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The Effect of an Inverted Internal Limiting Membrane Flap on Retinal Function after Macular Hole Surgery

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Purpose: To study the effect of an inverted internal limiting membrane (ILM) flap on the retina.

Design: Prospective case series.

Participants: Twenty-nine patients with large (>400 μm) unilateral macular holes underwent surgery using a modified inverted ILM flap technique.

Methods: The macular ILM was peeled, and a large (2−3 disc diameter) ILM flap was made on the superior side of the hole, and then the flap was inverted on the inferior side.

Main Outcome Measures: In all patients, multifocal electroretinograms (mfERGs) were recorded from operated eyes and normal fellow eyes. The peak time and amplitude of N1, P1, and N2 in the focal ERG from the upper retina without the ILM flap and those from the lower retina with the ILM flap were evaluated. In 14 patients, microperimetry was also performed in both eyes, and the averaged sensitivity was measured from the upper and lower areas.

Results: The peak times of P1 and N2 from the upper and lower retina were significantly longer in operated eyes than in the fellow eyes (P1 upper and lower: $P < 0.04$, N2 upper: $P < 0.01$, and N2 lower: $P < 0.04$), although we could not identify a significant difference in peak time and amplitude of N1, P1, and N2 between the upper retina and lower retina in both eyes (fellow eye—N1 amplitude: $P > 0.2$, N1 peak time: $P > 0.5$, P1 amplitude: $P > 0.9$, P1 peak time: $P > 0.4$, N2 amplitude: $P > 0.9$, N2 peak time: $P > 0.9$; operated eye—N1 amplitude: $P > 0.8$, N1 peak time: $P > 0.4$, P1 amplitude: $P > 0.6$, P1 peak time: $P > 0.4$, N2 amplitude: $P > 0.9$, N2 peak time: $P > 0.9$). We could not observe a significant difference in sensitivity between the upper and lower retinas in both eyes (fellow eye: $P = 0.28$, operated eye: $P = 0.66$).

Conclusions: The results of this study revealed no significant difference between the upper retina without the ILM flap and the lower retina with the ILM flap, suggesting that an inverted ILM flap has little effect on retinal function. *Ophthalmology Retina 2017;■:1−7 © 2017 Published by Elsevier Inc. on behalf of the American Academy of Ophthalmology*

Kelly and Wendel[1] and Wendel et al[2] reported that macular holes could be closed by vitrectomy, and it was later reported that the use of internal limiting membrane (ILM) peeling increased the success rate.[3] However, the success rate was not satisfactory for large macular holes, for which the inverted ILM flap technique was developed.[4,5] Using this technique, macular holes larger than 400 μm can be closed with a high success rate. This technique has been applied for macular holes in highly myopic eyes,[6,7] macular holes in patients who cannot be in a facedown position,[8] and macular holes in patients with uveitis.[9] Further, several modified techniques have been reported.[10−12]

However, the effect of an inverted ILM flap on retinal function has not been studied, though that of ILM peeling on the retina has been investigated.[13] It is well known that the ILM, which represents the basement membrane of retinal glial cells (Müller cells), buffers intraretinal potassium,[14] and a recent report indicated that disturbance in potassium buffering affects the function of the retina.[15] Thus, it is possible that the inverted ILM flap technique exerts some effects on retinal function by disturbing ion buffering. We recorded multifocal electroretinograms (mfERGs) using skin electrodes and measured subjective sensitivity with microperimetry to evaluate the effects of the inverted ILM flap on retinal function.

Methods

Subjects

Participant characteristics are shown in Table 1. Twenty-nine patients (age: 69.0±7.33 years; 21 women and 8 men) with large unilateral idiopathic macular holes were recruited for this study. Patients with ocular diseases in fellow eyes were excluded. Patients whose eyes exhibited traumatic macular holes and those with pathologies other than macular holes were also excluded. The average diameter of the macular holes was 590.5±100.5 μm

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Table 1. Patient Information

Patient Characteristics	
Age (yrs)	69.0±7.33
Sex	
Male	8
Female	21
Preoperative acuity (LogMAR)	0.82±0.28
Postoperative acuity (LogMAR)	0.23±0.25
Size of macular hole (μm)	590.5±100.5 (minimum, 427; maximum, 761)
ERG recording, microperimetry	31.5±10.9 months after surgery

ERG = electroretinogram.

(minimum: 427 μm; maximum: 761 μm). Informed consent was obtained from all patients after explanation of the surgery and this study. Institutional Review Board/Ethics Committee approval was obtained from Fujita Health University. The described research adhered to the tenets of the Declaration of Helsinki.

Surgical Technique

Our technique was similar to the modified inverted ILM flap technique reported by Shin et al.[11] First, the ILM was peeled off from the inferior side of the macular hole (Fig 1A) and a large ILM pedicle flap (2−3 disc diameters) was made (Fig 1B). The ILM pedicle flap was attached to the retina around the macular hole. This flap was inverted to cover the macular hole (Fig 1C), and a small amount of viscoelastic was placed on the flap. The differences between our technique and Shin's technique were that we used viscoelastic instead of perfluoro-octane and that our ILM flap was much larger than Shin's flap.

Retrobulbar anesthesia was induced via the sub-Tenon space using a technique we had previously developed, following which surgery was initiated.[16] We performed phacoemulsification and intraocular lens (IOL) insertion in all eyes. We performed vitrectomy using a 25-gauge system and operating microscope with a wide-angle-view system that we had previously developed.[17,18] A posterior vitreous detachment was formed using a cutter in cases without posterior vitreous detachment, and we removed as much of the peripheral vitreous as possible. Using triamcinolone acetonide,[19] we visualized the ILM and made and inverted an ILM flap (Fig 2). A small amount of viscoelastic was injected on the inverted flap, and we performed fluid−air exchange. Without removing the viscoelastic on the flap, we injected 18% sulfur hexafluoride (SF6) into the vitreous cavity. Recently, Brilliant Blue dye has been used for visualizing the ILM,[20] although we used triamcinolone acetonide because it provides a better view of the ILM flap after fluid−air exchange.

After the surgery, patients were maintained in a sitting position for 3 hours, and then in the facedown position. The patients were asked to remain in the facedown position for 3 days.

Evaluation Methods

Multifocal Electroretinogram. We recorded mfERGs using the VERIS system (Science version 4.0; EDI, San Mateo, CA) and recording techniques reported previously.[21,22] In this study, we used 4-spot stimuli designed for recording a focal response from the retina without the ILM (upper semicircle) and from the retina with the inverted ILM (lower semicircle) (Fig 3A, B). Figure 3A illustrates the stimulus on the monitor, and Figure 3B shows the focal ERGs and stimulated area superimposed on the fundus. The postoperative ocular surface may be vulnerable, so we used skin electrodes instead of contact lens electrodes for recording: The active electrode was on the lower lid, the reference electrode was on the temple, and the ground electrode was on the earlobe. The parameters for mfERG were as follows: 75 Hz base rate, 2.67 cd/m^2 stimulus intensity, and 10−300 Hz band-pass filter. Recording time was 7 minutes and 17 seconds.

Microperimetry. Subjective retinal sensitivities were measured with microperimetry (MP-1; Nidek Technologies, Padova, Italy). The MP-1 provides a 45° view of the fundus with automated correction for eye movement. In this study, we performed microperimetry with pupil dilation. The grid selected was a 45-point stimulus covering the central 6°, with a Goldmann size of III (Fig 4A). The white stimuli were projected onto a white background illumination, 1.27 cd/m^2, and the presentation time was 100 ms. The maximum luminance of the stimulus intensity

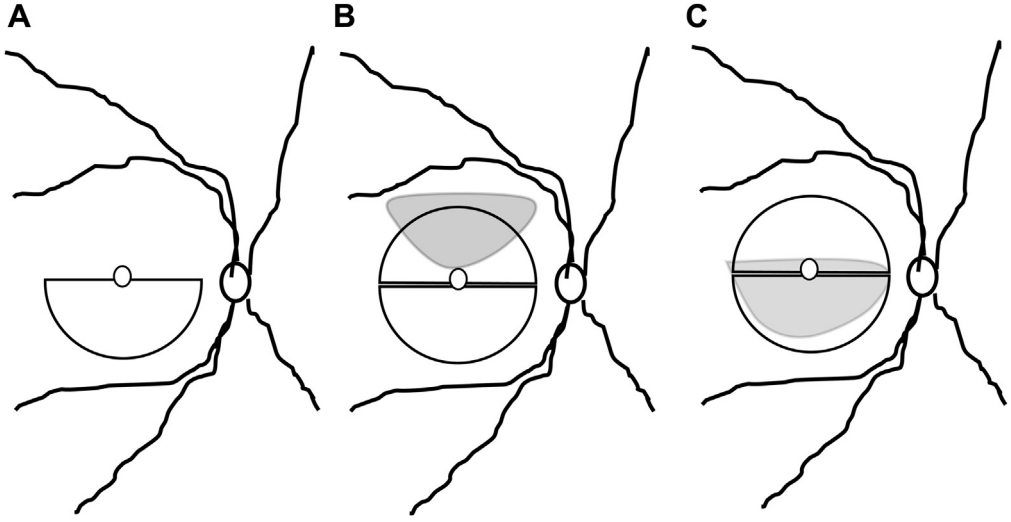

Figure 1. The inverted internal limiting membrane (ILM) flap procedure. **A**, The ILM on the inferior side of the macular hole is peeled off. **B**, A large ILM pedicle flap (2−3 disc diameters) is made, and this flap is attached to the edge of the macular hole. **C**, This flap is inverted to cover the macular hole, and a small amount of visco-elastic is placed on the flap.