Objective: To investigate the relation between foveal findings and visual function in eyes with a resolved idiopathic macular hole after vitreous surgery.

Methods: We divided 28 eyes with postoperative idiopathic macular hole resolution into 3 groups based on postoperative biomicroscopic foveal findings of complete closure, partial closure, or atrophic closure. To evaluate foveal retinal function, scanning laser ophthalmoscope (SLO) microperimetry was performed preoperatively and 6 months postoperatively.

Results: Postoperatively in 18 eyes (64%), the foveal images became normal or almost normal and were classified as having complete closure, 6 eyes (21%) were classified as having partial closure, and 4 eyes (14%) as having atrophic closure. The corresponding visual acuity levels 6 months postoperatively were, respectively, 0.10, 0.35, and 0.64 (P<.01) based on LogMAR analysis. Preoperative SLO microperimetry detected an absolute scotoma at the bottom of all macular holes; postoperatively, the absolute scotoma disappeared in the 18 eyes with complete hole closure, but a relative scotoma was detected in 6 eyes. Of 6 eyes with partial closure, 1 had an absolute scotoma and 5 had a relative scotoma. An absolute scotoma was detected in 4 eyes with atrophic closure.

Conclusions: After macular hole closure, SLO findings correlate both with biomicroscopic findings and foveal function. Better anatomical foveal recovery in eyes after macular hole closure results in better improvement of vision than in eyes in which the foveal anatomical findings are not as good.

PATIENTS AND METHODS

We studied 28 eyes of 24 patients (15 women and 9 men) with a resolved idiopathic macular hole after vitreous surgery, which was performed in the Department of Ophthalmology, Asahikawa Medical College, Asahikawa, Japan. Four patients underwent bilateral surgery. The mean patient age was 61 years (range, 46-72 years).

A macular hole was diagnosed on the basis of the presence of a full-thickness neurosensory retinal defect on biomicroscopic observation, a positive Watzke-Allen test result, and central hyperfluorescence on fluorescein angiography. The holes were graded according to the Gass classification.13 Seven eyes (25%) were classified as having a stage 2 hole, 17 stage 3 (61%), and 4 stage 4 (14%). Vitreous surgery was performed as described previously.7 Surgery consisted of a 3-port pars plana vitrectomy; for stage 2 and 3 holes, the posterior cortical vitreous was detached by using an aspirating forceps to grasp the Weiss ring, and vitrectomy was completed as far as possible at the vitreous base. If a preretinal membrane was present around the hole, it was removed. Fluid-gas exchange was performed, followed by aspiration of the residual fluid 10 minutes later. Approximately 0.1 mL of autologous serum was applied to the hole. Finally, the vitreous cavity was filled with a mixture of 16% perfluoropropane and air. The patients were placed on their backs for the first 3 to 6 hours postoperatively and then were instructed to remain facedown for 2 weeks.

In the present study, eyes were defined as having achieved macular hole closure if at least the neurosensory retinal detachment surrounding the macular hole was resolved and the edge of the hole was flat. The biomicroscopic foveal findings of hole resolution were classified into 3 categories by a masked observer (T.H.): complete closure, in which the foveal image was normal or almost normal (Figure 1), with limited discoloration of the retinal pigment epithelium (RPE) (Figure 2); partial closure, in which the edge of the macular hole flattened but was not apposed (Figure 3); and atrophic closure, in which the edge of the macular hole flattened but was not apposed, and massive RPE degeneration was present at the bottom of the hole, which allowed the choroid to be easily observed (Figure 4).14

Scanning laser ophthalmoscope (Rodenstock Inc, Munich, Germany) microperimetry was performed in all eyes preoperatively and approximately 6 months postoperatively. Small flashing spots produced by a helium-neon red laser were used as visual stimuli of static microperimetry. With SLO microperimetry, the stimulus intensity can vary in 0.1-logarithmic steps from 0 to 31 dB; 0 dB (equivalent to the standard value of 6200 candela [cd]/m2) represents the brightest luminance. We used 0 dB and 20 dB as the test stimuli. We defined an absolute scotoma as one in which the stimulated area could not be detected with a 0-dB spot, and a relative scotoma as one in which the stimulated area could be detected by a 0-dB spot but not by a 20-dB spot. The other parameters were as follows: stimulation time, 100 milliseconds; stimulation spot size, 12 × 12 pixels squared (equivalent to 557.8 minutes of arc square, which corresponds to a Goldmann size III stimulus on the retina); with a resolution of 2 minutes of arc (10 µm); and retinal background illumination, 10 cd/m2 of a helium-neon laser.

The best-corrected visual acuity was recorded in all patients preoperatively and at various times postoperatively. Color fundus photography and fluorescein angiography also were performed.

Visual acuity levels 6 months postoperatively were converted to the logarithm of the minimum angle of resolution (LogMAR) for statistical analysis. The Kruskal-Wallis test was used for statistical comparison of the variables among the 3 groups of postoperative biomicroscopic foveal findings. The research protocol was approved and written informed consent was obtained from all patients.

Our results showed that functional assessment performed by SLO microperimetry demonstrated different types of anatomical macular hole closure, and that better anatomical foveal recovery in eyes after macular hole surgery may facilitate greater improvement of visual function compared with eyes in which good anatomical foveal recovery was not achieved postoperatively. The degree of scotoma resolution correlated with the foveal anatomical findings. Better scotoma resolution can result in better visual acuity postoperatively. Moreover, the duration of the disease was related to the type of hole clo-
sure, which correlated with visual function, after successful surgery.

The mechanism of visual function recovery in eyes after successful macular hole surgery has not yet been confirmed. In 1995, Gass\(^1\) postulated that in eyes with a macular hole, retinal photoreceptors are displaced centrifugally and most prehole opacities probably do not have retinal receptors. Furthermore, he suggested that surgical retinal reattachment surrounding the hole and centripetal movement of the foveolar retina induced by gliosis might restore foveal anatomy and function to near normal. Other studies demonstrated that prehole opacities found intraoperatively did not have retinal photoreceptors,\(^1\) which supported the hypothesis of Gass. The histopathologic appearance after successful macular hole surgery suggested a progressive reapproximation of tissues, because the extent of the photoreceptor defect was much smaller than the size observed clinically before surgery. Centripetal relocation of the photoreceptors also may account for visual functional improvement.\(^1\)\(^9\)\(^2\)

It is well known that cataract formation has a significant effect on visual acuity results. Generally, cataract surgery is performed from about 6 months after macular hole surgery, with a peak at 12 months after macular hole surgery.\(^2\)\(^1\) It also is known that although improvement in visual function continues for 3 years after macular hole surgery, rapid progressive visual acuity improvement has been shown within the first 6 months postoperatively.\(^2\)\(^1\) Therefore, we used the 6-month postoperative visual acuity measurements as representative of the postoperative visual acuity levels.

We classified eyes as having atrophic closure when the edge of the macular hole flattened but was not apposed and when massive RPE degeneration was present at the bottom of the hole, and categorized these eyes separately from those with partial macular hole closure, because our clinical impression before the onset of this study was that eyes with massive RPE degeneration had poor visual acuity improvement after macular hole surgery. One of 17 eyes with a stage 3 hole and 3 of 4 eyes with a stage 4 hole were classified with atrophic closure. In all 4 eyes classified with atrophic closure, drusen formation and RPE depigmentation were observed preoperatively. In these eyes, the estimated duration of macular hole was longer. It is well known that drusen formation and RPE depigmentation in the area of the hole and surrounding cuff are observed in some eyes with a macular hole of several months’ or years’ duration.\(^2\)\(^2\)\(^3\) In eyes such as these, even if the macular hole is closed successfully...
with vitreous surgery, visual function may not recover because of this long-term damage. Thus, patients with chronic macular holes may not be good candidates for vitreous surgery. Good anatomical recovery is necessary to obtain good visual function after macular hole surgery. From the results of the present study, we recommend performing macular hole surgery soon after hole development to obtain good functional recovery.

Guez and associates reported that using the SLO, they observed that the scotoma disappeared in 19 (76%) of 25 cases in which the macular holes closed completely and 4 (57%) of 7 cases in which the hole shrank or was barely visible postoperatively. Similar to our findings, those authors demonstrated that there is a correlation between different types of macular hole closure and foveal function.

After macular hole closure, the SLO findings correlated both with biomicroscopic findings and foveal function. The SLO demonstrates different types of macular hole closure and can provide valuable information to evaluate the results of macular hole surgery.

Figure 5. Preoperative scanning laser microscopic microperimetry. An absolute scotoma (small black circle) was detected at the bottom of the hole in all 28 eyes. A relative scotoma (large black circle) also was detected corresponding to the surrounding cuff if one was present. The red and yellow circles indicate where 0- and 20-dB test stimuli could be detected, respectively. The red and yellow triangles indicate where 0- and 20-dB test stimuli could not be detected, respectively.

Figure 6. Postoperative scanning laser microscopic microperimetry of eyes with complete hole closure. Both absolute and relative scotomata resolved. The red and yellow circles indicate where 0- and 20-dB test stimuli could be detected, respectively.

Figure 7. Postoperative scanning laser microscopic microperimetry of eyes with partial hole closure. A relative scotoma was detected within the area indicated by the black circle. The red and yellow circles indicate where 0- and 20-dB test stimuli could be detected, respectively. The yellow triangle indicates where 20-dB test stimuli could not be detected.

Figure 8. Postoperative scanning laser microscopic microperimetry of eyes with atrophic closure. An absolute scotoma was detected within the area indicated by the black circle. The red and yellow circles indicate where 0- and 20-dB test stimuli could be detected, respectively. The red triangles indicate where 0-dB test stimuli could not be detected.

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Reprints: Taiichi Hikichi, MD, Department of Ophthalmology, Asahikawa Medical University, 4-5 Nishikagura, Asahikawa 078-8307, Japan (e-mail: hikichi@asahikawa-med.ac.jp).

REFERENCES

A look at the past . . .

The graft must be in contact with good corneal stroma in as great an area as possible, otherwise satisfactory clarity will not result. The recent trend to the use of larger grafts has been attended with greater visual success. Scarring at the edges of a large graft has less chance of encroaching on the central visual area. The graft must not be large enough to interfere with the angle of the anterior chamber or to allow incarceration or prolapse of the iris at the edges. Beveling of the edges of the graft or the recipient cornea is not necessary.