CASE SERIES

Hyperautofluorescent ring in eyes with macular holes

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Background: Fundus autofluorescence studies in eyes with macular holes (MHs) have shown a hyperautofluorescent spot corresponding to the hole and a hypoautofluorescent ring corresponding to the fluid cuff surrounding the hole. The purpose of this report is to present three cases of MH with a different fundus autofluorescence pattern.

Case reports: Case 1 was a 62-year-old woman who did not know the duration of the MH in her left eye. Her decimal best-corrected visual acuity (BCVA) was 0.08. The left eye had a one-half disc diameter MH with a depigmented ring surrounding the area of the fluid cuff. Fundus autofluorescence showed a hyperautofluorescent ring corresponding to the depigmented ring. After vitrectomy, fundus autofluorescence showed the same size hyperautofluorescent ring despite the decreased size of the opened MH. Case 2 was a 69-year-old woman who had been diagnosed with MH in the right eye 13 years earlier. Her decimal BCVA was 0.1. The right eye had a one-half disc diameter MH with a depigmented ring surrounding the area of the fluid cuff. Fundus autofluorescence showed a hyperautofluorescent ring corresponding to the depigmented ring. Postoperative fundus autofluorescence showed the same size hyperautofluorescent ring despite the hole being closed. The decimal BCVA was 0.2 in her right eye 6 months after vitrectomy. Case 3 was a 71-year-old woman who had been diagnosed with MH in the right eye 15 years earlier. Her decimal BCVA was 0.1. The right eye had a one-half disc diameter MH with a depigmented ring which corresponded with a hyperautofluorescent ring. Postoperative fundus autofluorescence showed the same size hyperautofluorescent ring despite the hole being closed. The decimal BCVA was 0.2 in her right eye 6 months after vitrectomy.

Conclusion: Our findings suggest that a hyperautofluorescent ring in eyes with MHs may be an indicator of a poor surgical prognosis both anatomically and functionally.

Keywords: macular hole, fundus autofluorescence, vitrectomy, predictor

Introduction

Macular hole (MH) is a full-thickness defect of the foveal retina that causes a severe reduction in central vision. The prevalence of MH has been reported to be 0.09%–0.17%.[1–4] The established treatment for MH is pars plana vitrectomy combined with internal limiting membrane peeling followed by intravitreal gas tamponade. Recent studies have shown that the anatomic success rate after primary pars plana vitrectomy is 89%–97%.[5–9] The size and duration of the MH are preoperative factors that are significantly associated with postoperative anatomic MH closure.[10–13] The size of MH can be estimated by biomicroscopy or more quantitatively by optical coherence tomography. However, the duration of MH is more difficult to determine accurately because some patients are unaware of the reduced vision until the fellow eye is accidentally covered.

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Fundus autofluorescence is a relatively new noninvasive method of assessing the retina and retinal pigment epithelium and has been used to evaluate eyes with MH.[14–17] Fundus autofluorescence is believed to be an indicator of the level of lipofuscin in retinal pigment epithelium cells,[18,19] and earlier studies on eyes with MH reported a hyperautofluoresence corresponding to the full-thickness MH and a hypoautofluoresence corresponding to the surrounding fluid cuff.[14–17]

We report a new fundus autofluorescence pattern in three eyes with MH, namely a hyperautofluorescent ring. We suggest that this fundus autofluorescence pattern may be an indicator of a poor postoperative prognosis for both anatomic and functional recovery of the retina.

Case reports

The procedures used in this study conformed to the tenets of the Declaration of Helsinki, and were approved by the institutional review board of Osaka Rosai Hospital. The three patients were informed on the nature and possible consequences of the procedures to be used. A signed informed consent was obtained from all patients.

Case 1

A 62-year-old woman was referred to our department with a diagnosis of MH in her left eye. She had not noticed the decrease in her central vision until it was pointed out by an optometrist. At presentation, her decimal best-corrected visual acuity (BCVA) was 1.0 in the right eye and 0.08 in the left eye. Fundus photographs and fundus autofluorescence images were taken with the Optos® 200Tx (Optos, Scotland, United Kingdom), and optical coherence tomography was performed with the Cirrus™ HD OCT (Carl Zeiss Meditec Japan, Tokyo, Japan). The left eye had a large MH with an operculum (Figure 1A and E). The minimal and maximal diameters of the MH were 864 µm and 1,345 µm, respectively, and a depigmented ring was observed surrounding the area of the fluid cuff (Figure 1A and E). Fundus autofluorescence showed a hyperautofluorescent ring corresponding to the depigmented ring (Figure 1A and C).

Combined phacoemulsification and vitrectomy with a 25-gauge system was performed on the left eye under local anesthesia. Core vitrectomy following the creation of posterior vitreous detachment was performed with an ultrahigh-speed cutter (5,000 cycles per minute, Alcon Laboratories Inc, Fort Worth, TX, USA). The internal limiting membrane was stained with 0.025% Brilliant Blue G[20] and peeled within the vascular arcade. The peripheral retina was examined for 360 degrees with scleral indentation to search for any
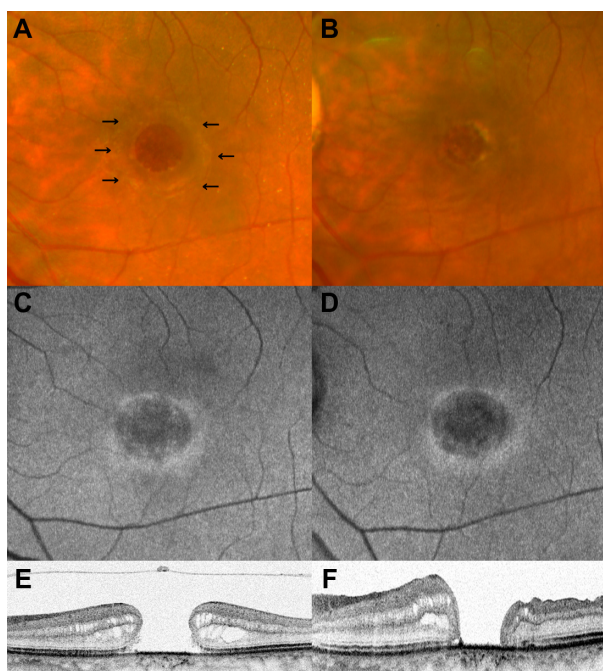

Figure 1 Fundus findings of the left eye in case 1 before (**A**, **C**, and **E**) and 6 months after (**B**, **D**, and **F**) vitrectomy. (**A** and **B**) Fundus photographs. The preoperative fundus photograph shows the depigmented ring surrounding the area of the fluid cuff (black arrows). (**C** and **D**) FAF images. The preoperative FAF image shows the hyperautofluorescent ring corresponding to the depigmented ring. The postoperative FAF shows the same size of hyperautofluorescent ring as the preoperative one. (**E** and **F**) Optical coherence tomographic images. An anatomical closure of the MH was not achieved after the vitrectomy although the MH size became smaller.
Abbreviations: FAF, fundus autofluorescence; MH, macular hole.

retinal breaks. The vitreous cavity was filled with 20% sulfur hexafluoride, and the patient was instructed to maintain a prone position for as long as possible.

An anatomic closure of the MH was not achieved. She did not want any additional treatment, and the MH remained open for 6 months after the vitrectomy (Figure 1B and F). Fundus autofluorescence at this time showed the same size hyperautofluorescent ring as the preoperative one in spite of a decrease in the postoperative size of the opened MH (Figure 1D). The decimal BCVA of the left eye 6 months after the vitrectomy was poor at 0.08.

Case 2

A 69-year-old woman was referred to our department with a diagnosis of MH in her right eye. She reported that her central vision had decreased 13 years earlier, and her doctor informed her that no treatment was available to close the MH at that time. At our initial examination, her decimal BCVA was 0.1 in the right eye and 1.0 in the left eye. The minimal and maximal diameter of the MH were 681 µm and 1,555 µm, respectively (Figure 2A and E). Optical coherence tomography showed disruptions of the photoreceptor inner
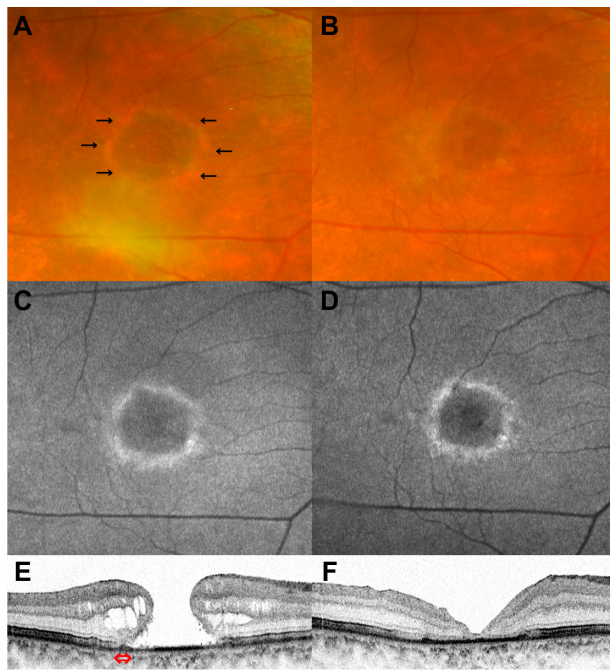
Figure 2 Fundus findings of the right eye in case 2 before (**A**, **C**, and **E**) and 6 months after (**B**, **D**, and **F**) vitrectomy. (**A** and **B**) Fundus photographs. The preoperative fundus photograph shows the depigmented ring surrounding the area of fluid cuff (black arrows). (**C** and **D**) FAF images. The preoperative FAF image shows the hyperautofluorescent ring corresponding to the depigmented ring. The postoperative FAF shows the same size of hyperautofluorescent ring as the preoperative one. (**E** and **F**) OCT images. The preoperative OCT image shows the disruptions of the photoreceptor inner and outer segment junction line and the external limiting membrane line at the edge of the cuff of subretinal fluid (red double-headed arrow). The MH was anatomically closed but the OCT images do not show a recovery of the photoreceptor inner and outer segment junction line and the external limiting membrane line 6 months after the vitrectomy.
Abbreviations: FAF, fundus autofluorescence; MH, macular hole; OCT, optical coherence tomography.

and outer segment junction (IS/OS) line and the external limiting membrane line at the edge of the cuff of subretinal fluid (Figure 2E). A depigmented ring was seen surrounding the area of the fluid cuff, and fundus autofluorescence showed a hyperautofluorescent ring corresponding to the depigmented ring (Figure 2A and C).

Combined phacoemulsification and vitrectomy was performed with a 25-gauge ultrahigh-speed cutter on the right eye under local anesthesia. After core vitrectomy followed by the creation of posterior vitreous detachment, peripheral vitrectomy and 360 degree vitreous shaving with scleral indentation was performed. The internal limiting membrane within the vascular arcade was peeled assisted by Brilliant Blue G staining. The vitreous cavity was filled with 12% perfluoropropane. She was instructed to maintain a prone position for as long as possible.

The MH was anatomically closed but the optical coherence tomography images did not show any recovery of the IS/OS line or the external limiting membrane line 6 months

after vitrectomy (Figure 2B and F). Fundus autofluorescence showed the same size of hyperautofluorescent ring as seen preoperatively despite the MH being closed (Figure 2D). The decimal BCVA of the right eye 6 months after the vitrectomy was 0.2.

Case 3

A 71-year-old woman was referred to our department with a diagnosis of MH in her right eye. She reported that her central vision had decreased 15 years earlier, and her doctor informed her that no treatment was available to close the MH at that time. At our initial examination, her decimal BCVA was 0.1 in the right eye and 0.8 in the left eye. The minimal and maximal diameter of the MH was 818 μm and 1,494 μm, respectively (Figure 3A and E). Optical coherence tomography showed disruptions of the IS/OS line and the external limiting membrane line at the edge of the cuff of subretinal fluid (Figure 3E). A depigmented ring and corresponding hyperautofluorescent ring were observed (Figure 3A and C).
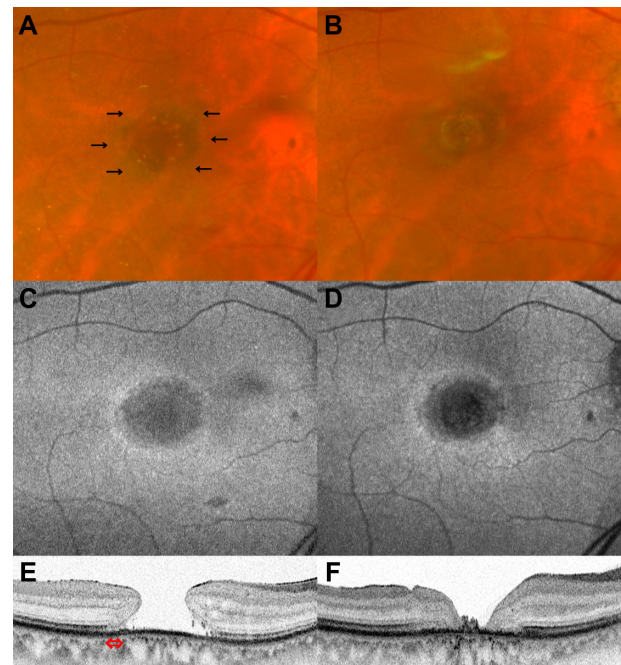

Figure 3 Fundus findings of the right eye in case 3 before (**A**, **C**, and **E**) and 6 months after (**B**, **D**, and **F**) vitrectomy. (**A** and **B**) Fundus photographs. The preoperative fundus photograph shows the depigmented ring surrounding the area of fluid cuff (black arrows). (**C** and **D**) FAF images. The preoperative FAF image shows the hyperautofluorescent ring corresponding to the depigmented ring. The postoperative FAF shows the same size of hyperautofluorescent ring as the preoperative one. (**E** and **F**) OCT images. The preoperative OCT images show disruptions of the photoreceptor inner and outer segment junction line and the external limiting membrane line at the edge of the cuff of subretinal fluid (red double-headed arrow). The MH was anatomically closed, and the OCT image does not show a recovery of the photoreceptor inner and outer segment junction line and the external limiting membrane line 6 months after the vitrectomy.
Abbreviations: FAF, fundus autofluorescence; MH, macular hole; OCT, optical coherence tomography.

Combined phacoemulsification and vitrectomy was performed on the right eye with a 25-gauge ultrahigh-speed cutter under local anesthesia. After core vitrectomy followed by the creation of posterior vitreous detachment, peripheral vitrectomy and 360 degree vitreous shaving was performed. The inverted internal limiting membrane flap technique[12] assisted by Brilliant Blue G staining was performed. The vitreous cavity was filled with 20% sulfur hexafluoride, and she was instructed to maintain a prone position for as long as possible.

Postoperatively, the MH was anatomically closed but a recovery of both the IS/OS line and the external limiting membrane line was not seen 6 months after vitrectomy (Figure 3B and F). Fundus autofluorescence showed the same size of hyperautofluorescent ring as seen preoperatively despite the MH being closed (Figure 3D). The decimal BCVA of the right eye 6 months after the vitrectomy was 0.2.

Discussion

As best we know, a hyperautofluorescent ring in eyes with MH has not been reported, and the surgical outcomes of treating such eyes have also not been reported. Our findings showed that the MHs in two of the three cases were anatomically closed although the visual acuities were still poor. The postoperative fundus autofluorescence images were unchanged, with the same size hyperautofluorescent ring in spite of a decrease in MH size in one eye and successful closure of the MH in two eyes.

The intensity of the fundus autofluorescence image is believed to be an indicator of the lipofuscin level within the retinal pigment epithelium cells.[18,19] It is generally accepted that lipofuscin is the byproduct of degradation of the photoreceptor outer segments phagocytosed by the retinal pigment epithelium cells.[21] Thus, an increase in intensity of the fundus autofluorescence is interpreted as higher turnover of photoreceptor outer segments or impaired metabolic activity of the retinal pigment epithelium cells.[16] In addition, the intensity of the fundus autofluorescence image is increased when retinal tissues are absent because the luteal pigment and the neurosensory retinal tissue attenuate the fundus autofluorescence signal.[16] On the other hand, a decrease in the intensity or absence of fundus autofluorescence signal is interpreted to result from lack of photoreceptors, loss of metabolic ability of the retinal pigment epithelium cells, or blocking of the fundus autofluorescence signal from the retinal pigment epithelium.[16]

In earlier studies, it was demonstrated that the intensity of fundus autofluorescence in eyes with MH is increased

corresponding to the hole because of loss of the foveal tissues and is decreased in the surrounding fluid cuff due to the presence of subretinal fluid and/or thickening of the neurosensory retina.[14–17] On the other hand, the preoperative fundus autofluorescence in our three cases with MH did not have an increase in intensity over the hole but a hyperautofluorescent ring surrounding the area of the fluid cuff.

The reason for the difference in fundus autofluorescence pattern between the earlier reports and our three cases was not determined. However, it is possible that the difference is because our cases were long-standing MHs; cases 2 and 3 were diagnosed with MH 13 and 15 years earlier, respectively, and case 1 had a large MH at presentation although the patient did not know the exact duration of the MH. Earlier studies on the natural course of untreated MHs showed that MHs detected early were generally small at <400 μm, and that they enlarge and develop into mature MHs of ≥400 μm.[22–24] In our cases, the preoperative minimal diameters of our MHs were 864 μm, 681 μm, and 818 μm.

Thus, we suggest that photoreceptors were absent in the central area of the hole for a long time in our three cases. In most cases of MH, the central area has a hyperautofluorescent image because of the absence of foveal tissues that attenuate the fundus autofluorescence signal. However, we suggest that the intensity of the central fundus autofluorescence image in our three cases was not increased because of the prolonged absence of photoreceptors. In addition, Chung et al discussed the possibility that the function of bare central retinal pigment epithelium would be compromised from photo-oxidative damage or long-term lack of normal interaction with retinal tissues.[25]

Shiragami et al[17] reported on the surgical results of 78 cases with MH, and showed a preoperative hyperfluorescence of the fundus autofluorescence corresponding to the central area of the full-thickness MH. The mean duration of the MHs was 3.4 months, and the mean preoperative visual acuity was 0.61 in logarithm of the minimal angle of resolution (logMAR) units. The mean visual acuity was 0.17 logMAR units 6 months after vitrectomy. A continuous external limiting membrane line was seen in 97.4% of the eyes and a continuous IS/OS line was seen in 83.3% of the eyes 6 months after the vitrectomy. In two of our cases, the duration of the MH was over 10 years. The mean preoperative and postoperative visual acuity of the three cases was 1.03 and 0.83 in logMAR units, respectively. One of the three cases was not closed anatomically, and the other two cases did not show a recovery of both the external limiting membrane and IS/OS lines 6 months after successful vitrectomy. These results

suggest that MHs with a hyperautofluorescent ring have poor outcomes both anatomically and functionally.

The long-term observational study with a follow-up period of ≥5 years by Casuso et al[24] reported that retinal pigment epithelium atrophy developed beneath the rim of the fluid cuff in eyes with untreated MH. They also mentioned that MHs generally enlarge and develop into mature MHs (≥400 μm), and visual acuity generally stabilizes at the 20/200 to 20/400 level. Our findings are in good agreement with their observations: in the three cases with the hyperautofluorescent ring corresponding to the depigmented ring, the size of the holes was ≥400 μm and the preoperative decimal BCVA ranged from 0.08 to 0.1. If the hyperautofluorescent ring results from retinal pigment epithelium atrophy, it is no wonder that the size of the hyperautofluorescent ring remained unchanged after vitrectomy despite the decrease in MH size or successful closure of the MH.

In conclusion, we reported three MH cases with a hyperautofluorescent ring. Our findings suggest that this fundus autofluorescence pattern in eyes with MH may be an indicator of poor surgical prognoses both anatomically and functionally.

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Disclosure

The authors have no proprietary interest or conflict of interest in any aspect of this report.

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