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Case Report

Macular Hole Repair: Result of the Inverted Flap Technique-A Case Series

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Abstract

Macular hole (MH) affects the central macula, causing visual impairment, metamorphopsia, and central scotoma. Vitrectomy with internal limiting membrane (ILM) peeling and tamponade is the standard treatment. The inverted ILM flap procedure is a newer surgical method that has shown promising anatomical results, particularly in large or chronic macular holes, by improving the rate of anatomical closure. This case series reports four patients with MH treated using vitrectomy with the inverted ILM flap technique using sulfur hexafluoride (SF6) gas tamponade. All patients presented with progressive central vision loss and were diagnosed via optical coherence tomography (OCT). Three of the four patients had a history of symptom duration exceeding three months, and one patient presented within one month of onset. Anatomical closure of the macular hole was achieved in all cases. One patient showed marked improvement in visual acuity, while the others exhibited limited functional recovery. Postoperative OCT imaging confirmed the closure of the defect in all patients. The visual outcomes appear to be influenced by factors such as the duration and size of the macular hole, as well as underlying ocular conditions. These findings highlight the importance of early diagnosis, timely surgical intervention, and patient education in optimizing outcomes for macular hole repair.

Keywords

Macular Hole, Inverted ILM Flap, Pars Plana Vitrectomy, ILM Peeling, Case Series

1. Introduction

A macular hole (MH) is a condition that affects the macula and arises at the vitreoretinal interface. An anatomical discontinuity in the neurosensory retina forms in the center of the macula or fovea. Macular holes lead to central visual impairment, metamorphopsia, and the presence of a central scotoma. The prevalence of idiopathic macular hole (IMH) is up to 1 in 200 people over 60, and bilateral occurrence is recorded in 10% of patients. The macular hole may be linked with severe myopia or result from ocular damage. Nevertheless, most instances are idiopathic. [1]

The categorization is founded on findings from optical coherence tomography. It considers the size and condition of vitreomacular contact. Complete-thickness macular holes are categorized by their dimensions as small (≤250 μm), medium (>250 μm to ≤400 μm), or large (>400 μm). They are further characterized by vitreous status (with or without vitreomacular traction). [2]

Treatment for macular holes has evolved significantly, with vitrectomy becoming the gold standard. In this case series, patients were treated with an inverted ILM flap where the

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internal limiting membrane (ILM) was not completely removed but positioned over the hole. The aim of this case series report is to describe anatomical closure and visual acuity post-operatively after the procedure, highlighting post-operative improvements.

2. Case Presentations

2.1. Case 1

A woman in her 60s presented with a four-month history of progressively blurred vision in both eyes, more severe in the left. She described central vision loss with a dark spot in the left eye. She had no prior ocular surgery, no high myopia, and no family history of similar issues. Her medical and trauma history were unremarkable. Initial examination showed best-corrected refraction 20/160 in the right eye and 2/60 in the left. The anterior segment has bilateral immature cataracts. Funduscopy on the left eye suggested a macular hole. OCT confirmed a complete-thickness macular hole. The laboratory was within normal limits. She underwent vitrectomy with an inverted ILM flap procedure and SF6 gas. At three-month follow-up, OCT showed complete anatomical closure. However, BCVA in the left eye remained 2/60. Figure 1

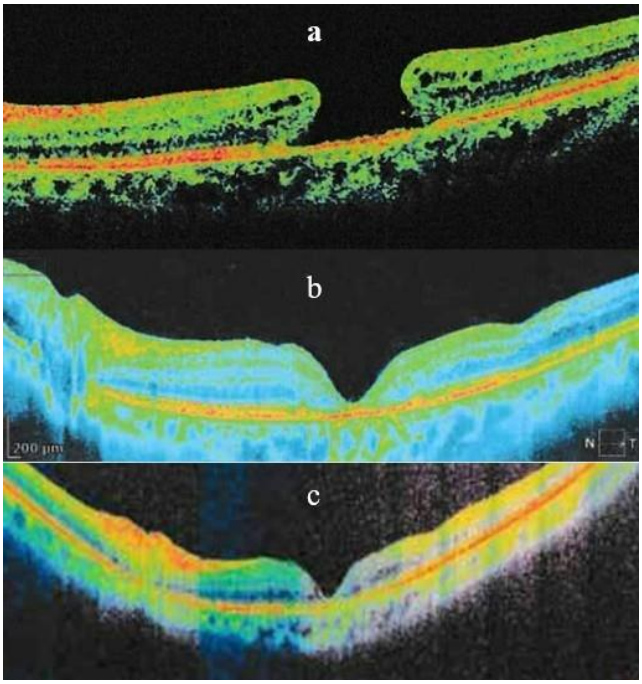

Figure 1. *Case 1. OCT of the macula shows a full-thickness macular hole (a) Two months following the inverted ILM flap method, OCT demonstrates closure of the macular hole (b) and Three months after the procedure (c).*

2.2. Case 2

A woman in her 50s reported with a one-month history of blurred central vision in her right eye. She denied prior ocular trauma, surgery, or medication use and reported no relevant family history. The initial examination showed uncorrectable vision acuity of 20/200 in the right eye and 20/25 in the left. The anterior chamber was normal. Posterior segment on the right eye revealed a macular hole and a 0.7 cup-disc ratio, the left eye was unremarkable. OCT confirmed a complete-thickness macular hole. The patient consented to vitrectomy with an inverted flap and SF6 gas. One month postoperatively, visual acuity improved to 20/100, and OCT confirmed anatomical closure. Four months post-surgery, the patient reported no complaints and was satisfied. Her right vision stabilized at 20/32 and normal intraocular pressure. Figure 2

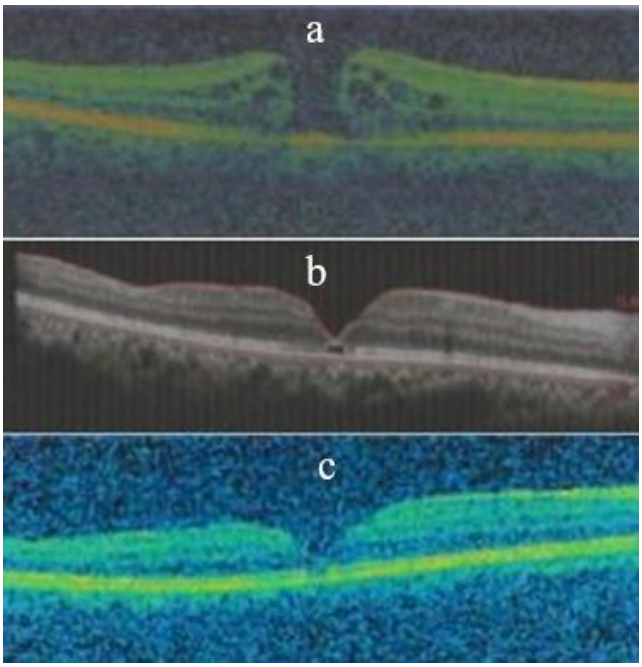

Figure 2. *Case 2. At the initial visit, the OCT of the right eye showed a full-thickness macular hole at the nasotemporal (a). The OCT was performed when the patient visited one month later (b) and 4 months later (c).*

2.3. Case 3

A man in his 70s has had a gradually worsening sight in his right eye for over a month. He had a history of bilateral phacoemulsification and hypertension with poor medication. There was no relevant family history. On initial examination, BCVA was 20/32 in the right and 20/125 in the left eye. The anterior segment showed intraocular lenses in both eyes without signs of inflammation. Posterior examination revealed a macular hole in the right eye and optic disc atrophy in the left eye. The patient consented to vitrectomy and inverted flap with SF6 gas after four months. Three months post-procedure, OCT confirmed anatomical closure, but visual acuity remained 20/100. Figure 3.

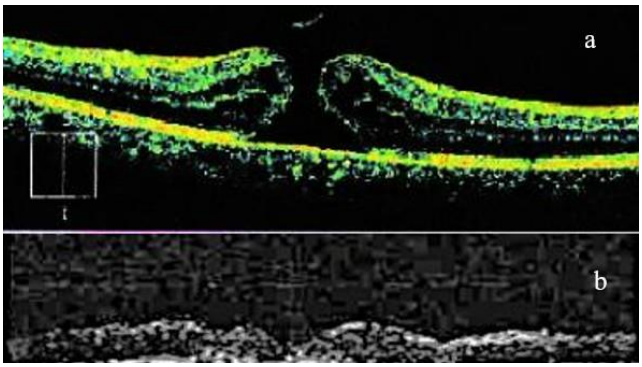

Figure 3. *Case 3. OCT right eye when the patient first came for examination, showing full-thickness macular hole (a), OCT 3 months post-VPP and inverted ILM flap procedure (b).*

2.4. Case 4

A woman in her 60s complained of progressive blurry and shadowy sight in her left eye over the past five months. Her history included cataract surgery with an intraocular lens in the left eye. There was no relevant family history. Refraction revealed 20/25 in the right and 1/60 in the left eye. The anterior segment of both eyes was normal. Posterior examination revealed a macular hole and reduced macular reflex in the left eye. The patient agreed to undergo vitrectomy with an inverted ILM flap and SF6 gas tamponade. After one and four months of follow-up, OCT confirmed anatomical closure of the macula. However, visual acuity in the left eye remained unchanged. Figure 4

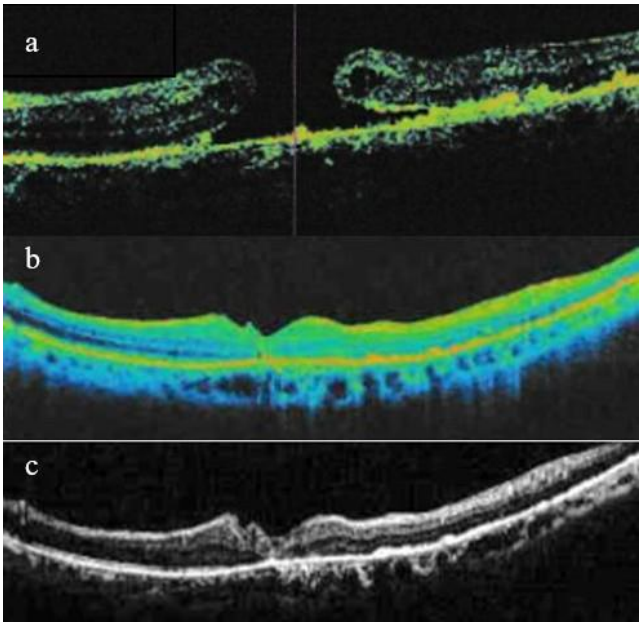

Figure 4. *Case 4. Upper for nasotemporal crossline and bottom for superoinferior crossline. OCT image of the patient's left eye, showing the result of a full-thickness macular hole (A), OCT macula one month post-inverted ILM flap technique (B), OCT macula 4 months post-procedure (C).*

3. Discussion

The definitive treatment for macular holes is vitrectomy combined with internal limiting membrane peeling and gas tamponade. This procedure is thought to enhance the macular structure in the presence of a hole and improve visual acuity, with favorable outcomes. Nonetheless, complicated situations such as extensive macular holes, individuals with severe myopia, and macular holes linked to retinal detachment are associated with unfavorable outcomes, necessitating alternative treatments. These treatment alternatives include an inverted ILM flap, autologous ILM transplant, lens capsular flap technique, neurosensory retinal graft, amniotic membrane, retinotomy, and hydrodissection. [3]

This case series showed that all patients receiving the inverted flap method had favorable retinal hole closure outcomes. All patients were fully informed about the surgical procedure, potential risks, and expected outcomes. Each patient provided written consent, ensuring that they understood the details of the treatment and agreed to participate in the case series. The inverted ILM flap was used because it is believed to provide a significantly improved anatomical closure in cases of macular holes. The ILM is not entirely excised but remains affixed to the peripheries of the MH with the inverted flap technique. The ILM folded toward the macula and stabilized the tissue at the macular hole while flattening the edges. This technique closes and bridges the hole in the macula, which is expected to help the hole's edges without disturbing the microstructure of the fovea. [4]

Shiode et al. found that neurotrophic factors and primary fibroblast growth factors (bFGF) on the ILM flap surface encouraged the growth and migration of Muller cells, providing the closure of the MH and enhancing the wound's healing. [5] Neurotrophic and growth factors are produced by activated Müller cells, which may improve the survival of particular retinal neurons. [6] Furthermore, the ILM flaps establish a sealed compartment that allows the retinal pigment epithelium (RPE) to expel fluid, maintain dryness from vitreous fluid, and stimulate glial cell growth, which later fills the MH and promotes closure. [7, 8] These findings explained the more favorable anatomical outcomes of the group using the inverted ILM flap approach.

Among the four patients in this case series, only the second patient has had a significant visual improvement after surgery. In the study conducted by Ota et al., it was explained that although the macular holes can be closed with this technique, the fovea also loses its layers. In the outer layers, this layer can experience gradual improvement. Still, not in all cases, and it explains that there is no significant difference in the structural changes of the layer after the inverted internal limiting membrane flap or conventional peeling. The findings may elucidate the constraints in the enhancement of visual acuity. [8]

In three patients, postoperative visual acuity was not statistically significant. This might be because the ILM was not

carefully moved while being put on top of the macular hole or into the macular hole. This could have damaged the fovea microstructure and the RPE. Additionally, the inserted ILM could obstruct the photoreceptors at the edges of the MH. The restoration of the foveal structure may be impeded, leading to unfavorable visual consequences. Moreover, the dimension of the macular hole correlates with the extent of the foveal floor, which is linked to the foveal avascular zone's size and results in larger macular holes. Previous research indicates that pre-operative visual acuity and hole size are associated with visual success. The duration of macular hole formation is a significant predictor of visual outcomes. A macular hole duration of over four months diminishes the likelihood of visual success by 50% in patients. Furthermore, reducing the duration before surgery enhances postoperative results and gives a better prognosis. The existence of age-related macular degeneration in individuals with retinal holes significantly influences surgical results. In older people with macular holes, satisfactory visual acuity can be attained without AMD. The closure of the macular hole is not influenced by age. [9-11]

Post-operative care for these four patients is recommended to be in a face-down position for roughly one to two weeks. This positioning is crucial for the procedure's success, allowing the gas bubble to press against the macula. The face-down position was believed to ensure that the gas tamponade remains in contact with the macular region, providing mechanical support for glial proliferation and tissue healing. Moreover, keeps the vitreous fluid from entering the subretinal spaces, which supports hole closure. The length of face-down posturing is significantly associated with the type of tamponade employed in the macular hole procedure. Even though room air may be utilized in MH procedures, prolonged gas has become prevalent to enhance its efficacy. The gases often utilized are sulfur hexafluoride (SF6) and perfluoropropane (C3F8). The long-term use of this gas has been widely adopted up to now, and to ensure the enhancement of its effect, the duration of its use has been extended to one month. [12, 13]

This case series has several limitations that should be acknowledged. One major limitation is that the OCT device used in this study did not support the measurement of the minimum diameter of the macular hole, preventing us from precisely classifying the hole size in each case. Furthermore, access to more advanced imaging technologies, such as enhanced depth imaging OCT, was limited, which restricted our ability to conduct a more detailed structural analysis. These factors may have influenced the interpretation of postoperative outcomes. Future studies with larger sample sizes, standardized measurement tools, and more comprehensive imaging modalities are recommended to validate these findings and to clarify further the predictive factors for anatomical and functional success in macular hole surgery.

4. Conclusion

The inverted ILM flap technique with vitrectomy shows effective anatomical closure in macular hole cases. In this series, all patients achieved anatomical closure, though visual improvement varied. Factors like hole size, duration, and related conditions affected outcomes. Further research with better imaging and larger samples is needed.

Abbreviations

MH	Macular Hole
IMH	Idiopathic Macular Hole
OCT	Optical Coherence Tomography
ILM	internal Limiting Membrane
RPE	Retinal Pigmen Epithelium
SF6	Sulfur Hexafluoride
C3F8	Perfluoro Propane
bFGF	Basic Fibroblast Growth Factors

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The authors have no acknowledgment to declare.

Ethical Approval and Informed Consent

This study was conducted following the ethical standards of the Declaration of Helsinki (1964) and its later amendments. Formal ethical approval was not required for this case series, as per the policies of our institution, given the descriptive nature of the report and the absence of experimental intervention. Written informed consent was obtained from all patients for participation and for the publication of anonymized clinical information and images.

Author Contributions

Reynaldo: Conceptualization, Writing-original draft, Writing-review & editing

Puranto Budi Susetyo: Conceptualization, Writing-original draft, Writing-review & editing, Supervision

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Puranto Budi Susetyo is an ophthalmologist in the Indonesian Army with advanced training in vitreoretinal care. He completed his ophthalmology residency at the University of Indonesia and later pursued a fellowship in vitreoretinal surgery at the same institution. His clinical interests focus on retinal and macular diseases and vitreoretinal procedures.

Reynaldo is a general practitioner who graduated from Universitas Kristen Krida Wacana. He is currently undertaking an internship program in the Department of Ophthalmology at RSPAD Gatot Soebroto, Jakarta, Indonesia. He is actively learning and gaining experience in the field of ophthalmology as part of his preparation to pursue a residency program in ophthalmology in the near future.