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Macular Hole After Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment

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Abstract

Purpose—To report the clinical features, possible associations and treatment outcomes of patients with macular hole after pars plana vitrectomy (single or multiple) for rhegmatogenous retinal detachment.

Methods—Retrospective consecutive case series from July 2009 to July 2014.

Results—In the 15 study patients, the average time from retinal detachment surgery to macular hole diagnosis was 119 days (range: 41 – 398 months). Possible associations include epiretinal membrane (73%, 11/15 patients), macula-off retinal detachment (60%, 9/15 patients), recurrent retinal detachment (47%, 7/15 patients) and high myopia (56%, 5/9 patients). Single surgery was successful in hole closure in 8/15 patients (Group A) while 7/15 patients underwent multiple surgeries (Group B). Macular hole closure was achieved in 7/8 (87.5%) patients in Group A compared to 4/7 (57.1%) patients in Group B. Improvement of at least two lines of Snellen's visual acuity was achieved in 4/8 (50.0%) and 4/7 (57.1%) patients in Group A and B respectively.

Conclusion—In patients with macular hole formation after pars plana vitrectomy for retinal detachment, possible associations were epiretinal membrane, macula-off retinal detachment, recurrent retinal detachment and high myopia. Even when macular hole closure was achieved, limited visual improvement occurred.

Keywords

Epiretinal Membrane; Macular Hole; Rhegmatogenous retinal detachment

Background

Macular hole is a well-known and extensively studied macular disease. Gass was the first to classify and propose tangential vitreo-foveal traction as the underlying cause.^{1, 2} More recently, data based on optical coherence tomography (OCT) has supported Gass' original hypothesis attributing macular hole (MH) to vitreo-foveal traction and an OCT based

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classification was developed.^{3, 4} This theory has been additionally reinforced by successful treatments of MH with cortical vitreous peeling.⁵ Thus, both removal of the posterior cortical vitreous and posterior vitreous detachment are thought to relieve these traction forces and be a protective factor to MH development.

The proposed mechanisms seem to be contradicted by a number of patients in which a MH develops after a complete posterior vitreous detachment or even after pars plana vitrectomy (PPV).^{6, 7} Brown was the first to describe secondary MHs after retinal detachment (RD) surgery.⁸ These initial reports were associated with scleral buckling surgery and pneumatic retinopexy.^{8–13} Other reports of MHs following pars plana vitrectomy (PPV) followed shortly thereafter.¹⁴

The incidence of MH following RD repair (pneumatic retinopexy, scleral buckle, vitrectomy or a combination of these) has been reported to be between 0.24% and 1.9%.^{11, 15–19} Because MH after RD surgery is uncommon, the pathogenesis and outcomes have been mostly described in small retrospective case series. Although, successful closure of the hole has been reported, visual outcomes are usually poor presumably from the preceding RD.¹⁹

The current study reports a larger consecutive case series of patients developing MH after RD surgery by PPV.

Methods

The study was conducted in accordance with the ethical standards established in the 1964 Declaration of Helsinki for research involving humans, and approved by the Institutional Review Board of the University of Miami.

This was a retrospective, single center, multi-surgeon, consecutive case series including all patients who underwent pars plana vitrectomy (single or multiple) for rhegmatogenous retinal detachment from July of 2009 to July of 2014 and subsequently developed a full thickness MH after successful retinal reattachment surgery. Patients who underwent a combined vitrectomy with scleral buckle procedure were also included. Patients with diabetic tractional RD at presentation or traumatic RD at presentation or MH identified before or during the retinal detachment surgery or iatrogenic MH or MH detected within 1 month of initial PPV for RD were excluded from the study.

The medical records of these patients were reviewed and patient data including age, refractive error, visual acuity at initial presentation, status of macula, surgical procedure, number of surgeries performed for RD, indication of silicone oil for recurrent RD, surgical procedure for recurrent RD, time interval between initial vitrectomy and MH formation, visual acuity at time of MH diagnosis, presence of additional retinal pathology such as proliferative vitreoretinopathy (PVR), surgical procedure performed for MH surgery (internal limiting membrane [ILM] peeling, C₃F₈ or silicone oil injection), visual acuity at final follow-up, status of MH at final visit were recorded.

Results

Fifteen patients met the study criteria. Eight female and 7 male patients with the average age of 64 years (range 50–86) were included in the study. The refractive error or axial length was known for 9 of 15 eyes. High myopia (refractive error of more than 6 diopters or an axial length of >26.5mm) was noted in 5/9 (56%) patients. In the current study, epiretinal membrane (ERM) (73%, 11/15 patients), macula-off RD (60%, 9/15 patients), recurrent RD (60%, 9/15 patients) and high myopia (56%, 5/9 patients) were noted.

For MH, single surgery was successful in 8/15 patients (**Group A**) while 7/15 patients underwent multiple surgeries (**Group B**). History, clinical presentation and initial surgical management of patients developing macular hole after retinal detachment surgery are shown in Table 1. All patients underwent PPV for rhegmatogenous RD repair. Nine patients received a simultaneous scleral buckle (60%). During the initial pars plana vitrectomy surgery performed for retinal detachment, no staining agents were used and no membrane (ERM/ILM) peeling in the macular area was performed. None of the patients with high myopia in the current study had myopic macular retinoschisis. Surgical procedure performed and outcomes (anatomical and visual) of MH after RD surgery are shown in Table 2. The average time from initial RD surgery to MH diagnosis was 93 days in Group A and 149 days in Group B with an average in all 15 eyes of 119 days (range 41 – 398 months).

Group A

Among Group A (eyes undergoing single PPV for RD), 7/8 eyes received long acting gas as a tamponade agent. Silicone oil was used in one patient (patient number 8) as an intraoperative choroidal detachment was noted. This patient had presented with macula-off RD at presentation and developed a macular hole while silicone oil was in the eye 180 days after initial PPV. Among these 8 patients, ERM and ILM was noted in 5 and 6 patients and membrane peeling was performed subsequently during MH surgery.

Group B

Among group B (eyes undergoing multiple PPV for RD), 71.4% (5/7) patients presented with a simultaneous recurrent RD and MH (patients 11–15). PVR was noted in 57.1% (4/7) patients (patient number 12, 13, 14, 15) and underwent silicone oil injection because of the simultaneous retinal detachment. One patient (patient number 11) did not receive silicone oil at the time of MH surgery as retina was attached and stable. Another patient (patient number 9) developed a MH while silicone oil was in the eye after first PPV for RD and underwent silicone oil removal and ILM peeling for MH. Among 7 patients in Group B, ERM and ILM was noted in 6 and 4 patients and membrane peeling was performed during MH surgery.

MH closure was accomplished in 11/15 (73%) eyes at last follow up (average 302 days, range 18 days to 3 years). MH closure was achieved in 7/8 (87.5%) patients in group A while 4/7 (57.1%) patients in group B. No patients had more than one MH surgery. Of the 11 eyes with macular hole closure, 20/200 or better was achieved in 8 eyes but only 5 eyes achieved 20/80 or better. Mean visual acuity at time of diagnosis of MH was 1.13 ± 0.5 (approximately 200/300, range 20/60 to 6/200) in group A and 1.74 ± 0.7 (approximately

20/1000, range 20/100 to hand motions) in group B respectively. Mean visual acuity at final follow-up was 0.80 ± 0.5 (approximately 20/120, range 20/60 to 20/400) and 1.50 ± 1.2 (range 20/30 to hand motions) in group A and group B respectively. Improvement of at least two lines of Snellen's visual acuity was noted in 4/8 (50.0%) patients and 4/7 (57.1%) patients in group A and group B respectively. No improvement or worsening of visual acuity was noted in 7/15 (46.7%) patients.

In the current study, none of the patients in Group A had proliferative vitreoretinopathy (PVR) at presentation while 4/7 patients in Group B had PVR. Because of PVR, these 4 cases in Group B underwent silicone oil injection along with ILM peeling during MH surgery. Mean visual acuity improved in Group B after MH surgery but since the number of patients were small, no statistically significant conclusions can be made. Two of the 4 patients with PVR did not achieve MH closure at the last follow-up.

Visual acuities among various subgroups (high myopic versus non-high myopic patients, macula-on RD versus macula-off RD at the time of diagnosis of MH, scleral buckling versus no scleral buckling during initial pars plana vitrectomy) are shown in Table 3. Because the number of patients in these subgroups was small, no statistically significant conclusions can be made.

Discussion

The current study reports a consecutive case series of patients with macular hole after pars plana vitrectomy performed for retinal detachment (single or multiple surgeries). These macular holes appear to be different from idiopathic macular holes in terms of etiology, as well as visual and anatomical outcomes. The study reports possible associations (high myopia, macula off retinal detachment, recurrent retinal detachment, presence of epiretinal membrane) and visual acuity and anatomic outcomes in these patients.

The current retrospective analysis included 15 patients with MH formation following PPV for rhegmatogenous RD. The prevalence for MH following RD ranges from 0.24–1.9%.^{15, 16} This includes cases of scleral buckle and pneumatic retinopexy procedures for retinal re-attachment (Table 4).^{15–25} Clinical characteristics and outcomes from the current study were compared with published data. In the current study, 67% of patients were younger than 65 years of age. This is similar to published data, where 82% of patients were younger than 65 years of age. Also similar to published data was the presence of a macula off RD at presentation (73% vs. 60%) and the presence of ERM (69% vs. 73%). The percentage of MH closure as lower in the current study (73% vs. 92%). This might be due to the fact that none of the patients in the current study underwent more than one procedure for MH repair because of the guarded visual prognosis. The current study also found a higher rate of recurrent RD compared to the published literature (60% vs. 21%) (Table 5).

In the current study, macula-off RD and high myopia although seen in 60% and 56% patients respectively, did not show any statistically significant effect on the visual and anatomical outcomes. Membrane peeling was not performed in the initial PPV for RD. Although a clinical posterior vitreous detachment was noted in 60% of patients, no vitreous

staining agents used during initial RD repair. The risk of residual cortical vitreous with subsequent contraction or absence of a complete posterior vitreous detachment secondary to vitreoschisis remains a possibility. Furthermore contraction of residual vitreous, ERM formation, and proliferative vitreous retinopathy may all have contributed to the residual tractional forces following PPV for RD repair that may have been responsible for MH formation in some of the cases (Figure 1).

Cystoid macular edema (CME) has been postulated as a mechanism for MH formation in the absence of tangential traction. MH in patients without visible vitreofoveal traction or epiretinal membranes by OCT indicate that non-tractional factors may be contributing to hole formation. There was absence of ERM on OCT in 4 patients (Patient number 3, 5, 6, 10). OCT images of two such patients from current study are shown who developed macular hole despite the absence of visible traction (**Patients number 5 & 6** - Figure 1B & 1C). We did not measure the size of macular hole in these patients because the color images and OCT images were not taken in a standardized prospective protocol. Instead, multiple cameras (Topcon, Optos, and Heidelberg) were used in imaging these patients.

Patients with prior successful MH surgery have been found to be at greater risk for hole reopening from cystoid macular edema following cataract surgery.²⁶ Anti-inflammatory treatment with for resolution of the cystoid changes in patients with macular hole without vitreo-foveal traction has been successful in closing macular holes.²⁷

PVR at the time of MH diagnosis (4/7 patients in current study), was associated with limited visual improvement. Mean visual acuity in these 4 patients were generally poor (20/100, 20/150, HM, HM) and 2/4 had persistent MH. Overall, MH closure occurred in 73% (11/15) patients. Current series had few limitations in being a retrospective study, small number of patients and cases operated by multiple surgeons. Despite various limitations, the current study showed that MH formation after PPV for RD may be associated with ERM (73%, 11/15 patients), macula-off RD (60%, 9/15 patients), recurrent RD (60%, 9/15 patients) and high myopia (56%, 5/9 patients). MH closure was achieved in the majority of patients (73%, 11/15 patients) but with limited visual improvement. The possible reasons for limited recovery of vision in the group of eyes in which the macular hole was closed include progressive cataract, retained silicone oil in the eye or myopic macular degeneration. Because this is a retrospective study, information on the exact reasons of reduced visual acuity in these patients was not always recorded in the medical records. Among patients with persistent MH at final follow-up, two patients (patient number – 12 and 13) had very poor final visual acuity (hand motions) and both these patients had multiple procedures and had retained silicone oil at last follow-up.

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References

1. Gass JD. Reappraisal of biomicroscopic classification of stages of development of a macular hole. *Am J Ophthalmol*. 1995 Jun; 119(6):752–9. [PubMed: 7785690]
2. Gass JD. Idiopathic senile macular hole. Its early stages and pathogenesis. *Arch Ophthalmol*. 1988 May; 106(5):629–39. [PubMed: 3358729]
3. Gaudric A, Haouchine B, Massin P, et al. Macular hole formation: new data provided by optical coherence tomography. *Arch Ophthalmol*. 1999 Jun; 117(6):744–51. [PubMed: 10369584]
4. Duker JS, Kaiser PK, Binder S, et al. The International Vitreomacular Traction Study Group classification of vitreomacular adhesion, traction, and macular hole. *Ophthalmology*. 2013 Dec; 120(12):2611–9. [PubMed: 24053995]
5. Kelly NE, Wendel RT. Vitreous surgery for idiopathic macular holes. Results of a pilot study. *Arch Ophthalmol*. 1991 May; 109(5):654–9. [PubMed: 2025167]
6. Gordon LW, Glaser BM, Ie D, et al. Full-thickness macular hole formation in eyes with a pre-existing complete posterior vitreous detachment. *Ophthalmology*. 1995 Nov; 102(11):1702–5. [PubMed: 9098265]
7. Smiddy WE. Macular hole formation without vitreofoveal traction. *Arch Ophthalmol*. 2008 May; 126(5):737–8. [PubMed: 18474794]
8. Brown GC. Macular hole following rhegmatogenous retinal detachment repair. *Arch Ophthalmol*. 1988 Jun; 106(6):765–6. [PubMed: 3370002]
9. Benson WE, Cruickshanks KC, Fong DS, et al. Surgical management of macular holes: a report by the American Academy of Ophthalmology. *Ophthalmology*. 2001 Jul; 108(7):1328–35. [PubMed: 11425696]
10. Boscia F, Recchimurzo N, Cardascia N, et al. Macular hole following conventional repair of bullous retinal detachment using air injection (D-ACE procedure). *Eur J Ophthalmol*. 2004 Nov-Dec; 14(6):572–4. [PubMed: 15638111]
11. Moshfeghi AA, Salam GA, Deramo VA, et al. Management of macular holes that develop after retinal detachment repair. *Am J Ophthalmol*. 2003 Nov; 136(5):895–9. [PubMed: 14597042]
12. Avins LR, Krummenacher TR. Macular holes after pneumatic retinopexy. Case reports. *Arch Ophthalmol*. 1988 Jun; 106(6):724–5. [PubMed: 3369990]
13. Hejny C, Han DP. Vitrectomy for macular hole after pneumatic retinopexy. *Retina*. 1997; 17(4): 356–7. [PubMed: 9279957]
14. Smiddy WE. Atypical presentations of macular holes. *Arch Ophthalmol*. 1993 May; 111(5):626–31. [PubMed: 8489442]
15. Lee SH, Park KH, Kim JH, et al. Secondary macular hole formation after vitrectomy. *Retina*. 2010 Jul-Aug; 30(7):1072–7. [PubMed: 20168267]
16. Schlenker MB, Lam WC, Devenyi RG, Kertes PJ. Understanding macular holes that develop after repair of retinal detachment. *Can J Ophthalmol*. 2012 Oct; 47(5):435–41. [PubMed: 23036545]
17. Benzerroug M, Genevois O, Siahmed K, et al. Results of surgery on macular holes that develop after rhegmatogenous retinal detachment. *Br J Ophthalmol*. 2008 Feb; 92(2):217–9. [PubMed: 18227202]
18. Shibata M, Oshitari T, Kajita F, et al. Development of macular holes after rhegmatogenous retinal detachment repair in Japanese patients. *J Ophthalmol*. 2012; 2012:740591. [PubMed: 22315662]
19. Garcia-Arumi J, Boixadera A, Martinez-Castillo V, et al. Macular holes after rhegmatogenous retinal detachment repair: surgical management and functional outcome. *Retina*. 2011 Oct; 31(9): 1777–82. [PubMed: 21606891]
20. Kimura H, Kuroda S, Nagata M. Macular hole formation in postvitrectomized eyes. *Retina*. 2005 Jun; 25(4):521–3. [PubMed: 15933604]
21. Tsilimbaris MK, Gotzaridis S, Charisis SK, et al. Spontaneous closure of macular holes developed after pars plana vitrectomy. *Semin Ophthalmol*. 2007 Jan-Mar; 22(1):39–42. [PubMed: 17366118]
22. Sheth HG, Bainbridge J. Development of full-thickness macular hole despite previous posterior vitreous detachment and vitrectomy for retinal detachment: two cases. *Eur J Ophthalmol*. 2008 Nov-Dec; 18(6):1025–7. [PubMed: 18988183]

23. Kumagai K, Ogino N, Furukawa M, et al. Surgical outcomes for patients who develop macular holes after pars plana vitrectomy. *Am J Ophthalmol*. 2008 Jun; 145(6):1077–80. [PubMed: 18378210]
24. Rahman W, Georgalas I, da Cruz L. Macular hole formation after vitrectomy for retinal detachment. *Acta Ophthalmol*. 2010 Jun; 88(4):e147–8. [PubMed: 19764913]
25. Fabian ID, Moisseiev E, Moisseiev J, et al. Macular hole after vitrectomy for primary rhegmatogenous retinal detachment. *Retina*. 2012 Mar; 32(3):511–9. [PubMed: 21799463]
26. Bhatnagar P, Kaiser PK, Smith SD, et al. Reopening of previously closed macular holes after cataract extraction. *Am J Ophthalmol*. 2007 Aug; 144(2):252–9. [PubMed: 17543876]
27. Kurz PA, Kurz DE. Macular hole closure and visual improvement with topical nonsteroidal treatment. *Arch Ophthalmol*. 2009 Dec; 127(12):1687–8. [PubMed: 20008730]

Summary Statement

In this retrospective case series, 15 patients developed full thickness macular hole following retinal detachment repair using vitrectomy. Hole closure was achieved in the majority of patients surgically but closure was associated with only modest visual improvement.

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Figure 1.

OCT images (preoperative and postoperative) of patients from current study (number 4, 5 and 6) developing macular hole after pars plana vitrectomy for retinal detachment. (A) - Preoperative OCT of patient number 4 shows full thickness macular hole with visual acuity 20/400. Postoperative OCT (4 months after macular hole surgery) shows closure of macular hole, foveal thinning and loss of IS-OS layer with 20/150 visual acuity. (B) Preoperative OCT of patient number 5 shows full thickness macular hole and 20/400 visual acuity. Postoperative OCT (6 weeks after macular hole surgery) shows macular hole closure and foveal thinning with 20/200 visual acuity. (C) Preoperative OCT of patient number 6 shows full thickness macular hole and visual acuity 20/400. Postoperative OCT (4 weeks after macular hole surgery) macular hole closure and cystic changes at fovea with 20/60 visual acuity.

Table 1

Clinical Profile I: History, clinical presentation and initial surgical management of patients developing macular hole after retinal detachment.

No	Age/Sex	Macula at Initial Presentation	Clinical PVD	Procedure for RD	Procedures for Recurrent RD prior to MH (if Present)	High Myopia	Time from Initial RD Surgery to MH Diagnosis (days)
Group A – Macular hole in RD patients							
1	76/F	Mac-Off	Yes	SBP/PPV/AFX/EL/10% C ₃ F ₈	-	No	99
2	60/M	Mac-Off	No	SBP/PPV/AFX/EL/20% SF ₆	-	No	91
3	50/F	Mac-Off	Yes	SBP/PPV/AFX/EL/C ₃ F ₈	-	Yes	85
4	60/M	Mac-On	Yes	SBP/PPV/AFX/EL/16% C ₃ F ₈	-	Unknown	105
5	57/F	Mac-Off	No	SBP/PPV/AFX/EL/PPL/C ₃ F ₈	-	Yes	44
6	63/F	Mac-Off	Yes	PPV/AFX/EL/C ₃ F ₈	-	Yes	76
7	59/M	Mac-On	Yes	PPV/AFX/EL/14% C ₃ F ₈	-	Yes	63
8	63/F	Mac-Off	Yes	SBP/PPV/PPL/SO	-	No	180
Group B – Macular hole in persistent or recurrent RD patients							
9	51/F	Mac-On	No	PPV/SPB/AFX/Gas	RRD×1 PPV/MP/AFX/EL/SO	Unknown	188
10	82/F	Mac-Off	No	PPV/AFX/EL/CRYO/Gas	RRD×1 PPV/AFX/EL/Gas	Unknown	140
11	74/M	Mac-On	No	SBP/PPV/AFX/CRYO/10% C ₃ F ₈	RRD×1 PPV/EL/ERM-P/ILM-P/Gas (at time of MH repair)	Unknown	47
12	60/M	Mac-On	Yes	PPV/AFX/EL/ERM-P/Gas	RRD×1 PPV/ERM-P/Oil (at time of MH repair)	No	41
13	86/F	Mac-On	Yes	PPV/FAX/EL/Gas	RRD×1 PPV/ERM-P/Oil (at time of MH repair)	Unknown	149
14	50/M	Mac-Off	Yes	SBP/PPV/AFX/EL/PFO/IVT/SO	RRD×1 after PPV/SOR PPV/ERM-P/ILM-P/Oil (at time of MH repair)	Yes	396
15	67/M	Mac-Off	No	SBP/PPV/AFX/EL/C ₃ F ₈	RRD×2 PPV, ERM-P, EL 10% C ₃ F ₈ PPV/ERM-P/ILM-P/Oil (at time of MH repair)	Unknown	81

AFX–air fluid exchange, EL–endolaser, ERM–P–epiretinal membrane peeling, F–female, High myopia=6diopters or axial length>26mm, IVT–intravitreal triamcinolone, M–male, MH–macular hole, MP–membrane peeling, PFO–perfluoro-n-octane, PPV–pars plana vitrectomy, PPL–pars plana lensectomy, PR–Pneumatic Retinopathy, PVD–posterior vitreous detachment, RD–primary retinal detachment, RRD–recurrent retinal detachment, SBP–scleral buckling procedure, SO–silicone oil, SOR–Silicone Oil Removal,

Table 2

Clinical Profile II: Surgical procedure performed and outcomes (anatomical and visual) of patients developing macular hole after pars plana vitrectomy for retinal detachment.

No	Procedure for MH	Initial BCVA *	BCVA at time of MH diagnosis	Final BCVA	Retinal status at the time of MH diagnosis	ERM at time of MH diagnosis	Macular hole at final visit	Follow-up (days)
Group A – Macular hole in RD patients								
1	PPV/ERM-P/ILM-P/Gas	5/200	20/400	20/200	No RD	Present	MH Open	80
2	PPV/ERM-P/Gas	HM	6/200	20/400	No RD	Present	MH Closed	18
3	PPV/Phaco/IOL/ILM-P/Gas	20/400	20/300	20/60	No RD	Absent	MH Closed	237
4	PPV/ERM-P/ILM-P/Gas	20/25	20/400	20/150	No RD	Present	MH Closed	215
5	PPV/ILM-P/Gas	HM	20/400	20/200	No RD	Absent	MH Closed	1067
6	PPV/ILM-P/Gas	3/200	20/200	20/60	No RD	Absent	MH Closed	114
7	PPV/ERM-P/ILM-P/Gas	20/40	20/60	20/70	No RD	Present	MH Closed	163
8	SOR/PPV/ERM-P/Gas	HM	20/200	20/100	No RD under Oil	Present	MH Closed	50
Group B – Macular hole in persistent or recurrent RD patients								
9	PPV/ERM-P/Gas	20/70	20/100	20/30	No RD under Oil	Present	MH Closed	142
10	PPV/ILM-P/Gas	20/200	20/200	20/80	No RD	Absent	MH Closed	109
11	PPV/ERM-P/ILM-P/Gas	20/30	HM	3/200	No RD	Present	MH Open	660
12	PPV/ERM-P/Oil	HM	HM	HM	Mac-Off	Present	MH Open	42
13	PPV/ERM-P/Oil	LP	5/200	HM	Mac-Off	Present	MH Open	182
14	PPV/ERM-P/ILM-P/Oil	HM	20/800	20/150	Mac-Off	Present	MH Closed	400
15	PPV/ERM-P/ILM-P/Oil	8/200	20/400	20/200	Mac-Off	Present	MH Closed	1051

BCVA-best corrected visual acuity, ERM – epiretinal membrane, ERM-P-epiretinal membrane peeling, HM-hand motions, ILM-P - inner limiting membrane peeling, IOL-intraocular lens, LP-light perception, MH-macular hole, SOR-silicone oil removal

Subgroup analysis (refractive status, macula off RD at presentation, use of silicon oil during MH surgery) and visual outcomes in patients developing macular hole after pars plana vitrectomy for retinal detachment.

Table 3

Group	Evaluation parameter	Initial Visual Acuity LogMAR (Snellen equivalent)	Final Visual Acuity LogMAR (Snellen equivalent)
Group A	Mac-on at presentation (n=2)	0.89 ± 0.6 (20/160)	0.71 ± 0.2 (20/100)
	Mac-off at presentation (n=6)	1.21 ± 0.2 (20/300)	0.82 ± 0.3 (20/125)
	Silicon oil during MH surgery (none)	na	na
	No silicon oil during MH surgery (n=8)	1.13 ± 0.3 (20/260)	0.80 ± 0.3 (20/125)
	High myopia (n= 4)	0.99 ± 0.4 (20/200)	0.62 ± 0.2 (20/80)
	No high myopia (n= 3)	1.27 ± 0.2 (20/400)	1.00 ± 0.3 (20/200)
	Scleral buckle (n=6)	1.27 ± 0.2 (20/400)	0.89 ± 0.3 (20/160)
	No scleral buckle (n=2)	1.06 ± 0.4 (20/200)	0.51 ± 0.1 (20/60)
Group B	Mac-on at presentation (n=4)	2.08 ± 1.1 (20/2400)	2.00 ± 1.3 (20/2000)
	Mac-off at presentation (n=3)	1.30 ± 0.3 (20/400)	0.82 ± 0.2 (20/125)
	Silicon oil during MH surgery (n=4)	1.88 ± 0.8 (20/1600)	1.97 ± 1.2 (20/2000)
	No silicon oil during MH surgery (n=3)	1.57 ± 1.2 (20/800)	0.87 ± 0.8 (20/160)
	High myopia (n=1)	1.60 (20/800)	0.88 (20/160)
	No high myopia (n=1)	3.00 (HM)	3.00 (HM)
	Scleral buckle (n=3)	1.87 ± 1.0 (20/1600)	2.20 ± 1.4 (20/3000)
	No scleral buckle (n=4)	1.65 ± 0.9 (20/800)	0.96 ± 0.7 (20/200)

HM-hand motions, Mac-on-macula on, Mac-off-macula off, MH-macular hole, na-Information not available, RD-retinal detachment

Table 4

Literature review - Demographics and surgical management of macular holes occurring after various retinal detachment procedures.

Author	Eyes (Patients)	M : F	Average Age	<65 : 65	Prevalence	Macula On/Off	Time to MH Average (range)	PPV	PPV+SBP	ERM present	ILM peeled	MH Closure
Kimura et al. 2005	2 (2)	2 : 0	68 (60–75)	1 : 1	NA	2/0	27.5 (9–36)	2	0	0	Yes	2/2 (100%)
Tsilimbiris et al. 2007	2 (2)	0 : 2	57 (53–60)	2 : 0	NA	NA	1.75	2	0	NA	NA	2/2 (100%)
Benzerroug et al. 2008	3 (3)	3 : 0	52 (43–64)	3 : 0	9/1007 (0.9%) (including SBP and PR)	1/2	7 (1–18)	0	3	NA	NA	2/3 (66%)
Shen et al. 2008	2 (2)	2 : 0	66 (62–79)	1 : 1	NA	0/2	30 (24–36)	2	0	1/2	Yes	1/1 (100%)
Kudragai et al. 2008	5 (5)	3 : 2	67 (NA)	NA	NA	NA	NA	5	0	NA	Yes or No	4/5 (80%)
Lee et al. 2008	5 (5)	1 : 4	57 (27–78)	3 : 2	8/3279 (0.24%) MH after PPV for any etiology	NA	25.8 (0.6–168)	5	0	1/5	Yes	5/5 (100%)
Rahman et al. 2011	5 (5)	5 : 0	59.6 (56–71)	4 : 1	NA	0/1 (1 unknown)	1.85	5	0	1/5	Yes	4/5 (80%)
Garcia Argani et al. 2011	14 (14)	6 : 8	52 (29–67)	13 : 1	20/2356(0.85%) (including SBP)	0/14	10 (0.75–67)	14	0	9/20	Yes	14/14 (100%)
Shibata et al. 2012	5 (5)	3 : 2	49 (16–60)	5 : 0	4/1260 (0.32%)	2/2 (1 unknown)	25 (0.27–65)	4	1	NA	Yes	5/5 (100%)
Schwenker et al. 2012	7 (7)	4 : 3	44 (9–62)	6 : 1	18/985 (1.9%) (including SBP and PR)	0/7	2.4 (0.25–12)	7	0	2/7	Yes	6/7 (86%)
Fabian et al. 2012	7 (6)	2 : 4	62 (50–79)	5 : 1	7/609 (1.1%)	4/3	20 (1–48)	1	6	1/7	Yes	4/4 (100%)
Khurana et al. 2016	14 (14)	8 : 6	61 (43–80)	10 : 4	NA	5/9	15 (1–78)	9	6	14/14	Yes	14/14 (100%)

ERM - epiretinal membrane, F-female, ILM- inner limiting membrane, M-male, m-months, MH-macular hole, NA-not available, PPV-pars plana vitrectomy, PR-pneumatic retinopexy, SBP-scleral buckling procedure

Table 5

Comparison of the current study with previously published studies.

	Published data	Current Study
Eyes (Patients)	71 (70)	15 (15)
Average age in years (range)	61 (9–80)	64 (50–86)
Male : Female	39 : 31	7 : 8
Average time from RD Surgery to MH (Range)	13 months (7 days to 14 years)	4 months (41–398 days)
Pseudophakic at Time of RD	21/41 (51%)	8/15 (53%)
Possible associations <ul style="list-style-type: none">• High Myopia• Macula off RD• Recurrent RD• Presence of ERM at the time of MH diagnosis	<div>10/28 (36%)</div> <div>37/51 (73%)</div> <div>15/71 (21%)</div> <div>22/32 (69%)</div>	<div>4/9 (44%)</div> <div>9/15 (60%)</div> <div>9/15 (60%)</div> <div>11/15 (73%)</div>
MH Closure at Last Follow Up	65/71 (92%)	11/15 (73%)

ERM-epiretinal membrane, MH-macular hole, RD-primary retinal detachment