Macular Hole Surgery with Inverted ILM Flap

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Disclosure

No financial interests or commercial relationships

Summary

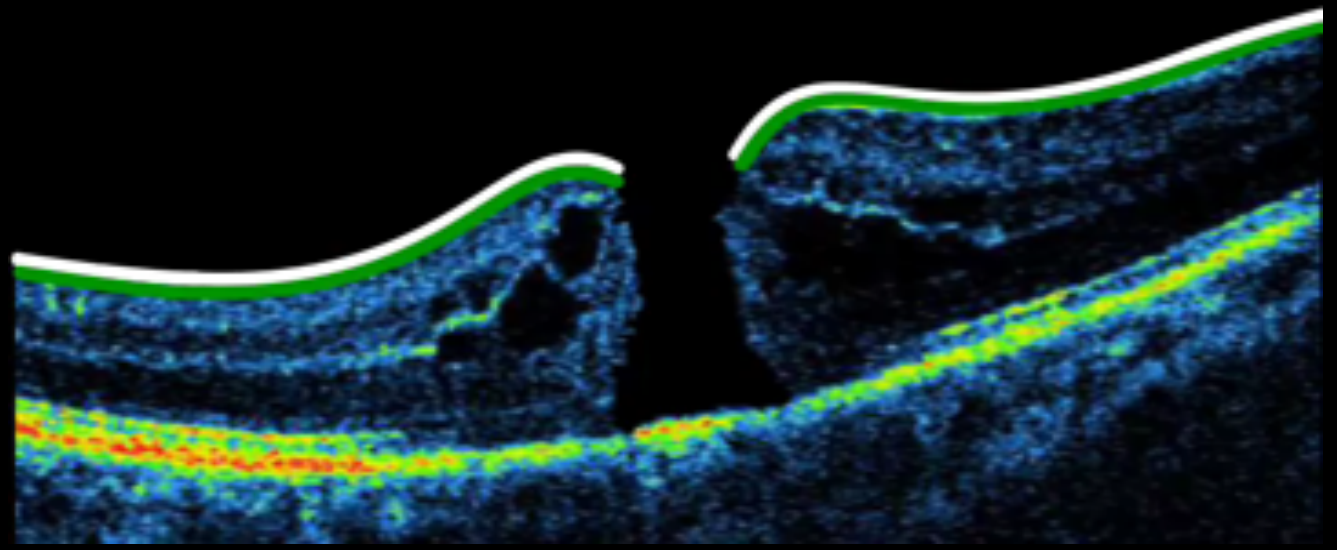
- Inverted ILM flap technique has evolved since its introduction in 2010
- There are over 110 papers on PubMed regarding ILM flap
- The totality of evidence suggest that inverted ILM flap may be considered for a variety of macular holes such as large macular holes, myopic macular holes, macular holes associated with retinal detachment, and refractory holes.

ILM and Macular Hole Surgery

- ILM peel works well in straightforward macular holes
- But ……

ILM and Macular Hole Surgery

- ILM peel works well in straightforward macular holescases.
- But there were challenges with:
    - -Very large macular holes
    - -Macular holes in pathologic myopia
    - -Macular holes with retinal detachment
    - -Refractory macular holes



Ophthalmology 2010; 117:2018-25

Inverted Internal Limiting Membrane Flap Technique for Large Macular Holes

Zofia Michalewska, MD, PhD,[1] Janusz Michalewski, MD, PhD,[1] Ron A. Adelman, MD, MPH,[2] Jerzy Nawrocki, MD, PhD[1]

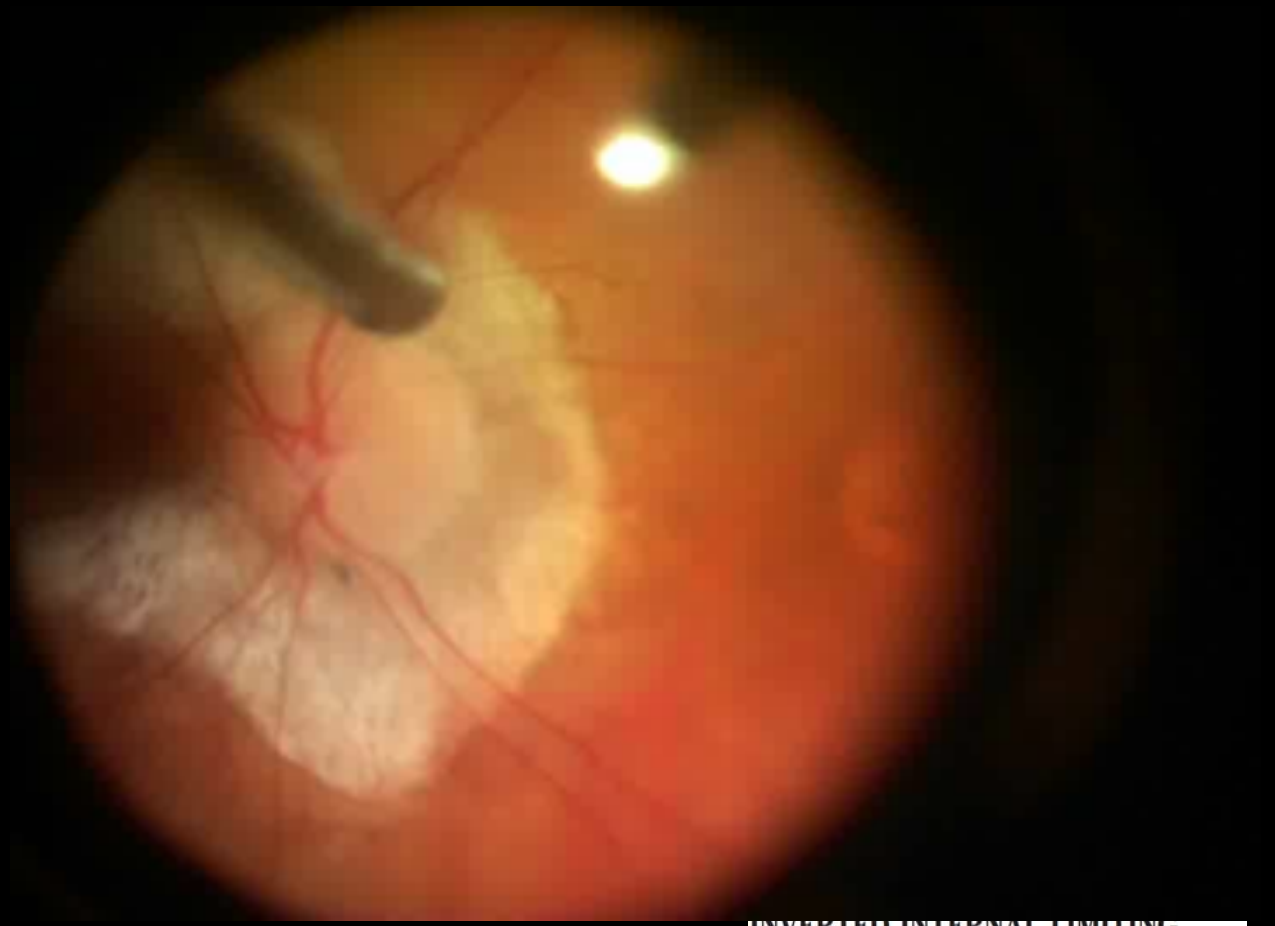
Macular Holes: Comparing Inverted ILM Flap versus Standard ILM Peel

- Stanislo Rizzo compared inverted ILM flap versus ILM peel in a large study
- 620 eyes: 300 eyes standard peel and 320 eyes inverted ILM flap
- Closure rate for inverted flap was 92% versus 79% for ILM peeling P=0.001
- In axial length >26 mm success rate for inverted flap was 88% versus 39% for ILM peeling P=0.001

- Rizzo S, et al. Retina. 38 Suppl 1:S73, 2018

Myopic Macular Holes

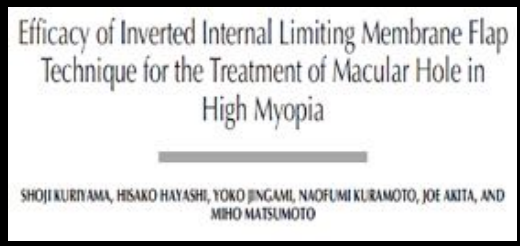
- Prospective, interventional study
- 19 eyes of 18 patients (3 male, 15 female)
- Myopia>6D or axial lenght >26.5mm
- Inverted ILM flap technique
  - 100% closure confirmed with SD-OCT
  - U shape 57%
  - V shape 26%
  - Irregular 16%



	Before surgery	1 week	3 months	6 months	12 months
Mean visual acuity logMAR (Snellen)	1.2 (0.09)	1.2 (0.13)	0.61 (0.38)	0.55 (0.39)	0.56 (0.41)
U type closure		10 (52%)	12 (63%)	12 (63%)	11 (57%)
V type closure		4 (21%)	6 (31%)	5 (26%)	5 (26%)
W type closure		2 (10.5%)	1 (5%)	2 (10.5%)	3 (15.7%)
“flap closure”		3 (15.7%)	0	0	0
Photoreceptor defects		18/19 (94.7%)	14/19 (73.6%)	7/19 (36.8%)	5/19 (26.3%)
ELM defects		18/19 (94.7%)	14/19 (73.6%)	6/19 (28.5%)	6/19 (28.5%)


INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE FOR SURGICAL REPAIR OF MYOPIC MACULAR HOLES

ZOFIA MICHALEWSKA, MD, PhD,* JANUSZ MICHALEWSKI, MD, PhD,* KAROLINA DULCZEWSKA-CICHECKA, MD,† JERZY NAWROCKI, MD, PhD*


Efficacy of Inverted Internal Limiting Membrane Flap Technique for the Treatment of Macular Hole in High Myopia

SHOJI KURIYAMA, HISAKO HAYASHI, YOKO JINGAMI, NAOFUMI KURAMOTO, JOE AKITA, AND MIHO MATSUMOTO

Myopic Macular Hole

- Hu et al compared Inverted ILM flap versus standard ILM peel for myopic macular holes
- 40 eyes
- Anatomic closure of inverted flap was 100% versus 67% for standard peel P=0.009
- Conclusion: ILM flap had better efficacy than ILM peel for patients with myopic hole in closure rate, foveal microstructure and postoperative BCVA

- Hu XT, et al. Br J Ophthalmol 103:1495;2019

TEMPORAL INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE VERSUS CLASSIC INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE

A Comparative Study

ZOFIA MICHALEWSKA, MD, PhD,* JANUSZ MICHALEWSKI, MD, PhD,* KAROLINA DULCZEWSKA-CICHECKA, MD,* RON A. ADELMAN, MD, MPH,† JERZY NAWROCKI, MD, PhD*

Retina, 35:1844, 2015

Prospective, comparative study Inverted ILM flap technique (40 eyes) vs. Temporal Inverted ILM flap technique (40 eyes)

Anatomical closure

- Inverted flap 38/40 eyes
- Temporal inverted flap 37/40 eyes
- No statistically significant difference

TEMPORAL INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE VERSUS CLASSIC INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE

A Comparative Study

ZOFIA MICHALEWSKA, MD, PhD,* JANUSZ MICHALEWSKI, MD, PhD,* KAROLINA DULCZEWSKA-CICHECKA, MD,* RON A. ADELMAN, MD, MPH,† JERZY NAWROCKI, MD, PhD*

	Before surgery	1 week	3 months	6 months	12 months
Mean visual acuity logMAR (Snellen) Inverted Flap	0.92 (0.12)	0.95 (0.11)	0.5 (0.31)	0.56 (0.27)	0.42 (0.38)
Temporal Inverted Flap	0.82 (0.15)	0.92 (0.12)	0.53 (0.29)	0.56 (0.27)	0.33 (0.46)

第67回日本臨床眼科学会講演集（8）原著（上-講演64-4）　臨眼 68(10)：1449-1453, 2014

Hemi-Inverted ILM flap technique 手術を行った黄斑円孔の1年後経過

櫻井 寿也　木下 太賀　田野良太郎
福岡佐知子　高岡 源　真野 富也

Large Holes: Meta-analysis

- Shen et al 2020: Meta-analysis of inverted ILM flap versus standard ILM peel
- Eight studies involving 593 eyes (4 randomized trials and 4 retrospective)
- Hole closure with ILM flap was higher than ILM peel OR=3.95, P=0.003
- Visual acuity on month 3 was significantly better in ILM flap P<0.00001
- Visual acuity on month 6 was not statistically different
- ILM flap has better anatomical outcome the ILM peeling. Flap has significant visual gain in the short term

- Shen Y, et al. BMC Ophthalmol 20:14, 2020

CASE REPORT

Surgical repair of a giant idiopathic macular hole by inverted internal limiting membrane flap

Riddhima Deshpande,[1] Raja Narayanan[2]

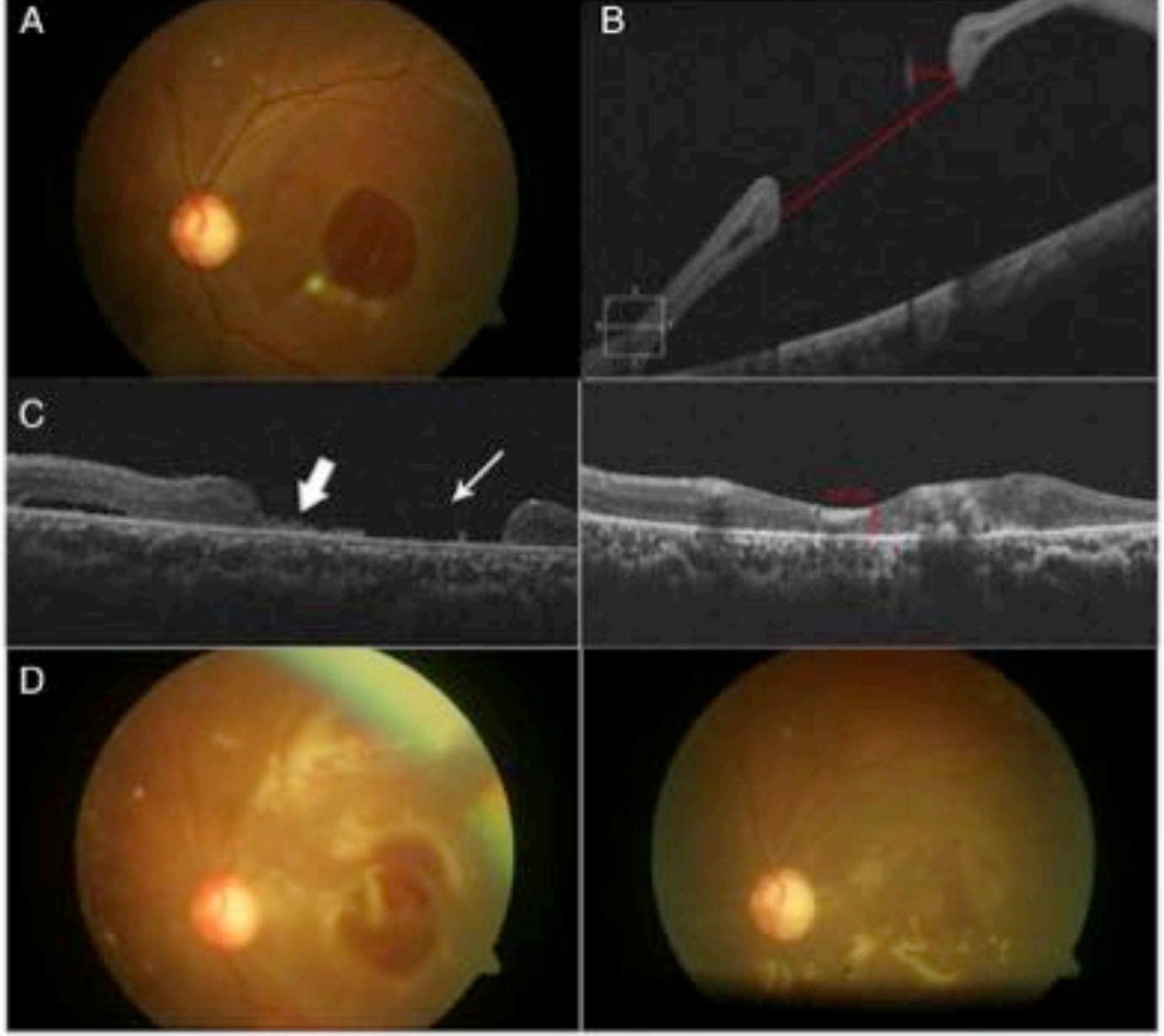


Figure 1 (A) Baseline colour fundus photograph showing a giant macular hole. (B) Optical coherence tomography (OCT) at baseline showing a large hole with retinal detachment. (C) OCT at 1 week showing a thin internal limiting membrane (ILM) flap with edges of the hole attached to the retinal pigment epithelium. Retinal tissue (thick arrow) is seen to be growing under the ILM flap (thin arrow). (D) OCT at 2 months showing the hole to be completely closed.

Macular Hole Retinal Detachment: Meta-analysis

- Yuan et al performed meta-analysis of four retrospective comparative studies of mac hole retinal detachment
- Four studies involving 98 eyes
- The rate of retinal re-attachment (P=0.02) and macular hole closure (P<0.00001) was higher with inverted ILM flap compared with standard ILM peeling
- No significant difference in improvement in postoperative BCVA

- Yuan J et al. BMC Ophthalmol 28;17:219, 2017

High Myopia with Macular Hole and Retinal Detachment: Meta-analysis

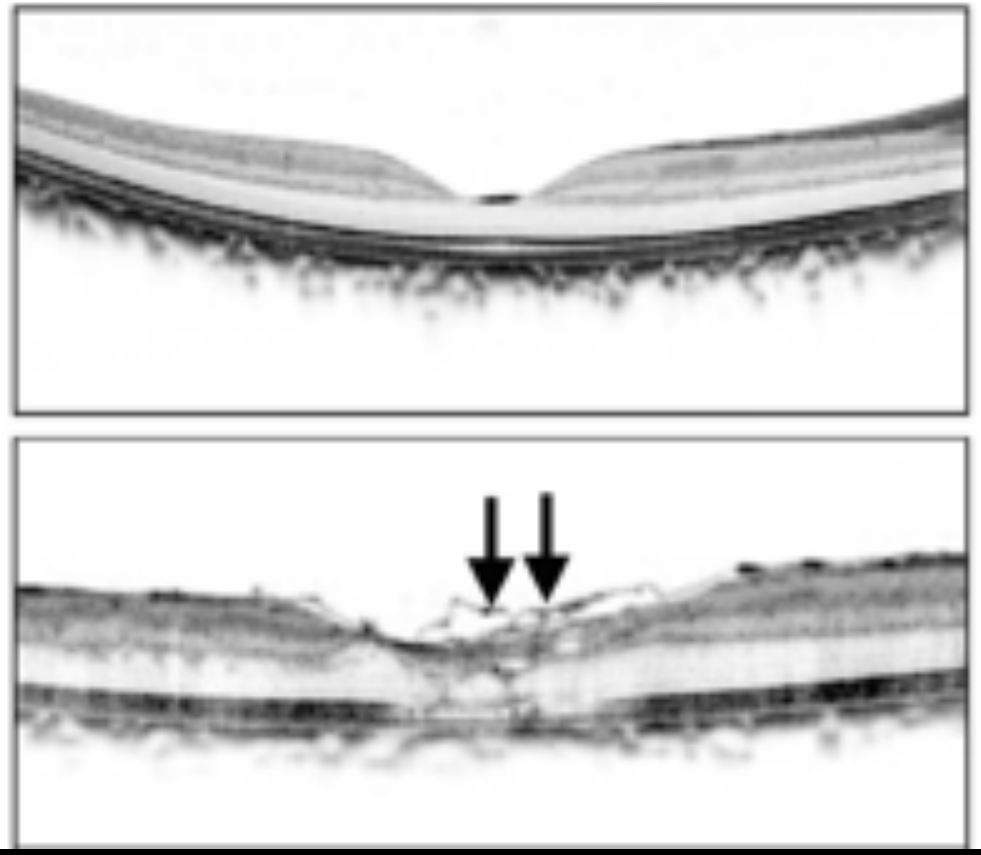
- Xu and Luan performed meta-analysis of seven retrospective comparative studies of mac hole retinal detachment in high myopia
- Seven studies, 228 eyes
- The macular hole closure rate was higher with inverted ILM flap than with standard ILM peeling $P<0.00001$, OR 11.86
- No significant difference in improvement in postoperative BCVA

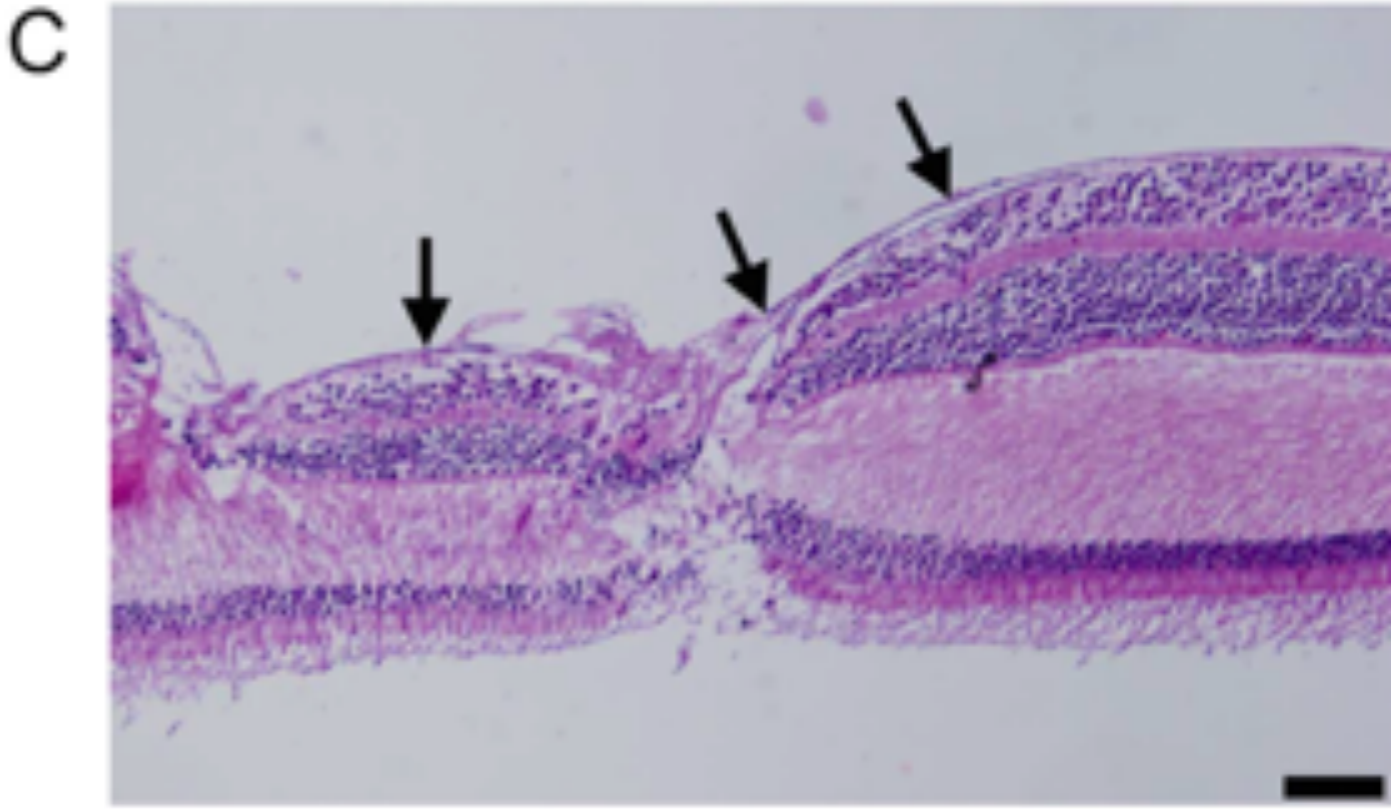
- Xu Q, Luan J. Eye (Lond) 33:1626, 2019

Retinal Cell Biology

The Role of Inverted Internal Limiting Membrane Flap in Macular Hole Closure

Yusuke Shiode,[1] Yuki Morizane,[1] Ryo Matoba,[1] Masayuki Hirano,[1] Shinichiro Doi,[1] Shinji Toshima,[1] Kosuke Takahashi,[1] Ryoichi Araki,[1] Yuki Kanzaki,[1] Mika Hosogi,[1] Tomoko Yonezawa,[2] Atsushi Yoshida,[3] and Fumio Shiraga[1]





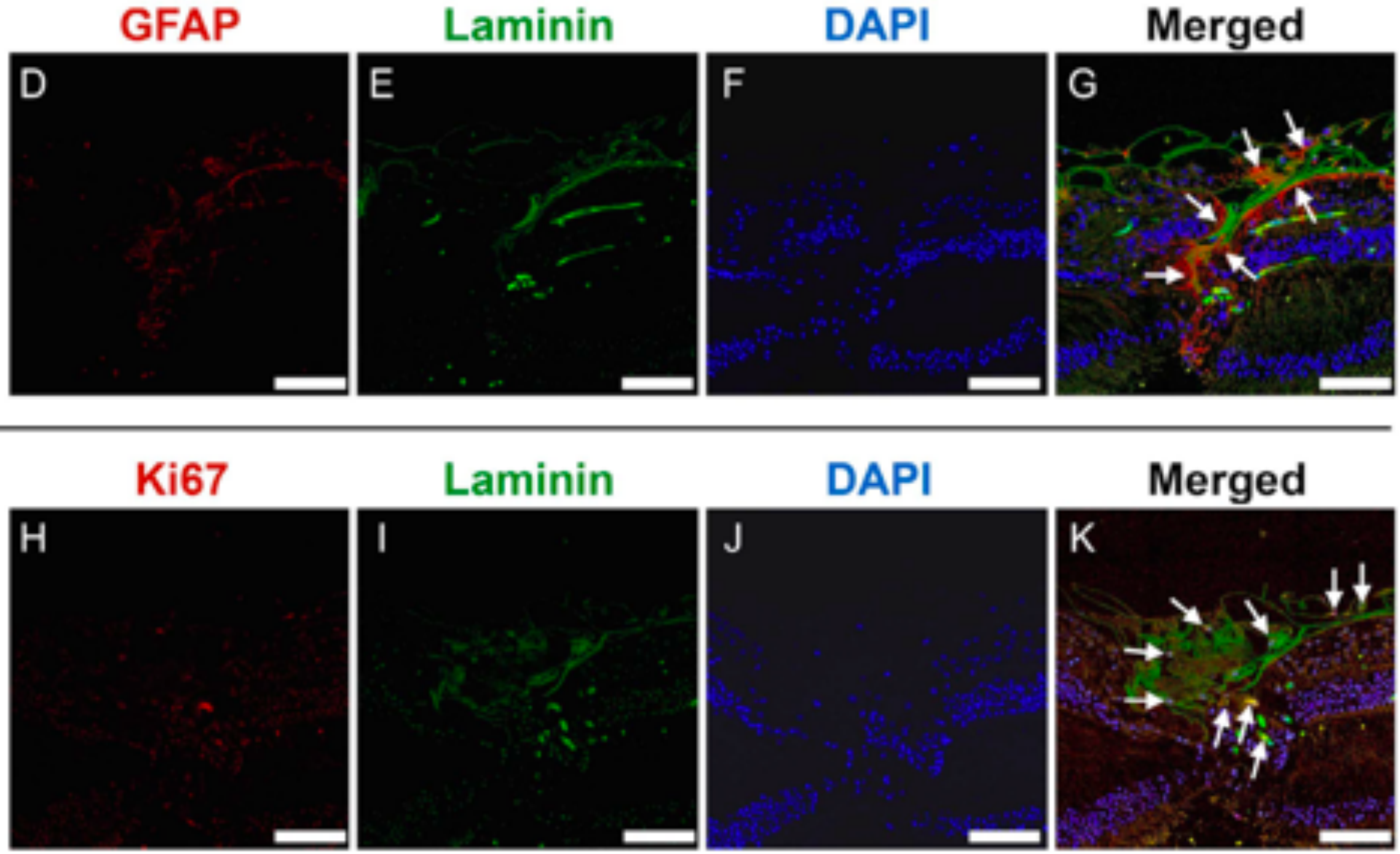


FIGURE 3. OCT images and histologic analysis of an experimental MH after inverted ILM flap technique. Preoperative OCT showing a normal macular structure in a monkey eye (**A**). OCT 10 days after surgery, showing the closure of the MH and the presence of an inverted ILM flap (*arrow* [**B**]). Hematoxylin-eosin staining showing the presence of the ILM flap (*arrows* [**C**]). (**D**–**K**): Immunostaining micrographs showing GFAP-positive cells (*arrows* in [**G**]) and Ki67-positive cells (*arrows* in [**K**]) in contact with and surrounding the ILM flap (laminin in [**E**, **I**]). *Scale bars*: 100 μm.

Citation: Shiode Y, Morizane Y, Matoba R, et al. The role of inverted internal limiting membrane flap in macular hole closure. *Invest Ophthalmol Vis Sci.* 2017;58:4847–4855. DOI: 10.1167/iovs.17-21756

Mechanism: How ILM Flap Contributes to Mac Hole Closure?

- ILM flap is a scaffold for proliferation and migration of Muller cells
- ILM flap dehydrates mac hole by covering macular hole
- Bridge formation between the walls of mac hole under the flap
- Proliferation of glial fibrillary acidic protein cells (GFAP)
- Migration of MIO-MI cells
- Neurotrophic factors and bFGF are present on human ILM
- Type IV collagen, fibronectin and laminin

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Modifications of ILM Flap Technique

- Shape of ILM flap
- Size of ILM flap
- Position and type of ILM flap
  - All around the hole
  - C shape
  - Temporal
  - Upper
  - Single layer
  - Multilayer
  - Pedunculated flap
  - Free flap
- Additional substances (Viscoelastic, perfluorocarbon, blood)

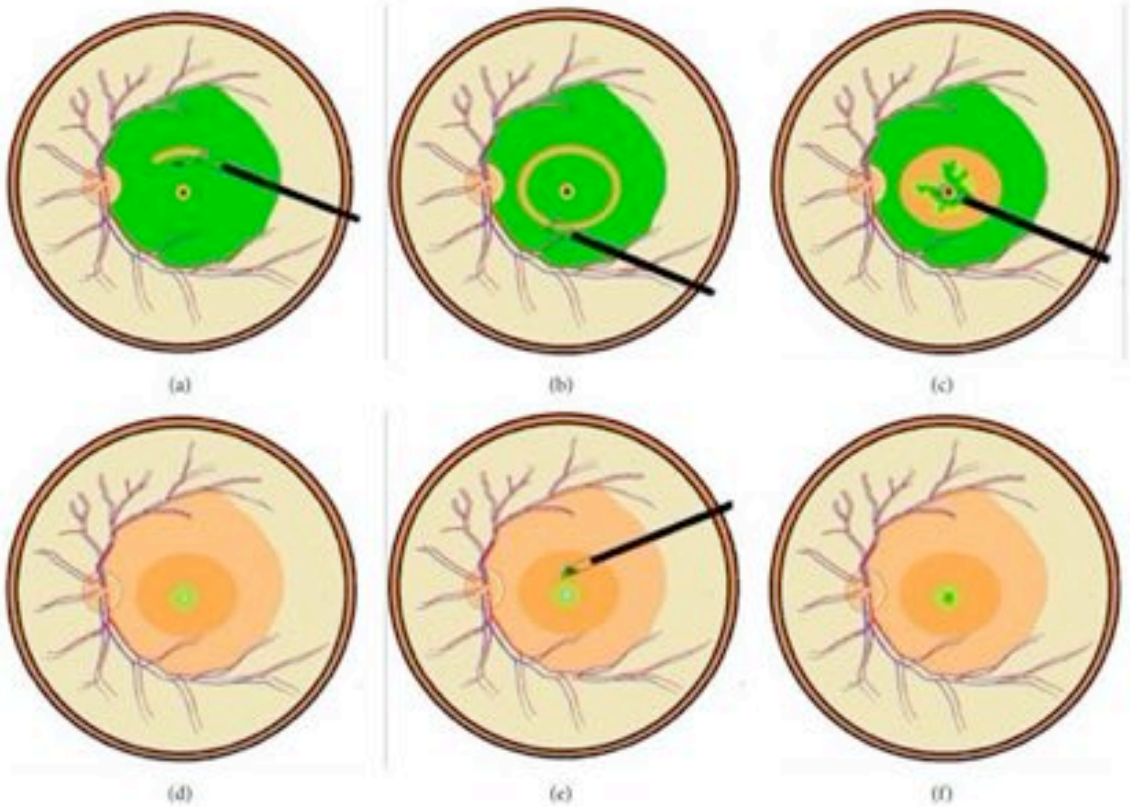


Figure 1

Direct forceps grasping was used to create an ILM break where a good ICG staining had been obtained (a). A ring-shaped ILM flap was created around the macular hole (b). The ILM was detached from the retina to the edge of the macular hole (c). Further anterior ILM peeling was performed up to the arcade along with the overlying ERM. The ILM flap anchoring on the hole edge was inverted and inserted into the hole using microforceps (d). A small amount of Viscoat was then carefully applied on top of the hole. After the infusion was turned off, a piece of the previously obtained free ILM flap was released from the microforceps on top of the macular hole (e). The microforceps with closed tips was used to guide the ILM tissue to fall on the hole and to nudge the free ILM tissue into the hole (f).

J Ophthalmol. 2017; 2017: 3236516.
Published online 2017 Jul 30. doi: 10.1155/2017/3236516
PMCID: PMC5560081
PMID: 28845304

Double Internal Limiting Membrane Insertion for Macular Hole-Associated Retinal Detachment

San-Ni Chen [1, 2] and Chung-May Yang [3, 4, *]

Vitrectomy with Internal Limiting Membrane Repositioning and Autologous Blood for Macular Hole Retinal Detachment in Highly Myopic Eyes

Chi-Chun Lai, MD,[1,2] Yen-Po Chen, MD, PhD,[1,2] Nan-Kai Wang, MD, PhD,[1,2] Lan-Hsin Chuang, MD,[2,3] Laura Liu, MD, PhD,[1,2] Kuan-Jen Chen, MD,[1,2] Yih-Shiou Hwang, MD, PhD,[1,2] Wei-Chi Wu, MD, PhD,[1,2] Tun-Lu Chen, MD[1,2]

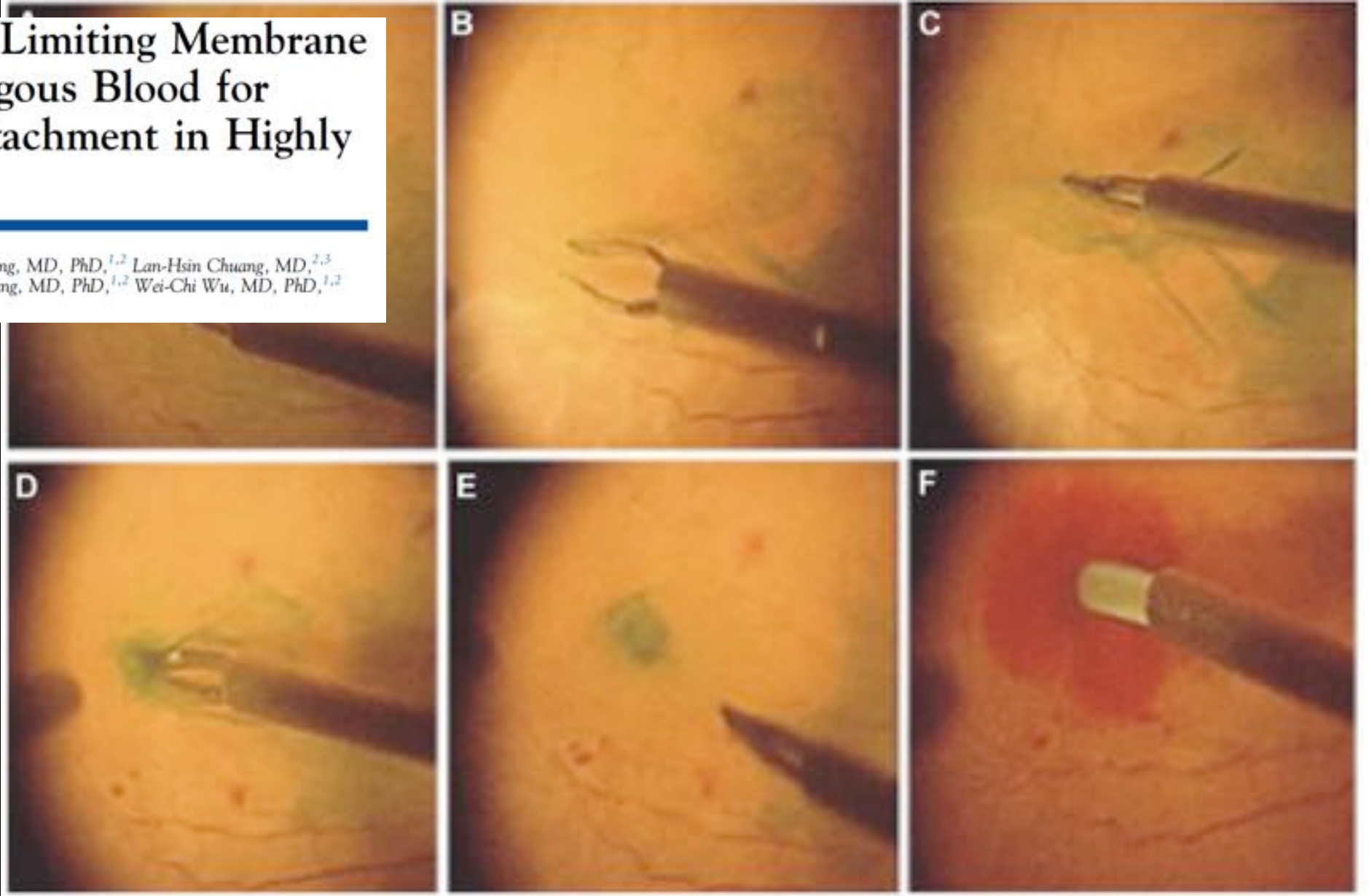
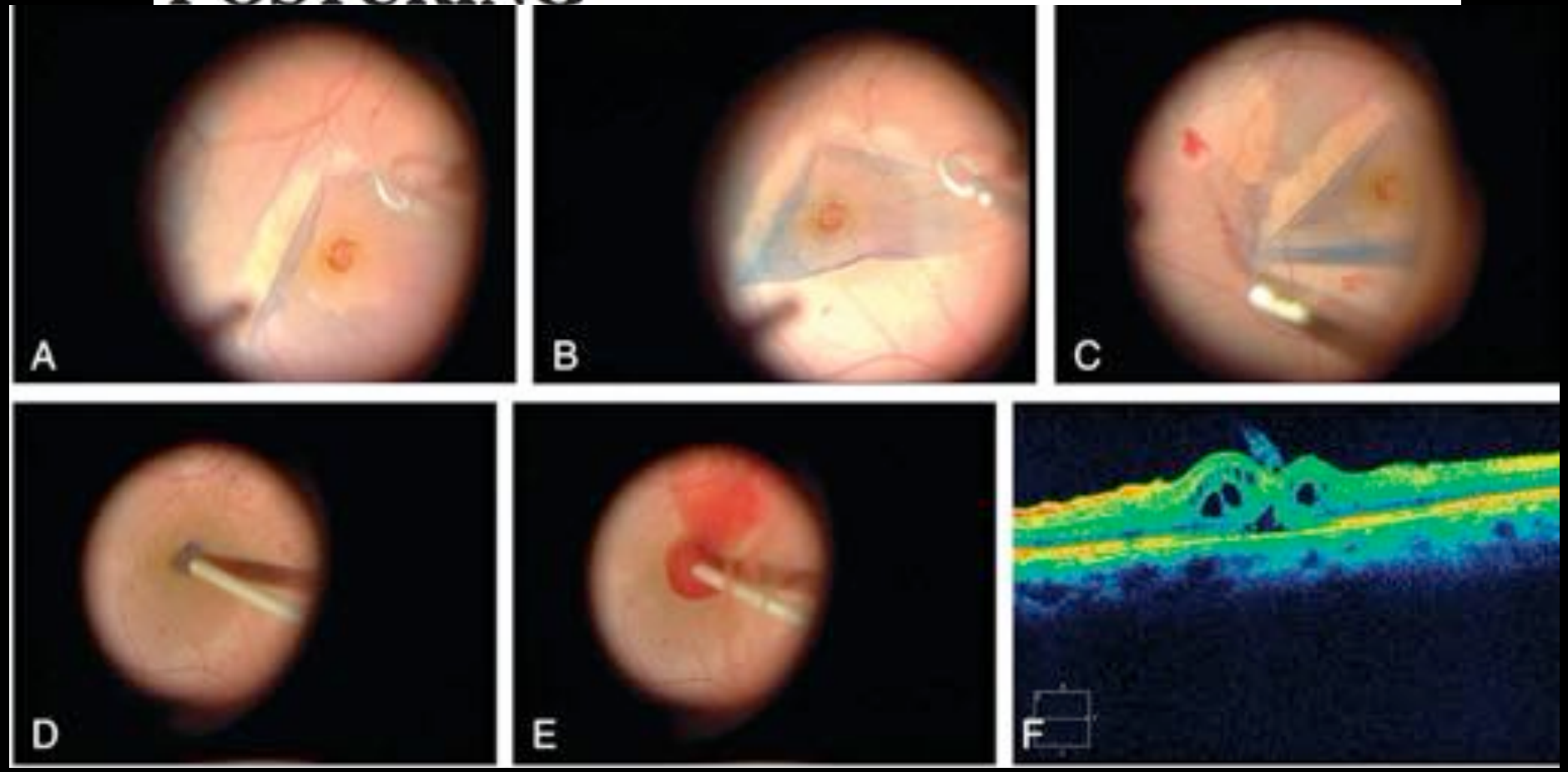


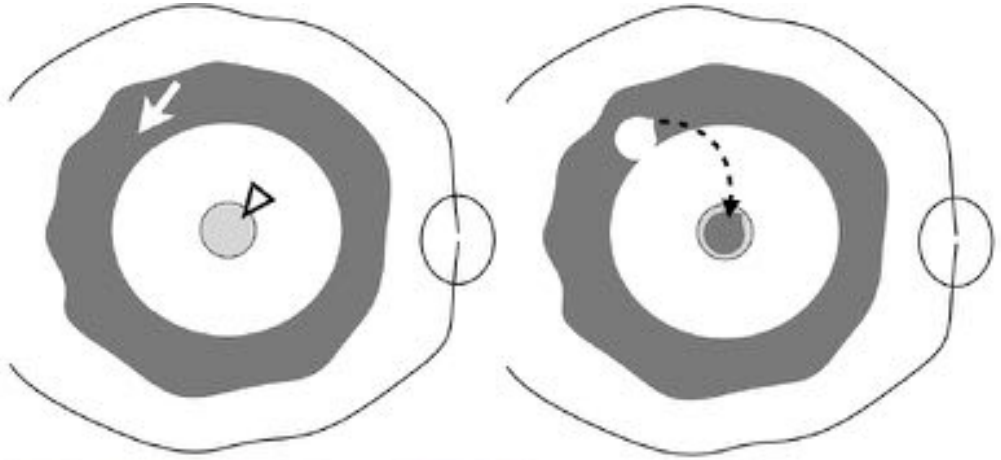
Figure 1. The surgical procedure of macular hole retinal detachment repaired by a vitrectomy combined with inverted internal limiting membrane (ILM) repositioning and autologous blood clot in highly myopic eyes. A, B, After a vitrectomy, ILM lifting was assisted by staining with indocyanine green without intentional drainage of the subretinal fluid. The lifted ILM was not detached completely from the retina and remained attached to the edge of the macular hole. C, D, Then, the lifted ILM was inverted and placed into the macular hole. E, The inverted ILM was used to fill the macular hole. F, Then, fresh blood from the patient was injected gently to cover the macula and seal the macular hole.

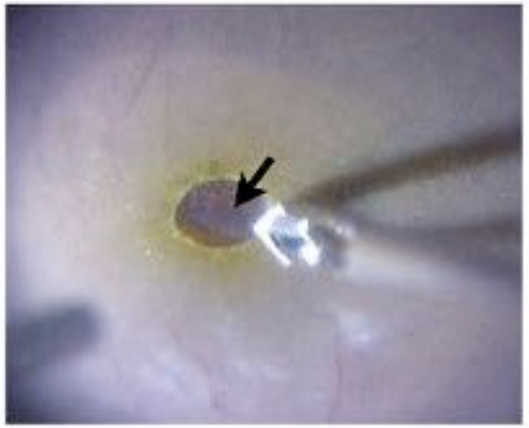
CLOSING MACULAR HOLES WITH "MACULAR PLUG" WITHOUT GAS TAMPONADE AND POSTOPERATIVE POSTURING

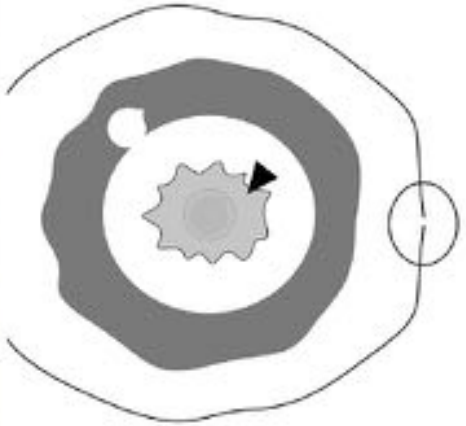


Autologous Transplantation of the Internal Limiting Membrane for Refractory Macular Holes

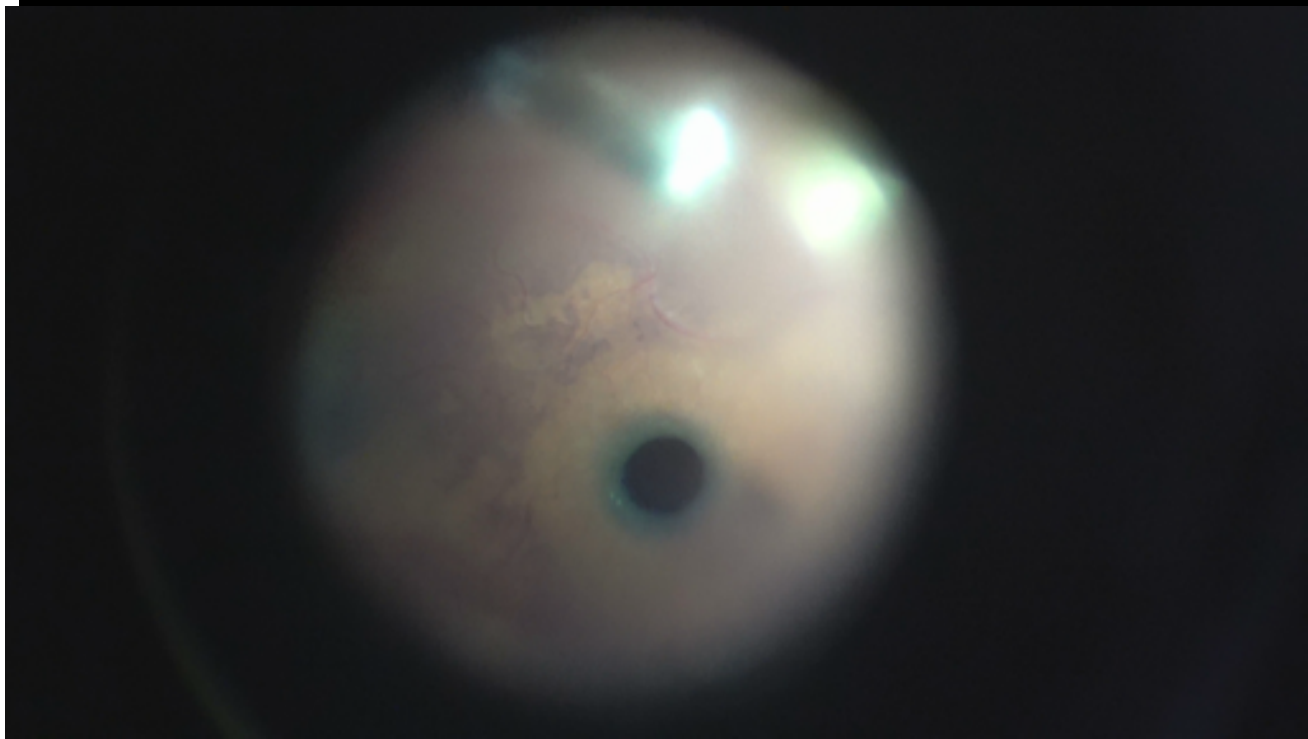
YUKI MORIZANE, FUMIO SHIRAGA, SHUHEI KIMURA, MIO HOSOKAWA, YUSUKE SHIODE, TETSUHIRO KAWATA, MIKA HOSOGI, YUKARI SHIRAKATA, AND TOSHIO OKANOUCHI







may warrant further investigation. (Am J Ophthalmol 2014;157:861–869.)



Recent Large Meta-analysis

- Marques et al 2020: Meta-analysis of inverted ILM flap versus standard ILM peel

- Sixteen studies involving 1403 eyes (733 ILM peel, 670 inverted flap)

- Hole closure with ILM flap was higher than ILM peel P<.0001
- Large mac holes: Closure was superior in ILM flap than ILM peel n=362, P<.001
- Myopic mac holes without detachment: Closure was superior in ILM flap than ILM peel n=133, P<.001
- Myopic mac holes with detachment: Closure was superior in ILM flap than ILM peel n=198, P<.001

- Marques, et al. Ophthalmic Surg Lasers Imaging Retina 51(3):187, 2020

Conclusions

- Inverted ILM flap technique has evolved since its introduction in 2010
- There are over 110 papers on PubMed regarding ILM flap
- The totality of evidence suggest that inverted ILM flap may be considered for a variety of macular holes such as large macular holes, myopic macular holes, macular holes associated with retinal detachment, and refractory holes.

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