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Case Report

Macular Hole Formation Six Months after Hemorrhage Displacement for Submacular and Henle Fiber Layer Hemorrhage due to Retinal Arterial Macroaneurysm Rupture

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A 78-year-old woman presented with sudden vision loss and central scotoma. Visual acuity in the right eye was 20/222, with submacular hemorrhage (SMH) and Henle fiber layer hemorrhage (HFLh) due to retinal arterial macroaneurysm (RAM) rupture. She underwent SMH displacement, including cataract surgery, vitrectomy, intravitreal injection of tissue-plasminogen activator, and air tamponade. Three months postoperatively the SMH and HFLh had disappeared and visual acuity had improved to 20/200. Six months postoperatively, a macular hole had developed. We performed an inverted internal limiting membrane flap and gas tamponade. Ten months later, the hole had closed and visual acuity had improved to 20/100.

Key words: submacular hemorrhage, Henle fiber layer hemorrhage, retinal arterial macroaneurysm rupture, macular hole, inverted internal limiting membrane flap technique

Macular holes (MHs) due to retinal arterial macroaneurysm (RAM) rupture are difficult to treat; the hole closure rate after the initial surgery is only 57% [1]. In earlier studies, we reported that all our RAM rupture cases having both submacular hemorrhage (SMH) and Henle fiber layer hemorrhage (HFLh) were characterized by an extremely thin retina (97.7 ± 53.5 μm), and that MH developed in approximately 30-40% of cases in which SMH displacement was performed [2,3]. In these cases, MH formation was identified intraoperatively or within 2 weeks postoperatively, and our search of the relevant literature identified no reports of MH development that occurred long after SMH displacement.

For refractory MHs such as large MHs (*i.e.*, hole diameter > 400 μm), old MHs, and MHs that did not close after internal limiting membrane (ILM) peeling (including MHs due to RAM rupture), it is difficult to achieve closure of the MH by conventional ILM peeling alone [4,5]. Surgical techniques such as the inverted ILM flap technique, ILM autologous transplantation, lens capsular flap transplantation, autologous neurosensory retinal free flap transplantation, and intentional macular detachment have been reported to be effective for refractory MHs, with the most commonly used being the inverted ILM flap technique [5-9]. In the ILM method, the inverted ILM functions as a scaffold to facilitate glial cell migration to the site of the refractory MH [10].

In this report, we present the case of an adult patient with SMH and HFLh due to RAM rupture. She was

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treated with SMH displacement, and by 6 months postoperatively a large MH had developed. We used the inverted ILM flap technique and successfully closed the MH.

Case Report

A 78-year-old Japanese woman visited our hospital complaining of a sudden decrease in visual acuity and a central scotoma that she had experienced since the previous day. At the initial visit, her best-corrected visual acuity (BCVA) was 20/222 in the right eye and 20/29 in the left eye. The intraocular pressure and anterior segment findings in both eyes and the fundus of the left eye were normal. The fundus of the right eye showed a macular hemorrhage with a fluffy sign [2] in the macula and rupture of the RAM in the superior arcade vessel (Fig. 1). Optical coherence tomography (OCT) of the

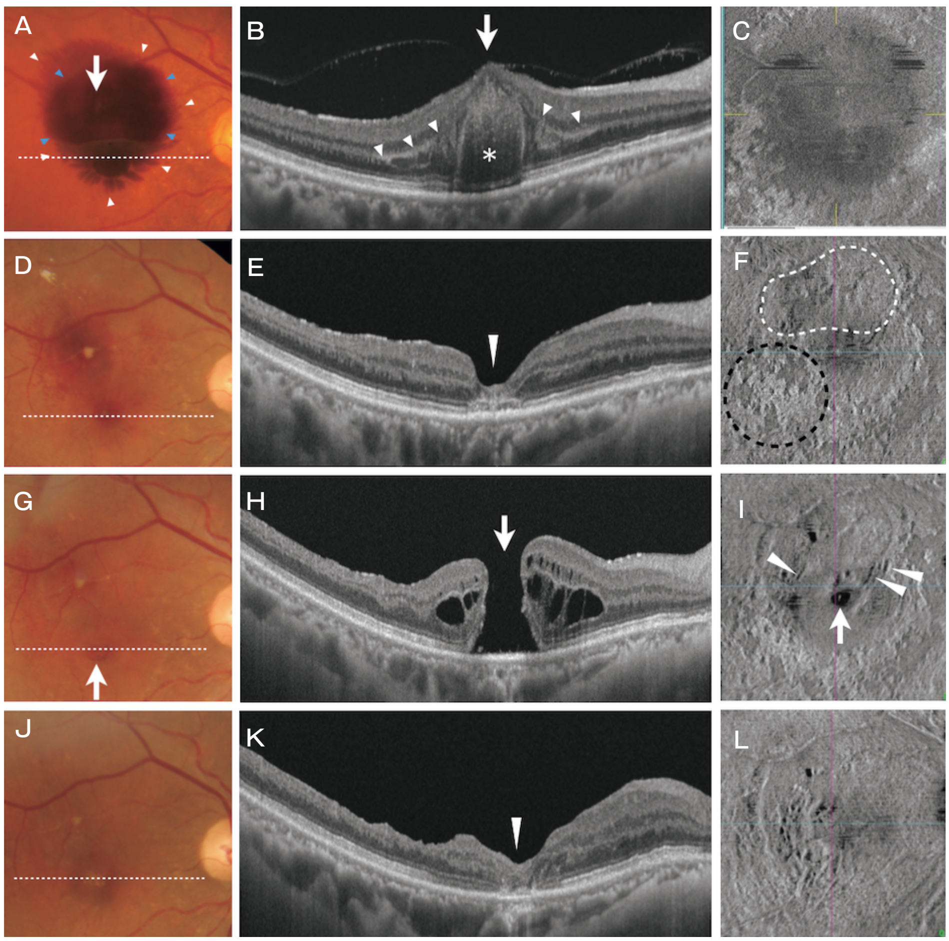

Fig. 1 A 78-year-old woman initially presented with Henle fiber layer hemorrhage (HFLh) (A, B, *white arrowheads*) and submacular hemorrhage (SMH) (B, *asterisk*) due to a retinal arterial macroaneurysm (RAM) rapture (A, *arrow*) and thinning fovea (B, *arrow*) in her right eye. Sub-internal limiting membrane hemorrhage (A, *blue arrowheads*) was observed around the RAM. SMH displacement with cataract surgery was performed. Three months postoperatively, the SMH and HFLh had disappeared, and the fovea was atrophic (E). En face OCT revealed the area of the peeled internal limiting membrane (ILM) in the first surgery (F, *white dotted line*) and the epiretinal membrane without retinal folds (F, *black dotted line*). A macular hole (MH) was observed (G-I, *arrow*). Outside the area of the peeled ILM, retinal folds were observed near the MH, maximum retinal fold depth was 10.4 µm (I, *arrowheads*). A vitrectomy was performed using the inverted ILM flap technique. The MH had closed at 2 weeks postoperatively. At the final follow-up visit, the MH remained closed (J-L), and the fovea was atrophic (K, *arrowhead*). *Dotted lines* in panels A, D, G, and J indicate the imaging locations in panels B, E, H, and K, respectively. Panels C, F, I, and L are en face OCT images of the retinal surface (depth 0–2.4 µm based on the ILM surface).

right eye showed SMH and HFLh and a thinned macula (central retinal thickness [CRT] = 56 μm). The axial length was 22.75 mm, and the patient had a medical history of hypertension. Three days after the initial visit, she underwent displacement of the SMH, including vitrectomy, intravitreal injection of tissue-plasminogen activator (t-PA), and air tamponade combined with cataract surgery in the right eye. The surgical procedure included a 25-gauge microincision vitrectomy conducted using the Constellation Vision System (Alcon Laboratories, Fort Worth, TX, USA), after which the ILM of the subILM hemorrhage area was peeled off, but the ILM of the macular area was not (Fig. 2). Before the surgery was completed, fluid-air exchange was performed to displace the SMH. Before closure of the incision, 4000 IU/0.1 mL of t-PA (GRTPA; Mitsubishi Tanabe Pharma Corp., Osaka, Japan) was injected into the vitreous cavity. Phacoemulsification and implantation of an intraocular lens were performed simultaneously. The patient remained face-down for 3 days after the surgery.

At 3 months postoperatively, the SMH and HFLh had disappeared, atrophic fovea was observed (CRT = 114 μm), and the BCVA of the right eye was 20/200. At 6 months postoperatively, a large MH with a 624 μm diameter (1,228 μm diameter at the hole base) was observed. The epiretinal membrane (ERM) was detected by OCT, and en face OCT revealed a maximum depth of the retinal folds (MDRF) of 10.4 μm.

A vitrectomy was performed using the inverted ILM flap technique and a 20% SF6 gas tamponade [4]. The surgical procedure consisted of a 25-gauge microincision vitrectomy, after which the ERM was visualized using triamcinolone acetonide and peeled off. The ILM was stained with brilliant blue G (BBG), and the area of the ILM that peeled off during the first surgery was expanded while the nasal-side ILM of the MH was left as a flap (Fig. 3A). After inversion of the ILM flap, fluid-20% SF6 gas exchange was performed before completing the procedure (Fig. 3B, C). The patient remained face-down for 3 days after surgery. At 2 weeks after the second surgery, the MH had closed. At the patient's final visit 10 months after the second surgery, the MH remained closed, the CRT was 120 μm, and BCVA in the right eye had improved to 20/100.

This study complied with the principles of the Declaration of Helsinki and was approved by our Institutional Review Board. The patient provided written informed consent for the publication of her case details and images.

Discussion

We performed SMH displacement for a patient with SMH and HFLh due to RAM rupture, and a large MH was observed at 6 months postoperatively. We then performed a second surgery using the inverted ILM flap technique to successfully close the MH. The patient was followed-up for more than 10 months after the second surgery with no MH recurrence. SMH due to RAM rupture is associated with MH in approximately 30-40% of cases when HFLh is present, most of which occur

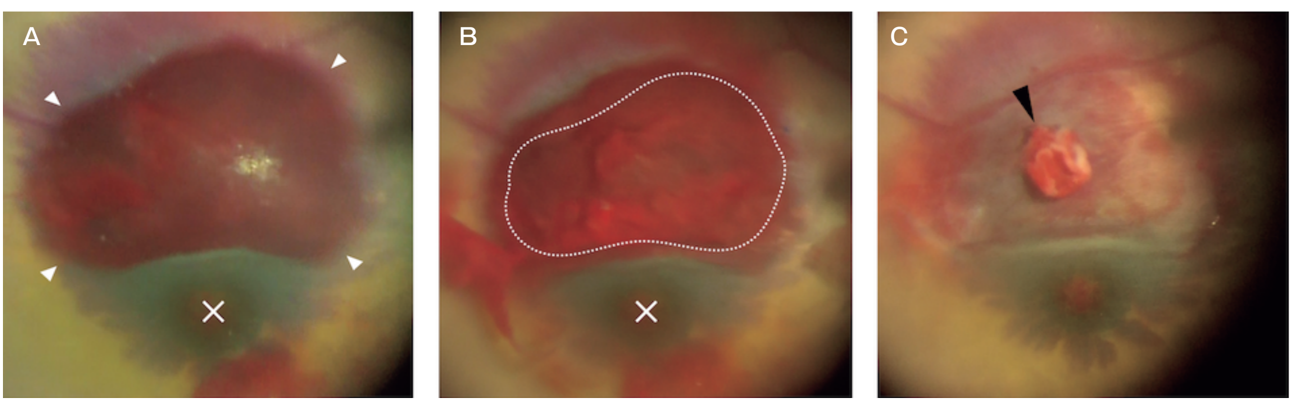

Fig. 2 Intraoperative fundus photograph of the first surgery. After the vitrectomy, subinternal limiting membrane (subILM) hemorrhage (*arrowhead*) was observed superior to the macula (A, × *mark*). The internal limiting membrane was partially peeled off (B, *dotted line*), and the subILM hemorrhage was aspirated. After the removal of the subILM hemorrhage, a retinal arterial macroaneurysm was observed (C, *arrowhead*).

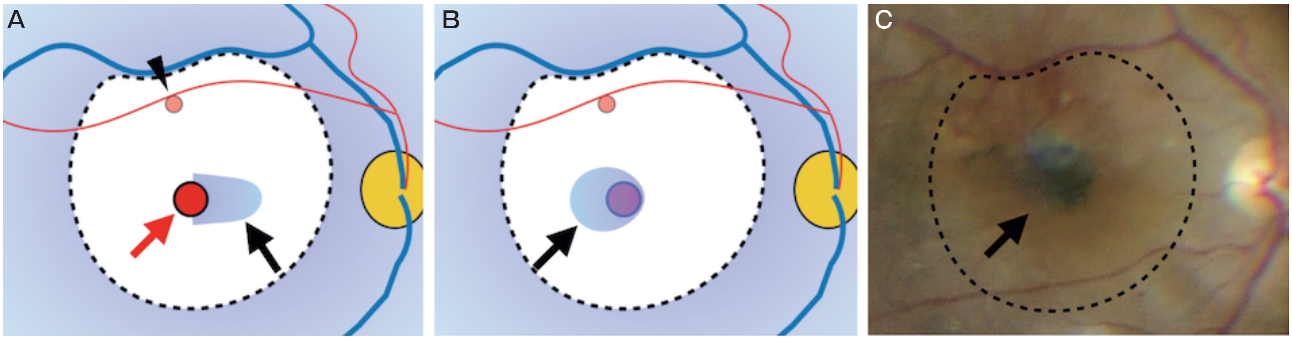

Fig. 3 Schema (**A**, **B**) and intraoperative fundus photograph (**C**) of the second surgery. At the beginning of the second surgery, a whitened retinal arterial macroaneurysm was observed (A, *arrowhead*). The peeled internal limiting membrane (ILM) area in the first surgery (see Fig. 2) was expanded to the area indicated by the *dotted lines* in panels A-C. Simultaneously, the ILM flap on the nasal side of the macular hole (MH) (A, *red arrow*) was left in place (A, *black arrow*). The ILM flap was inverted toward the temporal side to cover the MH (B, C, *arrow*).

intraoperatively or at an early postoperative timepoint (*i.e.*, immediately after air/gas disappearance) [2, 3]. In the present case, we believed that even if t-PA could be injected at a very low pressure into the subretinal space, there was a risk of MH formation at the time of subretinal injection because of the thinned fovea. Therefore, to prevent the intraoperative and early postoperative development of MH, we injected t-PA into the vitreous cavity instead of the subretinal space during the initial surgery.

MH formation after a vitrectomy is rare: Lee *et al.* reported an incidence of 0.24% (8/3, 279 eyes) and Kang *et al.* reported an incidence of 0.6% (38/6, 354 eyes) [11, 12]. Cases in which an MH occurs after vitrectomy are characterized by the formation of postoperative ERM or cystic macular edema (CME) and high myopia [12]. Our patient did not exhibit high myopia, and she had no postoperative CME. Although ERM developed, the MDRF measured by en face OCT due to ERM was 10.4 μm, and the traction on the macula was considered weak. As a point of reference, MDRF values for ERM that would be indicative for surgery have been reported as ≥69 μm [13]. However, because the macula in our patient was extremely thin and fragile, it is possible that the MH was formed by very weak traction from the ERM.

We used the inverted ILM flap technique for our patient's second surgery [4]. In cases of MHs complicated by SMH, general ILM peeling increases the risk of open MHs, and in such cases, difficult procedures such as ILM transplantation or autologous blood clot injection must be performed to close the MH [14, 15]. In the present patient, the MH was large (624 μm diameter). We thus applied the inverted ILM flap technique because conventional ILM peeling might have failed to close the MH. No recurrence of ERM or MH formation was observed at the patient's final examination. However, a long follow-up duration is required to observe whether ERM forms in the inverted area because the inverted ILM flap technique has been reported to cause ERM in the long term [16].

In this study, we performed SMH displacement for a patient with SMH and HFLh due to RAM rupture and the MH that occurred 6 months postoperatively. The MH was successfully closed using the inverted ILM flap technique; as a result, the patient's visual acuity improved. Since this is a single case report and the follow-up period was short, a multi-case and long-term study of SMH and HFLh due to RAM rupture is needed.

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