PARS PLANA VITRECTOMY WITH INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE FOR MYOPIC MACULAR HOLE RETINAL DETACHMENT

Abdel-Rahman Atalla, Mahmoud Soliman, Mohamed Zayed, Hassan Mortada

ArticleHistory:Received:20.04.2023 **Revised:**25.05.2023 **Accepted:**30.05.2023

Abstract

Context: Myopic macular hole retinal detachment (MMHRD) is difficult to treat due to its complex pathogenesis. The inverted internal limiting membrane (ILM) flap technique showed promising results in some studies.
Aims: to evaluate the functional and anatomic outcomes of the inverted ILM flap technique in patients with MMHRD.
Settings and Design:dareloyoun hospital, Cairo, Egypt, a retrospective interventional case series.
Materials and Methods: we reviewed the records of eyes that underwent pars plana vitrectomy for MMHRD. They were divided into two groups; peel & invert group and peel & remove group, we evaluated macular hole closure, retinal reattachment and visual acuity.
Results: retinal reattachment was achieved in all eyes of both groups but macular hole closure rate was higher in the peel & invert group. No difference in visual outcome was observed.
Conclusions: both techniques achieved high retinal reattachment rates. However, we prefer the inverted ILM flap technique because it promotes restoration of the outer retinal layers, as we observed in some cases.

Keywords:high myopia, MMHRD, inverted ILM flap technique

Ophthalmology Department, Kasr El-Aini School of Medicine, Cairo University, Cairo, Egypt

DOI: 10.31838/ecb/2023.12.5.340

1. INTRODUCTION

Treatment of myopic macular hole retinal detachment (MMHRD) has always been a challenge. Poor anatomical outcomes of pars plana vitrectomy (PPV) with internal limiting membrane (ILM) peeling may be caused by the discrepancy between the retina and sclera. Although ILM peeling may release the tangential traction exerted over the macula, it does not solve the problem of retinal shortening (Kuriyama et al., 2013). Covering the macular hole with ILM, as in the inverted ILM flap technique, acts as a scaffold for cellular proliferation. This technique was introduced by Michalewska et al for idiopathic large macular holes in 2010 and showed a higher success rate (Michalewska et al., 2010). Then the technique was used for myopic macular holes by Kuriyama et al in 2013 and by Michalewska et al in 2014 (Kuriyama et al., 2013), (Michalewska et al., 2014).

2. MATERIALS AND METHODS

This was a retrospective interventional case series that included patients who underwent vitrectomy for myopic macular hole retinal detachment (MMHRD) between March 2017 and April 2020 at dareloyoun hospital, Cairo, Egypt. The inclusion criteria were; high myopia with an axial length greater than 26.0 mm, retinal detachment due to a macular hole and postoperative follow-up of 6 months at least. The exclusion criteria were: previous retinal surgery, choroidal neovascularization and proliferative vitreoretinopathy higher than grade C-1.
Data collected from the patients' records for each case included preoperative best-corrected visual acuity (BCVA), slit lamp examination findings of the anterior segment, dilated fundus examination findings using the indirect ophthalmoscope and slit lamp biomicroscopy using the hand held +90 D lens. Macular hole diagnosis was confirmed either with spectral-domain optical coherence tomography (SD-OCT) (Heidelberg Spectralis; Heidelberg Engineering, Heidelberg, Germany) whenever possible or intraoperatively by the

surgeons. Data also included axial length which was measured by B- scan ultrasonography.

All patients signed an informed consent form after having a detailed discussion of the surgical procedure with the surgeon. The study was approved by the Review Committee of the (name removed to comply with the journal's blinding policy). All patients had consented to reviewing their records.

Included cases were divided into two groups; group 1 included eyes that underwent pars plana vitrectomy with the inverted ILM flap technique (peel and invert group) and group 2 included eyes that underwent pars plana vitrectomy with ILM peeling (peel and remove group).

All surgeries were done by two surgeons (initials removed to comply with the journal's blinding policy). All patients underwent 23-guage vitrectomy. Phacoemulsification with intraocular lens (IOL) implantation was performed in phakic eyes. An acrylic foldable IOL was implanted in the bag (AcrySof Single-Piece, Alcon Laboratories, Ft. Worth, TX). Core vitrectomy was performed, followed by triamcinolone acetonide assisted peeling of the posterior hyaloid to the posterior insertion of the vitreous base. The ILM was stained using Brilliant Blue G stain (Coomassie Brilliant Blue G 250; Sigma-Aldrich Corp, St Louis, MO). The subretinal fluid (SRF) was drained through a peripheral retinotomy in eyes with detachment extending to the periphery.

It was the surgeon who selected which technique to use in each case. In group 1 (peel and invert group); using a diamond dusted scraper and an ILM forceps, the ILM was grasped and peeled off in a circular fashion in the area central to the vascular arcades, towards the macular hole without exerting traction on it. Peeling was done without the use of perfluorocarbon liquid (PFCL) whenever possible to avoid losing the contrast due to choroidal and RPE atrophy. When this could not be done in extensive detachments, PFCL was injected slowly over the optic disc and the macular area to facilitate peeling. ILM peeling would be stopped short of the edge of the hole so that the ILM flap was left attached to the edges of the hole. If PFCL was not used during peeling it was injected at this step. Then, a rolled segment of the peeled ILM, was pulled over the macular hole from all sides with the ILM forceps, under PFCL, until the ILM was inverted. The macular hole was thus covered with multiple layers of the inverted ILM flap. In group 2 (peel and remove group); the ILM was completely peeled off the macular area and removed. Again, it was done without the use of PFCL whenever possible.

In both groups, if there was a posterior staphyloma, the ILM was peeled off the retina up to the edge of the staphyloma.

At the end of surgery, PFCL was exchanged by silicone oil directly. Only in two eyes in group 2, fluid-air exchange was performed then air was replaced by nonexpanding sulfur hexafluoride (SF_6) in one eye and perfluoropropane (C_3F_8) in the other eye. Patients were instructed to adopt a prone position for 5 days after surgery.

Postoperative assessment was done at 1 week and 1, 3 and 6 months. It included visual acuity measurement and dilated fundus examination using the indirect ophthalmoscope and slit lamp biomicroscopy using the hand held +90 D lens for all patients to confirm retinal reattachment, and to make sure the ILM flap was in place (in group 1 eyes). SD-OCT was done at one to three months postoperatively to assess closure of the macular hole. We only considered eyes with absence of a neurosensory defect in the macula as having macular hole closure; eyes with "flat-open" holes were considered as having open holes. We recorded BCVA as decimal value and converted them to the logarithm of minimal angle of resolution for statistical analysis. For patients who had silicone oil tamponade, we confirmed retinal reattachment after silicone oil removal 3 months following surgery.

Statistical analysis was done using SPSS computer software package, version 15.0, 2006, Echosoft Corporation, USA. Qualitative data were expressed as frequencies and percentages. Quantitative data were expressed as mean ± standard deviation (SD) for parametric data and median ± interquartile range (IQR) for non- parametric data. Differences between groups were assessed through independent t-test for parametric data and Mann–Whitney U test for non-parametric data. All tests were two tailed and considered significant at $P < 0.05$.

3. RESULTS

This study included 19 eyes of 18 patients which met the inclusion criteria. There were six men and 12 women. The mean age of patients was 60.1 ± 9.0years with a range of 45 to 82 years. There were nine phakic eyes and ten pseudophakic eyes preoperatively, and the mean preoperative axial length was 30.5 ± 1.2 mm with a range of 28.1 mm to 32.2 mm. There was no statistically significant difference in the baseline characteristics between both groups (Table 1).

Table (1): Baseline characteristics of study population in the two groups

	Peel and invert group (13 eyes, 12 patients)	**Peel and remove group (6 eyes, 6 patients)**	***P***
Age (year, mean ± SD)	63.3 ± 9.6	58.7 ± 8.9	0.7
Sex (male/female)	3/9	3/3	0.3
Axial length (mm, mean ± SD)	30.7 ± 1.1	30.5 ± 1.0	0.9
Lens status (phakia/pseudophakia)	7/6	2/4	0.6
Preoperative BCVA (logMAR unit, mean ± SD)	2.0 ± 0.4	2.3 ± 0.2	0.08

Thirteen eyes were in the peel and invert group and six eyes were in the peel and remove group. In the peel and invert group, seven eyes (53.8%) underwent phacoemulsification combined with vitrectomy in comparison to two eyes in the peel and remove group (33.3%). Silicone oil tamponade was used in all the eyes in the peel and invert group (100%) and in four eyes in the peel and remove group (66.7%). These differences were not statistically significant (P = 0.6 and P = 0.08 respectively).

A comparison of surgery outcomes between both groups is presented in Table 2. The retina was reattached in all the eyes in both groups. The MH was closed in 13 eyes (100%) in the peel and invert group (Figures 1-4), which was significantly higher than the four eyes (66.7%) in the peel and remove group (P < 0.05). No holes reopened after closure in the follow-up period.

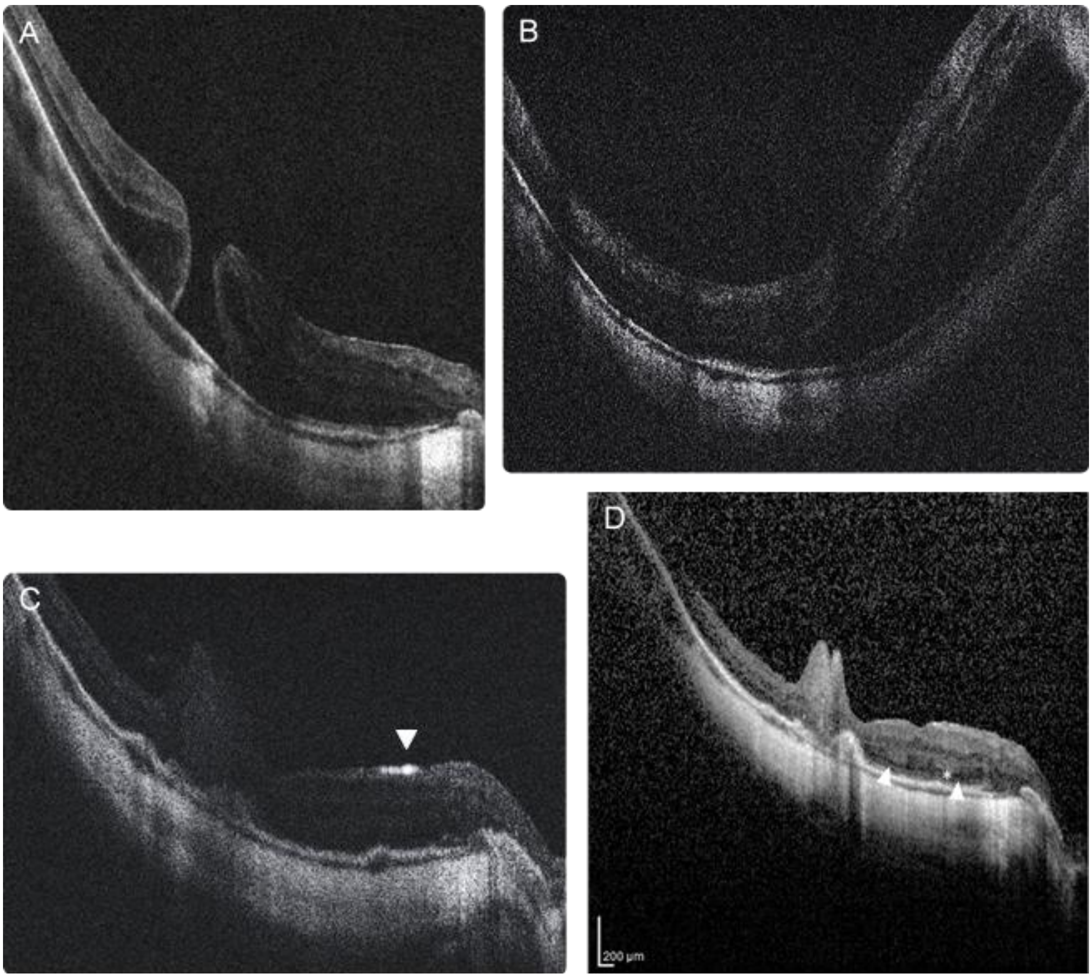

Figure 1. A 59-year-old woman with MHRD in the peel and invert group. (A, B) Preoperative SD-OCT shows an open macular hole with retinal detachment. Preoperative BCVA was 0.016. (C) Postoperative SD-OCT at 1 month shows closed MH under silicone oil (arrowhead). BCVA was 0.2 (D) Postoperative SD-OCT at 6 months following PPV (2 months following silicone oil removal) shows closed MH covered with multi-layered neural retinal tissue.The ELM, EZ (arrowheads) and ONL (asterisk) can be clearly seen at the closed MH. BCVA improved to 0.4.

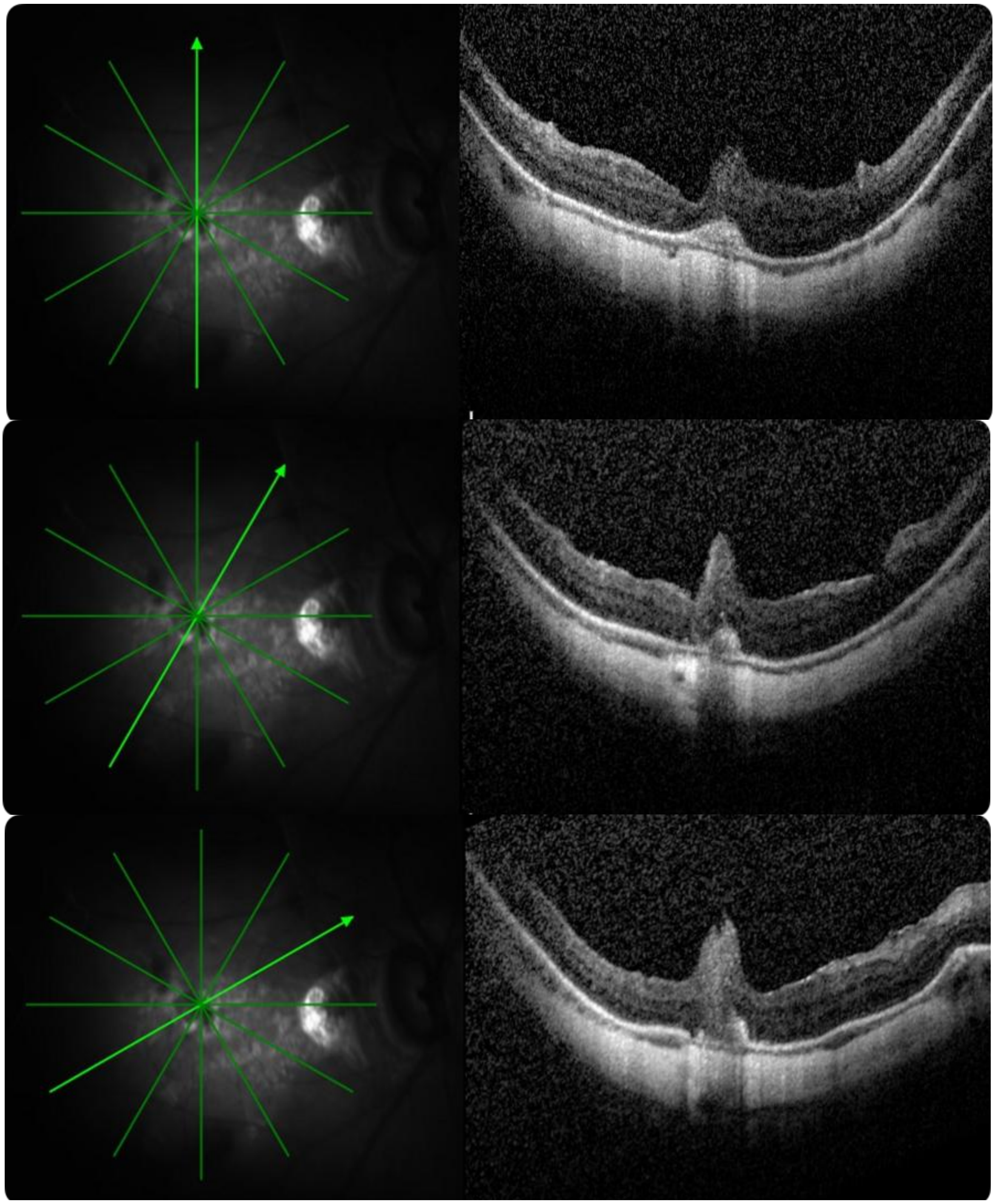

Figure 2.SD-OCT images of the same eye in figure 14. Twelve months following surgery, the ELM and ellipsoid zone were restored and BCVA improved to 0.6.

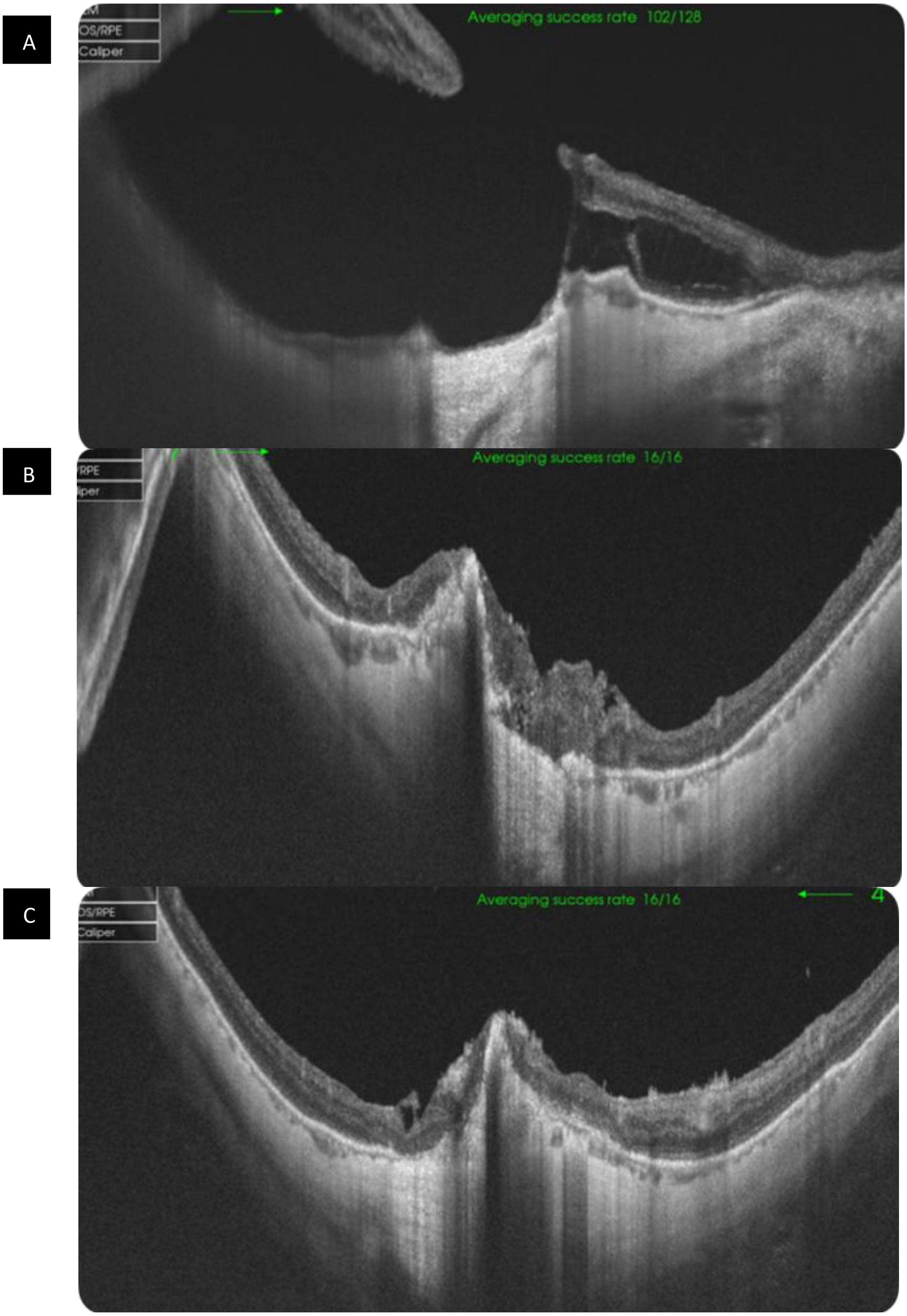

Figure 3.A 79-year-old woman with MHRD in the peel and invert group. (A) Preoperative SD-OCT shows an open macular hole with retinal detachment. Preoperative BCVA was counting fingers at 50 cm. (B, C) Three months after surgery SD-OCT shows that the hole was closed. Retinal layers at the margins of the hole approached and connected with one another forming a hyperreflective tissue. Post- operative BCVA improved to 0.1.

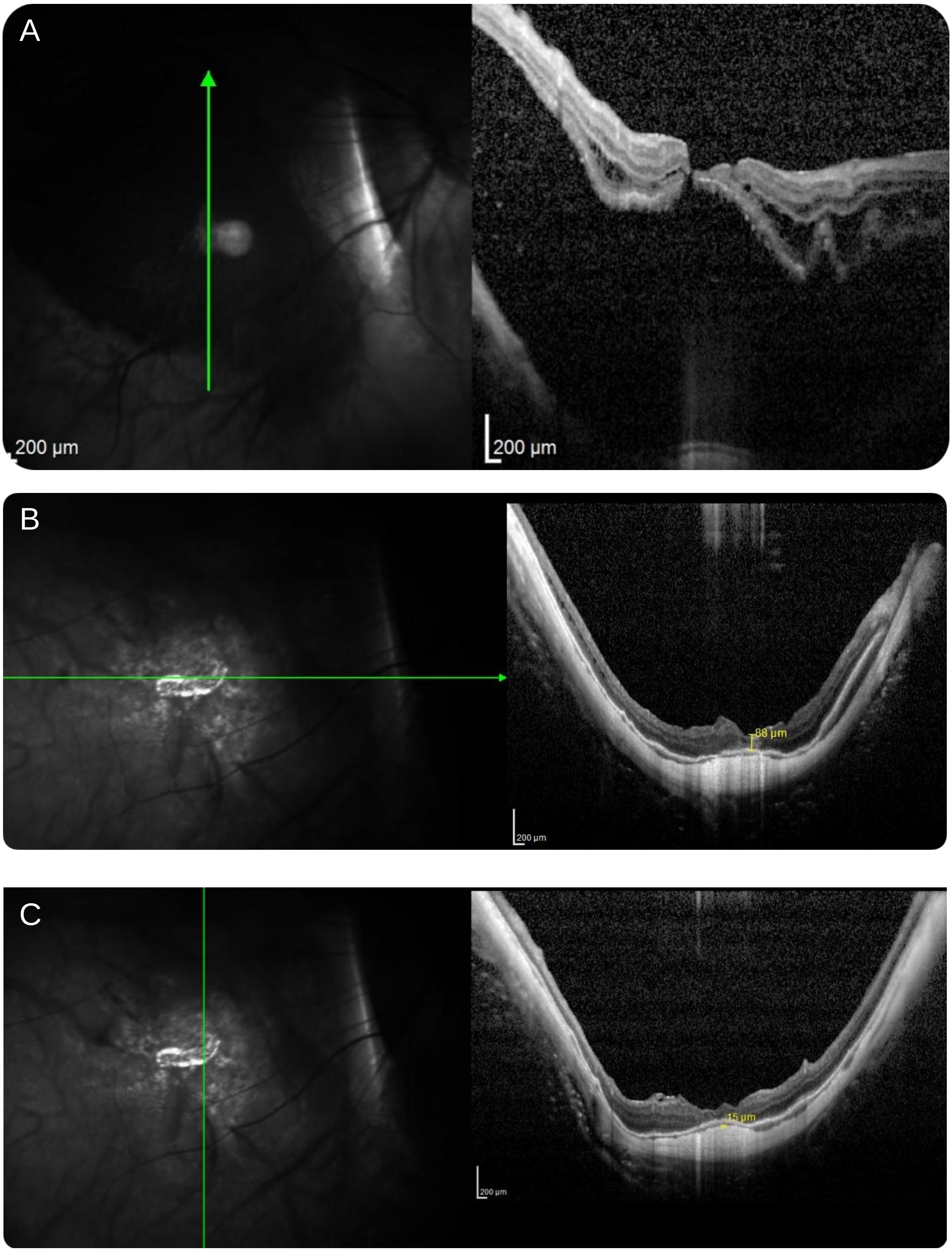

Figure 4. A 63-year-old woman with MHRD in the peel and invert group.(A) Preoperative SD-OCT shows an open macular hole with retinal detachment. BCVA was counting fingers at 50 cm. (B, C) One month after surgery SD-OCT shows closure of the hole. Post- operative BCVA improved to 0.3.

In both groups, vision significantly improved at six months after surgery from 2.0 ± 0.4 to 0.97 ± 0.5 in the peel and invert group (P<0.01) and from 2.3 ± 0.2 to 1.3 ± 0.5 in the peel and remove group (P<0.01). However, there were no statistically significant differences in BCVA at 1, 3 and 6 months postoperatively or in visual improvement at six months between both groups.

Table (2): Postoperative outcomes in the two groups

	Peel and invert group	Peel and remove group	*P*
Retinal reattachment (%)	13 (100)	6 (100)	N/A
MH closure (%)	13 (100)	4 (66.7)	<0.05
Postoperative BCVA (logMAR unit, mean ± SD)			
at 1 month	1.2 ± 0.5	1.4 ± 0.5	0.6
at 3 months	0.98 ± 0.5	1.2 ± 0.3	0.4
at 6 months	0.97 ± 0.5	1.3 ± 0.5	0.4
Postoperative BCVA improvement at 6 months (logMAR unit, mean ± SD)	1.02 ± 0.5	0.98 ± 0.4	0.7

We compared the eyes with closed macular holes with the eyes with open holes (Table 3). Six months following surgery, the mean logMARBCVA in 17 eyes with closed macular holes vs. two eyes with open holes was 1.2 ± 0.6. vs. 0.76 ± 0.3 (P = 0.3).

Table (3): Comparison of eyes with closed holes vs. eyes with open holes after surgery

	Eyes with closed holes (17 eyes)	**Eyes with open holes (2 eyes)**	***P***
Preoperative BCVA (logMAR unit, mean ± SD)	2.1 ± 0.4	2.1	0.9
Postoperative BCVA (logMAR unit, mean ± SD)			
at 1 month	1.4 ± 0.5	1.2 ± 0.7	0.8
at 3 months	1.1 ± 0.4	0.8 ± 0.2	0.4
at 6 months	1.2 ± 0.6	0.76 ± 0.3	0.3
Postoperative BCVA improvement at 6 months (logMAR unit, mean ± SD)	0.9 ± 0.5	1.3 ± 0.3	0.3

We also compared the postoperative BCVA at 6 months within the peel and invert group between the 13 eyes with closed macular holes and the four eyes with open holes (0.97 ± 0.5 vs. 1.6 ± 0.3) (P = 0.1).

4. DISCUSSION

Pathogenesis of myopic macular hole is complex and multifactorial. It includes tangential traction exerted by the posterior hyaloid and epimacular membranes, antero-posterior traction caused by axial elongation of the eye and posterior staphyloma, intrinsic rigidity of the ILM, retinal vascular traction, extensive liquefaction of the vitreous and chorioretinal atrophy (Wu et al., 2009).

Success rates of surgery in MMHRD cases have long been low (they ranged from 10% to 67%) (Ichibe et al., 2003), (Uemoto et al., 2004). Although ILM peeling alleviates the tangential traction on the macula, it does not solve the problem of retinal shortening caused by posterior staphyloma (Sasaki, 2017). In 2013, Kuriyama et al introduced the inverted ILM flap technique for macular holes in highly myopic eyes (Kuriyama et al., 2013). They reported a high closure rate of 80% in the whole study group (75% in eyes with RD) and improvement of BCVA by more than 2 lines in 50% of cases. In 2014, Michalewska et al used the technique in 19 eyes with myopic macular holes (Michalewska et al., 2014). They reported a 100% hole closure rate and more than 2-logMAR-line improvement of BCVA in 94% of cases. Based on the results of this study, they reached a hypothesis that the technique promotes proliferation of glial cells, allowing the photoreceptors to take positions that are closer to the fovea, thus improving BCVA. The inverted ILM flap technique made a significant improvement in anatomical and functional success after PPV for highly myopic macular holes and MMHRD.

Studies were performed to compare the inverted ILM flap technique with complete removal of the ILM for treatment of MMHRD. Takahashi et al and Matsumae et al reported a higher rate of hole closure and a significant improvement in BCVA with the inverted ILM flap technique (Takahashi et al., 2018), (Matsumae et al., 2020). Baba et al and Gu et al reported a higher macular hole closure rate with the inverted ILM flap technique than that with complete ILM removal. However, they found no significant difference in the retinal reattachment rate between both techniques (Baba et al., 2017), (Gu et al., 2021). Also, in the study conducted by

Baba et al there was no significant difference in the median postoperative BCVA.

The aim of our study was to compare the functional and anatomic outcomes of the inverted ILM flap technique with conventional ILM peeling and removal in patients with myopic macular hole retinal detachment.

We found a significantly higher MH closure rate with the inverted ILM flap technique. This supports the results of the previously mentioned reports (Takahashi et al., 2018), (Matsumae et al., 2020), (Baba et al., 2017), (Gu et al., 2021).

However, contrary to the results of many studies (Takahashi et al., 2018), (Matsumae et al., 2020), (Gu et al., 2021), we found that the inverted ILM flap technique did not achieve a significantly better postoperative visual acuity than complete ILM removal. Hayashi and Kuriyama studied the outcome of the inverted ILM flap technique in MMHRD (Hayashi and Kuriyama, 2014). They performed postoperative OCT and found that the ellipsoid zone (EZ) and the external limiting membrane (ELM) were restored in only 17% of cases. They suggested that the photoreceptors and the outer retinal layers may be permanently destroyed and cannot be recovered even after successful retinal reattachment and macular hole closure. In a similar study, Takahashi et al evaluated the inverted ILM flap technique and they observed restoration of the EZ and ELM in only 25% of the eyes that achieved macular hole closure (Takahashi et al., 2018). Although our study did not assess the retinal layers by OCT, we observed that, in some cases, the outer retinal layers i.e. ELM, EZ and ONL were restored (in these cases, BCVA showed marked and progressive improvement in the follow up period). When we analysed all the eyes that achieved MH closure, we found no significant difference in postoperative BCVA between the peel & invert group and the peel & remove group. This supports the conclusion that the retinal outer layer structure in the fovea may not be recovered even after successful surgery for MMHRD. The results of the study performed by Baba et al support our results (Baba et al., 2017). Within all the eyes with closed macular holes after surgery, they found no significant difference in postoperative BCVA between the inverted flap technique and complete removal of the ILM.

Several groups studied the relation between the anatomical outcome i.e. macular hole closure and the functional outcome i.e. postoperative BCVA after PPV for MHRD (without using the inverted flap technique). Ikuno et al and Lam et al found a better BCVA in eyes with macular hole closure than those in which the holes remained open (Ikuno et al., 2003), (Lam et al., 2006). However, in other studies conducted by Nakanishi et al, Nishimura et al and Nadal et al there was no significant difference in postoperative BCVA (Nakanishi et al., 2008), (Nishimura et al., 2011), (Nadal et al., 2012). Our results support these findings; we found no significant difference in postoperative BCVA at 6 months between eyes with closed holes and those with open holes.

In the first study that introduced the inverted flap technique, the flap would cover the hole (Michalewska et al., 2010). In our study we used a similar technique; we pulled the flap gently over the macular hole from all sides under PFCL. Lai et al described filling the hole with ILM and they suggested that this may create a stronger scaffold for glial proliferation thus increasing macular hole closure rate (Lai et al., 2015). This was also described by Chen and Yang (Chen and Yang, 2016). Using this technique, the reported hole closure rates were 96% and 100% respectively. Baba et al used a similar technique and they reported a closure rate of 80% (Baba et al., 2017). These reports suggest that this modification of the technique may reduce the risk of the ILM flap moving back to the previous position or being teared and lost during surgery. However, the surgical trauma in this technique may cause retinal pigment epithelium (RPE) damage and this may explain the finding of no statistically significant difference in BCVA between eyes with closed holes and eyes with open holes in the previously mentioned studies.

Many researchers studied the adverse effects of the use of indocyanine green (ICG) on the visual outcome of surgery (Sakamoto et al., 2002), (Engelbrecht et al., 2002), (Kusaka et al., 2003). Some groups found that using ICG for ILM staining in macular hole surgery had a negative effect on the anatomical and functional outcome of surgery (Sakamoto et al., 2002), (Engelbrecht et al., 2002), (Shiono et al., 2013). Baba et al compared using ICG with BBG for staining the ILM (Baba et al., 2012). They found a better anatomical and functional outcome in the BBG group (faster recovery of EZ and better BCVA). Chen and Yang used ICG as the adjuvant (Chen and Yang, 2016). This may explain their finding of no statistically significant differences in BCVA between the inverted ILM flap technique and ILM peeling. Although we used BBG in all cases, we found no statistically significant difference in postoperative BCVA between the two groups. But this is probably not related to the dye used. It can be explained by the preexisting damage of the photoreceptors that we discussed previously.

This study has some limitations. The number of cases was small especially in the peel and remove group. Also, we did not investigate the correlation between OCT findings and postoperative BCVA in eyes that achieved MH closure in the peel and invert group. We recommend larger prospective studies with longer follow-up.

5. CONCLUSION

This study showed that using the inverted ILM flap technique for MMHRD achieved a high rate of macular hole closure and retinal reattachment. Although it did not show a better functional outcome, we prefer this technique over complete ILM removal because it promotes restoration of the outer retinal layers, as we observed in some cases. To determine the actual benefits for postoperative outcome, especially visual function, further studies with long-term follow-up in a larger number of patients are required.

ACKNOWLEDGEMENT

We would like to thank Dr Abdussalam Mohsen Abdullatif from the Ophthalmology Department, Cairo University, for performing the statistical analysis of the study.

Abbreviation List

BCVA	best corrected visual acuity
ELM	external limiting membrane
EZ	ellipsoid zone
ICG	indocyanine green
ILM	internal limiting membrane
IOL	intraocular lens
LogMAR	logarithm of the minimal angle of resolution
MH	macular hole
MHRD	macular hole retinal detachment
MMHRD	myopic macular hole retinal detachment
mm	millimeter
OCT	optical coherence tomography
ONL	outer nuclear layer
P	calculated probability
PFCL	perfluorocarbon liquid
PPV	pars plana vitrectomy
RD	retinal detachment
RPE	retinal pigment epithelium
SD	standard deviation
SD-OCT	spectral domain optical coherence tomography
SF_6	sulfur hexafluoride
SRF	subretinal fluid

6. REFERENCES

Baba T, Hagiwara A, Sato E, Arai M, Oshitari T, Yamamoto S. Comparison of vitrectomy with brilliant blue G or indocyanine green on retinal microstructure and function of eyes with macular hole. Ophthalmology. 2012;119(12):2609-15.

Baba R, Wakabayashi Y, Umazume K, Ishikawa T, Yagi H, Muramatsu D, et al. Efficacy of the inverted internal limiting membrane flap technique with vitrectomy for retinal detachment associated with myopic macular holes. Retina. 2017;37(3):466-71.

Chen SN, Yang CM. Inverted internal limiting membrane insertion for macular hole–associated retinal detachment in high myopia. Am J Ophthalmol. 2016;162:99-106.

Engelbrecht NE, Freeman J, Sternberg Jr P, Aaberg Sr TM, Aaberg Jr TM, Martin DF, Sippy BD. Retinal pigment epithelial changes after macular hole surgery with indocyanine green-assisted internal limiting membrane peeling. Am J Ophthalmol. 2002;133(1):89-94.

Gu X, Hu Z, Qian H, Fransisca S, Mugisha A, Wang J, Zhang Z, Zhang W, Ji J, Liu Q, Xie P. PERFLUOROCARBON LIQUID–ASSISTED INVERTED INTERNAL LIMITING MEMBRANE FLAP TECHNIQUE VERSUS INTERNAL LIMITING MEMBRANE PEELING FOR HIGHLY MYOPIC MACULAR HOLE RETINAL DETACHMENT. Retina. 2021;41(2):317-23.

Hayashi H, Kuriyama S. Foveal microstructure in macular holes surgically closed by inverted internal limiting membrane flap technique. Retina. 2014;34(12):2444-50.

Ichibe M, Yoshizawa T, Murakami K, Ohta M, Oya Y, Yamamoto S, et al. Surgical management of retinal detachment associated with myopic macular hole: anatomic and functional status of the macula. Am J Ophthalmol. 2003;136(2):277-84.

Ikuno Y, Sayanagi K, Oshima T, Gomi F, Kusaka S, Kamei M, et al. Optical coherence tomographic findings of macular holes and retinal detachment after vitrectomy in highly myopic eyes. Am J Ophthalmol. 2003;136(3):477-81.

Kuriyama S, Hayashi H, Jingami Y, Kuramoto N, Akita J, Matsumoto M. Efficacy of inverted internal limiting membrane flap technique for the treatment of macular hole in high myopia. Am J Ophthalmol. 2013;156(1):125-31.

Kusaka S, Oshita T, Ohji M, Tano Y. Reduction of the toxic effect of indocyanine green on retinal pigment epithelium during macular hole surgery. Retina. 2003;23(5):733-4.

Lai CC, Chen YP, Wang NK, Chuang LH, Liu L, Chen KJ, et al. Vitrectomy with internal limiting membrane repositioning and autologous blood for macular hole retinal detachment in highly myopic eyes. Ophthalmology. 2015;122(9):1889-98.

Lam RF, Lai WW, Cheung BT, Yuen CY, Wong TH, Shanmugam MP, Lam DS. Pars plana vitrectomy and perfluoropropane (C3F8) tamponade for retinal detachment due to myopic macular hole: a prognostic factor analysis. Am J Ophthalmol. 2006;142(6):938-44.

Matsumae H, Morizane Y, Yamane S, Yanagisawa S, Sakurai T, Kobori A, et al. Inverted internal limiting membrane flap versus internal limiting membrane peeling for macular hole retinal detachment in high myopia. Ophthalmol Retina. 2020;4(9):919-26.

Michalewska Z, Michalewski J, Adelman RA, Nawrocki J. Inverted internal limiting membrane flap technique for large macular holes. Ophthalmology. 2010;117(10):2018-25.

Michalewska Z, Michalewski J, Dulczewska-Cichecka K, Nawrocki J. Inverted internal limiting membrane flap technique for surgical repair of myopic macular holes. Retina. 2014;34(4):664-9.

Nadal J, Verdaguer P, Canut MI. Treatment of retinal detachment secondary to macular hole in high myopia: vitrectomy with dissection of the inner limiting membrane to the edge of the staphyloma and long-term tamponade. Retina. 2012;32(8):1525-30.

Nakanishi H, Kuriyama S, Saito I, Okada M, Kita M, Kurimoto Y, et al. Prognostic factor analysis in pars plana vitrectomy for retinal detachment attributable to macular hole in high myopia: a multicenter study. Am J Ophthalmol. 2008;146(2):198-204.

Nishimura A, Kimura M, Saito Y, Sugiyama K. Efficacy of primary silicone oil tamponade for the treatment of retinal detachment caused by macular hole in high myopia. Am J Ophthalmol. 2011;151(1):148-55.

Sakamoto T, Itaya K, Noda Y, Ishibashi T. Retinal pigment epithelial changes after indocyanine green-assisted vitrectomy. Retina. 2002;22(6):794-6.

Sasaki H, Shiono A, Kogo J, Yomoda R, Munemasa Y, Syoda M, et al. Inverted internal limiting membrane flap technique as a useful procedure for macular hole-associated retinal detachment in highly myopic eyes. Eye. 2017;31(4):545-50.

Shiono A, Kogo J, Klose G, Ueno S, Takagi H. Effects of indocyanine green staining on the recovery of visual acuity and macular morphology after macular hole surgery. Ophthalmologica. 2013;230(3):138-43.

Takahashi H, Inoue M, Koto T, Itoh Y, Hirota K, Hirakata A. Inverted internal limiting membrane flap technique for treatment of macular hole retinal detachment in highly myopic eyes. Retina. 2018;38(12):2317-26.

Uemoto R, Yamamoto S, Tsukahara I, Takeuchi S. Efficacy of internal limiting membrane removal for retinal detachments resulting from a myopic macular hole. Retina. 2004;24(4):560-6.

Wu PC, Chen YJ, Chen YH, Chen CH, Shin SJ, Tsai CL, et al. Factors associated with foveoschisis and foveal detachment without macular hole in high myopia. Eye. 2009;23(2):356-61.