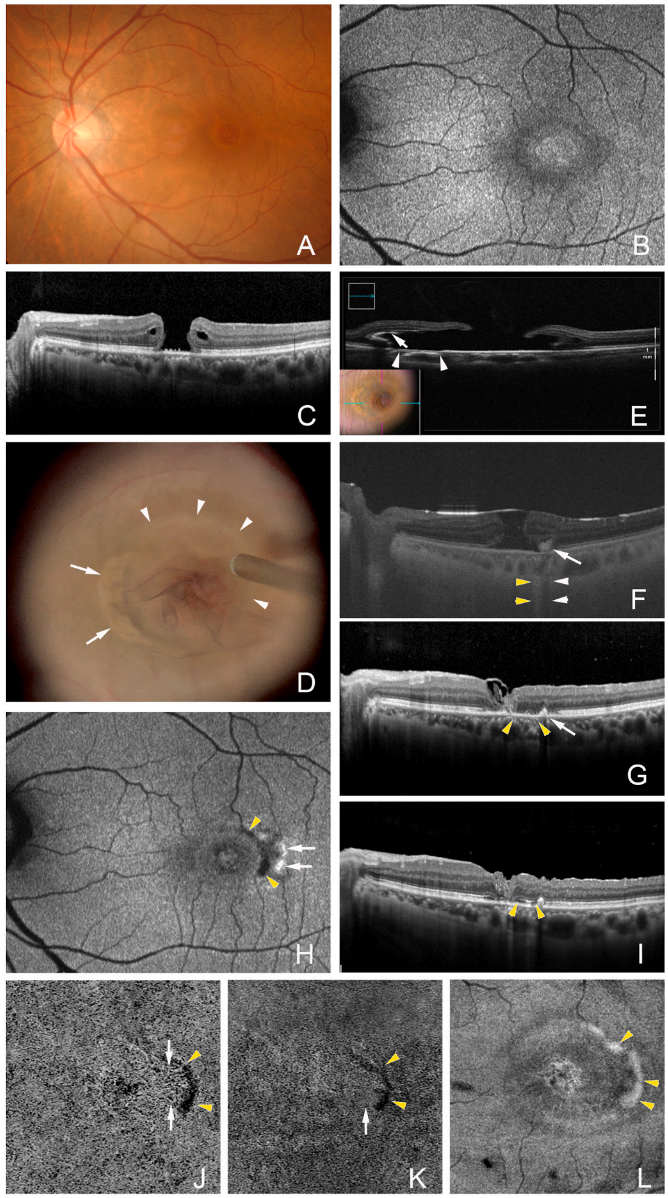


**Fig. 2.** Preoperative and postoperative images of Case 2.
A: Preoperative fundus photograph, (B) fundus autofluorescence (FAF), and (C) optical coherence tomographic (OCT) images show a full-thickness macular hole (MH). D: A macular detachment was created by the injection of dispersive and cohesive ophthalmic viscosurgical devices. Then a yellowish arch-shaped lesion (arrows) developed at the temporal edge of the macular detachment (arrowheads) away from the injecting needle. E: Intraoperative OCT image shows a macular detachment around the MH and a curled-up retinal pigment epithelium (RPE) adhering to the outer retina (arrow) and absence of the RPE layer (arrowheads) at the temporal edge of the macular detachment. F: Postoperative OCT image in a gas-filled eye on the following day indicates an open MH and a small piece of hyper-reflective lesion (arrow) with a decreased signal of choroid (white arrowheads) behind it and hypertransmission of choroidal signal (yellow arrowheads) at the nasal side of the lesion. G: Postoperative OCT image at 1 month shows that the macular hole is closed, the hyperreflective lesion (arrow) is smaller with an absence of the ellipsoid zone (yellow arrowheads) at the hypertransmission area of the choroidal signal. H: Postoperative FAF image at 4 months showing an arch-shaped hyper-autofluorescent lesion (arrows) and hypo-autofluorescent lesion (yellow arrowheads) remains at the temporal side of the closed MH. I: Postoperative OCT image at 4 months shows that the MH is closed with a recovery of the ellipsoid zone (yellow arrowheads) at the area of decreased hyper-transmission of the choroidal signal. J: En-face OCTA image of choriocapillaris (CC) slab on postoperative day 3 showing an area of arch-shaped hypo-signaling (yellow arrowheads) at the temporal side of the MH with an enhanced signaling area of the CC (arrows). K: En-face OCTA image of CC slab on postoperative 1 month showing that the arch-shaped hypo-signal area (yellow arrowheads) was still present on the temporal side of the macular hole with decreased CC signal at the enhanced signal area (arrow). L: En-face structure OCT image from the outer retina to CC slab on postoperative 1 month showing an arch-shaped hyper-signaling area (yellow arrowheads) corresponding to the temporal side of the hypo-signaling area shown in the CC slab (K). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

## 3. Discussion

Our technique of a combination of the inverted ILM flap technique and the viscostretch technique to create a macular detachment by injecting OVD through the MH was helpful in treating a large or chronic MH. In addition, the intraoperative OCT images were helpful in confirming that a complete macular detachment had been accomplished. In addition, the intraoperative OCT images showed the location of the inverted ILM flap during the surgery.

Several techniques have been described to release the adhesion between the edge of the MH and the RPE; the injection of fluid into the subretinal space to create an intentional retinal detachment outside to the MH,[7,8] or an injection of fluid combined with the inverted ILM flap technique.[9] With these hydrodissection techniques, the edges of the MH adjacent to the RPE were moved further apart with backflushing balanced salt solution (BSS) into the MH. Then, the flexible edges of the MH were brought closer together by the passive extrusion of the soft-tip cannula.[11] The rationale for the viscostretch technique is to release the adhesion around the MH by injecting a cohesive OVD through the MH which detaches the parafoveal retinal tissue around the MH.[10] The cohesive property and high molecular weight of the OVD create a vector force running tangentially.[10] During fluid/air exchange, the air-surface tension applies a downward force on the elevated flap of the MH edges, and the gentle aspiration of the margins of the MH with the silicone cannula acts to draw the retinal tissue together.[10]

Our intraoperative OCT findings indicated that the shape of the OVD injected through the MH appeared to be dome-shaped and the vector force of the OVD acted in the direction of peeling off of the sticking paper at the junction of the retracted retina and RPE. This finding may explain why the RPE detachment developed at the edge of the macular detachment in Case 2. An RPE tear has been reported in eyes with age-related macular degeneration after disruption of Bruch's membrane.[12] Our case is different from the typical RPE tear seen in macular degeneration because the vision recovered postoperatively. Recovery of the ellipsoid zone in Case 2 suggested that the RPE cells migrated postoperatively onto the intact Bruch membrane.

There are several advantages of this combined technique. First, it does not require multiple subretinal injections of fluid away from the MH and takes only injection through the MH, and the cohesive nature of OVD helps create complete macular detachment. Second, the inverted ILM flap may be reused if the MH fails to be closed. However, the cohesive nature of OVD may damage the RPE cells resulting in a delayed visual recovery.

This study has one important limitation. This was a study of only two cases which make is difficult to make strong conclusions.

## 4. Conclusions

A combination of the inverted ILM flap technique and the viscostretch technique led to the closing of a large or chronic or large MH in two patients. The complete detachment of the MH edges from the RPE can be accomplished by injecting cohesive OVD.

## Patients consent

Written consent to publish about details of the cases and photographs was obtained from the patients.

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## Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

## CRediT authorship contribution statement

**Xien Lu:** Writing – original draft, Resources, Methodology, Data curation. **Tadashi Yokoi:** Writing – original draft, Methodology, Data curation. **Keiko Kataoka:** Writing – review & editing, Supervision, Resources, Methodology, Formal analysis, Data curation. **Makoto Inoue:** Writing – review & editing, Supervision, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajoc.2024.102100.

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