Effect of the Coexistence of a Macular Hole and an Epiretinal Membrane on Surgical Outcomes

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ABSTRACT

Purpose: To investigate the effect of epiretinal membrane (ERM) presence on postoperative visual acuity and retinal nerve fiber layer (RNFL) thickness in patients undergoing surgery for macular hole.

Methods: Forty eyes of 39 patients who underwent vitrectomy for macular hole at our clinic were included. preoperative and postoperative (6-month) swept-source optical coherence tomography (SS-OCT; Topcon) was used to measure macular hole diameter and RNFL thickness. Medical records were reviewed to document preoperative and postoperative best-corrected visual acuity (BCVA, logMAR), intraocular pressure, anterior and posterior segment findings. Data were statistically compared between groups and between time points.

Results: Of 40 eyes, 28 had macular hole alone and 12 had macular hole combined with ERM. Mean hole diameter was 609 ± 192.8 µm in the ERM + macular hole group versus 504.3 ± 182 µm in the macular hole-only group ($p = 0.109$). RNFL thickness increased by 2.2 ± 11.1 µm in eyes without ERM, while a decrease of 1.6 ± 8.0 µm was observed in eyes with ERM ($p = 0.292$). Anatomical success was achieved in all eyes. Postoperative BCVA improvement was −0.599 ± 0.345 logMAR in the macular hole-only group and −0.413 ± 0.226 logMAR in the ERM + macular hole group; the between-group difference was not statistically significant ($p = 0.090$). Both groups demonstrated statistically significant postoperative BCVA improvement (macular hole only: $p < 0.001$; ERM + macular hole: $p = 0.002$).

Conclusion: Postoperative visual acuity improved significantly in both groups following macular hole surgery. The presence of ERM did not significantly affect visual outcomes, although improvement was numerically greater in eyes without ERM.

Keywords: Macular hole, Epiretinal membrane, Retinal nerve fiber layer (RNFL), vitrectomy

INTRODUCTION

A macular hole is a full-thickness defect of the foveal neurosensory retina.[1] It occurs 2–3 times more frequently in women than in men.[2,3] The majority of macular holes are idiopathic; other recognized etiologies include trauma, high myopia, cystoid macular edema (CME), ocular inflammation, solar retinopathy, vitreomacular traction (VMT), traction from epiretinal membranes (ERMs), and degenerative retinal disease.[4] An epiretinal membrane, commonly referred to as macular pucker or cellophane maculopathy, is a pathological fibrocellular tissue that forms at the vitreoretinal interface.[5]

The reported prevalence of ERM in idiopathic macular holes ranges from 30% to 73%.[6-8] Two opposing hypotheses have been proposed to explain this relationship. Some investigators suggest that ERMs surrounding a macular hole actively contribute to hole formation,[9,10] while others

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contend that ERMs develop as a secondary consequence of macular hole formation.[11]

The natural history of ERMs surrounding macular holes—and their potential relationship with subsequent anatomical and functional changes—remains incompletely characterized. The role of ERM in the pathophysiology of idiopathic macular holes and its influence on surgical outcomes have attracted growing clinical interest. We designed this study to investigate the effect of ERM presence on postoperative visual parameters and anatomical recovery as assessed by optical coherence tomography (OCT) in patients undergoing surgical repair of macular hole.

METHODS

This study was conducted in accordance with the ethical standards set out in the Declaration of Helsinki. Prior to enrolment, written informed consent was obtained from all patients and/or their legal guardians. The study was conceived as a retrospective case series.

A total of 98 patients with a diagnosed macular hole were identified through a review of medical records. Of these 98 patients, 55 were excluded from the study due to age, comorbidities, or lack of surgical indications. Two patients were also excluded from the study because they developed a retinal detachment following macular hole surgery. Forty eyes of 39 patients (one patient contributing both eyes) who underwent surgical repair for macular hole at a tertiary ophthalmology center were included. Patients with additional retinal pathology beyond ERM and macular hole—including degenerative myopia, rhegmatogenous retinal detachment, diabetic retinopathy, age-related macular degeneration, glaucoma and prior vitrectomy performed for indications other than ERM or macular hole—were excluded. The patients included in the study were selected from those with a postoperative hole that closed completely anatomically.

All patients underwent preoperative and 6-month postoperative SS-OCT imaging (Topcon). Macular hole diameter was classified according to the Gass grading system as small (<250 μm), medium (250–400 μm), or large (>400 μm). RNFL thickness was measured at both time points. Pre- and postoperative widefield fundus photographs (Figures 1 and 2) and OCT images (Figures 3 and 4) were obtained. Medical records were reviewed to document BCVA (logMAR), intraocular pressure, and anterior and posterior segment findings at each visit. All recorded data were compared statistically between groups and between time points.

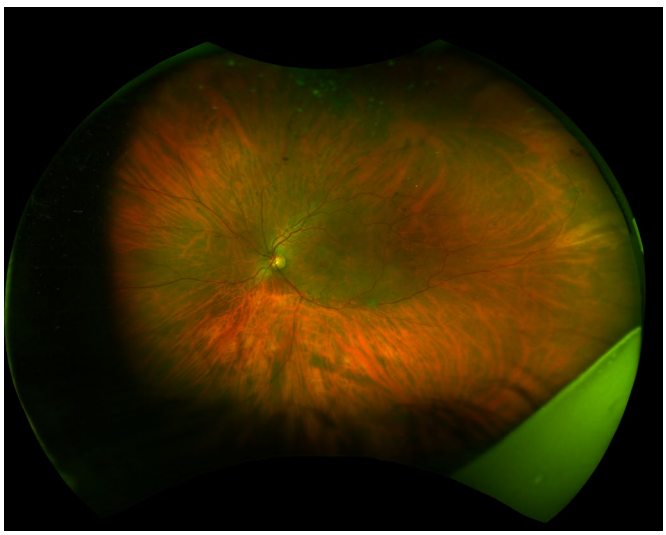

Figure 1. *Widefi eld fundus photograph of a patient with isolated macular hole.*

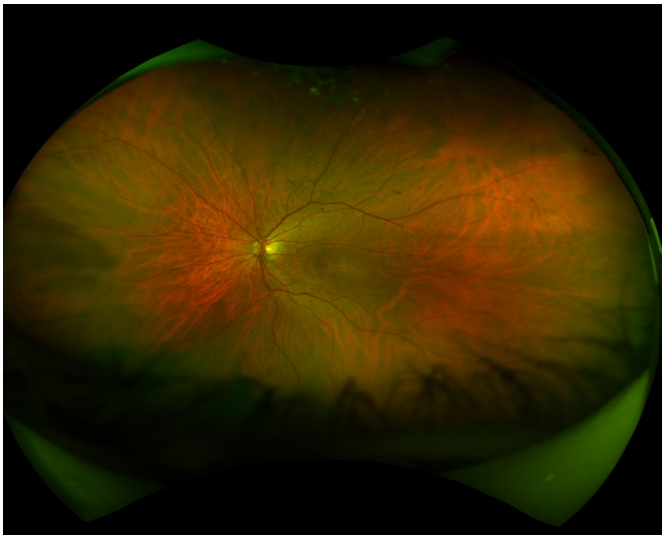

Figure 2. *Widefield fundus photograph of a patient with concurrent ERM and macular hole.*

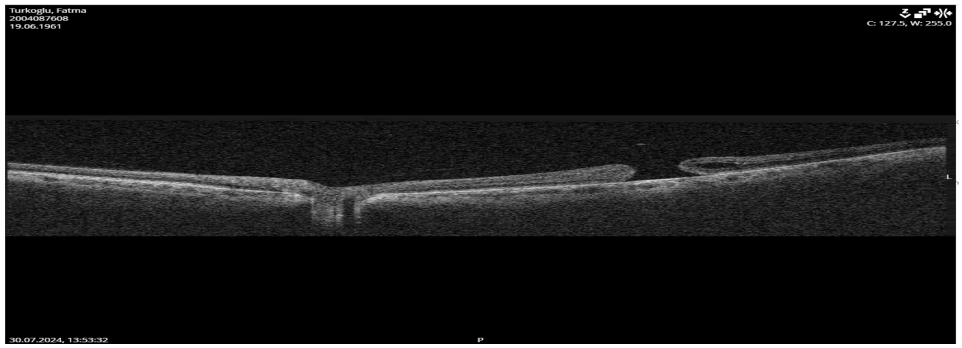

Figure 3. *Optical coherence tomography image of a patient with isolated macular hole.*

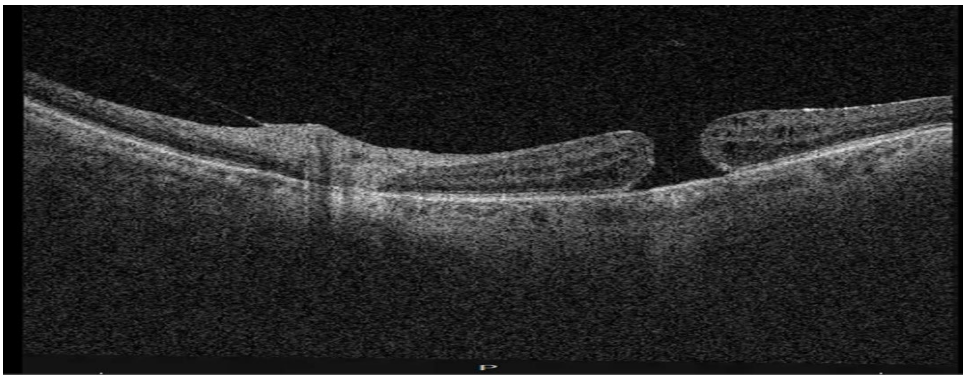

Figure 4. *Optical coherence tomography image of a patient with concurrent ERM and macular hole.*

Surgical Technique

All procedures were performed by a single experienced vitreoretinal surgeon using standard three-port trans pars plana vitrectomy with complete vitreous removal and posterior hyaloid separation. The decision to remove ERM was made during the operation by the operating surgeon. In all eyes, internal limiting membrane (ILM) peeling was performed after core vitrectomy and posterior hyaloid separation, assisted by intraoperative staining with Brilliant Blue G (BBG) dye, and was extended for approximately 1.5–2 optic disc diameters around the fovea. In eyes with concurrent ERM, ERM removal was always followed by ILM peeling within the same surgical session, using the same staining protocol; ILM peeling was not performed as an isolated step without prior ERM removal in this subgroup. In cases where a peripheral retinal scan revealed a tear or degeneration, 360-degree, 4-row laser photocoagulation was also performed. The next step was to perform fluid–air exchange to flatten the macular hole. The procedure was concluded with the injection of 16% perfluoropropane (C3F8) gas into the vitreous cavity. All patients were instructed to maintain strict face-down positioning for two weeks postoperatively, after which time they were allowed to sit up.

Statistical Analysis

The statistical analysis was done using SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed as the mean ± standard deviation (SD), or as a number and frequency where applicable. The normality of continuous variables was assessed using the Shapiro–Wilk test. For the purpose of between-group comparisons, the Mann-Whitney U test was applied to non-normally distributed variables, while the independent samples t-test was utilised for normally distributed variables. Categorical variables were compared using the chi-square test. For within-group pre- and postoperative comparisons, the Wilcoxon signed-rank test was used for non-normally distributed variables and the paired samples t-test for normally distributed variables. A p value of less than 0.05 was considered statistically significant.

RESULTS

Among the 40 eyes analyzed, 28 had isolated macular hole and 12 had concurrent macular hole and ERM. No statistically significant differences were found in terms of age and sex between the ERM group and the non-ERM group (p for age: 0.082, p for sex: 0.563). Of the eyes included in the study, 34 eyes underwent phacoemulsification plus vitrectomy; in the 9 eyes that underwent combined surgery, both ERM and a hole were present. Phacoemulsification was not performed on 6 eyes. The duration of symptoms among the patients included in the study ranged from an average of 6 months to 1 year. Mean hole diameter was 609 ± 192.8 µm in the ERM + macular hole group and 504.3 ± 182 µm in the macular hole-only group (p = 0.109). In eyes without ERM, postoperative RNFL thickness increased by a mean of 2.2 ± 11.1 µm, while eyes with ERM showed a mean decrease of 1.6 ± 8.0 µm (p = 0.292). Preoperative BCVA was 1.193 ± 0.418 logMAR in the macular hole-only group and 1.130 ± 0.284 logMAR in the ERM + macular hole group. Postoperative BCVA improvement was −0.599 ± 0.345 logMAR in the macular hole-only group and −0.413 ± 0.226 logMAR in the ERM + macular hole group. No statistically significant difference in the magnitude of BCVA improvement was detected between groups (p = 0.090) (Table 1).

Both groups achieved statistically significant postoperative visual acuity improvement (macular hole only: p < 0.001; ERM + macular hole: p = 0.002). Mean RNFL thickness in the macular hole-only group was 104.9 ± 13.2 µm preoperatively and 107.1 ± 10.9 µm postoperatively (p = 0.300). In the ERM group, corresponding values were 110.0 ± 10.9 µm and 108.4 ± 9.9 µm (p = 0.509) (Table 2).

Table 1. *Comparison of parameters by ERM status.*

Parameter	No ERM (n=28) Mean ± SD	ERM Present (n=12) Mean ± SD	p value
Age	68.1 ±6.3	72.3 ± 8.0	0.082[1]
Sex (M/F)	9/19	5/7	0.563[2]
Hole diameter (µm)	504.3 ± 182.1	609.2 ± 192.8	0.109[1]
Preoperative RNFL thickness (µm)	104.9 ± 13.2	110.0 ± 10.9	0.243[1]
Postoperative RNFL thickness (µm)	107.1 ± 10.9	108.4 ± 9.9	0.716[1]
Preoperative BCVA (logMAR)	1.193 ± 0.418	1.130 ± 0.284	0.833[3]
Postoperative BCVA (logMAR)	0.594 ± 0.340	0.717 ± 0.283	0.128[3]
ΔRNFL (µm)	2.2 ± 11.1	−1.6 ± 8.0	0.292[1]
ΔBCVA (logMAR)	−0.599 ± 0.345	−0.413 ± 0.226	0.090[3]
Phacoemulsification (no/yes)	3/25	3/9	0.246[2]

[1]Independent samples t-test; [2]Chi-square test. [3]Mann-Whitney U test; M=Male; F=Female; BCVA = best-corrected visual acuity; RNFL = retinal nerve fiber layer; SD = standard deviation.

Table 2. *Preoperative and postoperative parameter comparisons within each group.*

Parameter	Preoperative Mean ± SD	Postoperative Mean ± SD	p value
No ERM (n = 28)			
BCVA (logMAR)	1.193 ± 0.418	0.594 ± 0.340	0.000[1]
RNFL thickness (µm)	104.9 ± 13.2	107.1 ± 10.9	0.300[2]
ERM Present (n = 12)			
BCVA (logMAR)	1.130 ± 0.284	0.717 ± 0.283	0.002[1]
RNFL thickness (µm)	110.0 ± 10.9	108.4 ± 9.9	0.509[2]

[1]Wilcoxon signed-rank test; [2]Paired samples t-test. BCVA = best-corrected visual acuity; RNFL = retinal nerve fiber layer; SD = standard deviation.

Discussion

The coexistence of ERM and macular hole remains an area with many unresolved questions regarding both pathophysiology and surgical outcomes. To the best of our knowledge, this study is the first to compare RNFL thickness changes following macular hole surgery according to the presence or absence of ERM. Our findings show that visual acuity improvement was more pronounced in eyes with isolated macular hole, suggesting that even when anatomical closure is achieved in ERM-associated macular holes, functional recovery may not reach the same level as in eyes without ERM.

Idiopathic age-related macular holes have a prevalence of approximately 1 in 200 individuals over the age of 60 and are a common cause of significant central visual impairment, occurring bilaterally in up to 10% of patients.[12] These holes may arise from vitreous traction following posterior vitreous detachment, proliferative vitreoretinopathy, or ocular trauma.[13] Surgical removal of the premacular vitreous is widely accepted to achieve anatomical closure in approximately 58%–90% of cases.[14,15,16] Although some reports advocate membranectomy for surgically unclosed holes, the role of aggressive epiretinal peeling or internal limiting membrane (ILM) peeling remains debated.[17,18] Both cases reported by Taş and colleagues were diagnosed as excentric macular holes following ERM, and the development of the holes was attributed to Müller cell damage resulting from ILM peeling, the induction of glial apoptosis, and forceps trauma during surgery[19]

With modern vitreoretinal surgical techniques combining pars plana vitrectomy, ILM peeling, and gas tamponade, primary closure rates now exceed 90%. However, in refractory macular holes that have previously undergone ILM peeling, anatomical and functional success rarely exceeds 70%.[20] Large chronic holes and those in highly myopic eyes carry a greater risk of surgical failure.[21]

While some authors advocate for ERM removal in these cases, others have reported comparably favorable outcomes without ERM peeling.[22,23] Cheng et al. emphasized that ERMs in the setting of macular holes develop after hole formation, tend to progress over time, and may be responsible for hole enlargement.[24] That study reported an ERM + macular hole coexistence prevalence of 65%, compared with 30% in our series. The same group found that the likelihood of ERM coexistence was higher in stage III/IV macular holes than in stage II holes.[24] Consistent with this observation, we found larger hole diameters in patients with concurrent ERM (609 ± 192.8 µm vs. 504.3 ± 182 µm in those without ERM), though the difference did not reach statistical significance ($p = 0.109$). While eyes without ERM showed a postoperative RNFL increase of 2.2 ± 11.1 µm, those with ERM demonstrated a decrease of 1.6 ± 8.0 µm; this difference was also not statistically significant ($p = 0.292$). A review of the existing literature revealed no prior studies examining RNFL thickness changes in the combined setting of macular hole and ERM. To our knowledge, the present study is the first to assess this parameter.

The rationale for evaluating RNFL thickness, rather than ganglion cell layer or macular thickness, was that internal limiting membrane (ILM) peeling—performed in the majority of eyes in this series—may induce mechanical or apoptotic injury to the nerve fiber layer independent of the photoreceptor-level recovery captured by macular thickness measurements. Postoperative thinning or dissociation of the RNFL after ILM peeling, described as the “dissociated optic nerve fiber layer” (DONFL) phenomenon, has been well documented following vitrectomy with ILM peeling for both macular hole and ERM, and has been attributed to mechanical trauma to nerve fiber bundles or peeling-induced apoptosis of retinal ganglion cell axons.[25] We therefore considered RNFL thickness a potentially sensitive structural marker of surgical trauma in this setting, whereas ganglion cell layer analysis was not routinely available on our OCT platform for all study eyes. Outer retinal microstructural changes, including ellipsoid zone integrity, have also been shown to relate to visual recovery in eyes with combined macular hole and ERM, and may complement RNFL-based assessment in future studies .In a study comparing retinal thickness, the ellipsoid zone (EZ), and the interdigital zone (IZ) in patients with ERM and macular hole, it was found that retinal thickness was greater in the ERM group, the frequency of IZ integrity was higher in the macular hole group than in the ERM group, and there was no difference in the EZ integrity. The study demonstrated that photoreceptor integrity was preserved in eyes with ERM[26]

Among the factors associated with better visual outcomes after macular hole surgery, preoperative visual acuity and smaller hole diameter have been identified in multiple studies.[27] One large-cohort study additionally highlighted the duration of symptoms and the absence of age-related macular degeneration as independent contributors to postoperative BCVA.[21] Although anatomical hole closure is the primary determinant of postoperative visual recovery, the degree of improvement in surgically closed eyes is variable. In one large series, approximately 55% of cases achieved a gain of at least 0.30 logMAR units, while a large UK national audit found that only 35% attained a final BCVA of 0.30 logMAR or better.[28] In our cohort, postoperative BCVA improvement was 0.40 logMAR in the ERM + macular hole group and 0.50 logMAR in the macular hole-only group, with no statistically significant difference between groups. These results are consistent with earlier reports indicating that ERM presence does not adversely affect postoperative BCVA improvement.[14]

The most serious complications resulting from macular surgeries, including ERM and macular hole surgery, are endophthalmitis and rhegmatogenous retinal detachment (RRD)[29].In a study conducted in France following an 11-year follow-up, the rate of retinal detachment after ERM surgery was 1.95%, while the rate after macular hole surgery was 3.43%[30]. Wilkin Parke and colleagues found that the rate of rhegmatogenous retinal detachment following macular hole surgery was 2.0%.[31]. Postoperative RRD after macular surgery is due to retinal breaks, appearing either during or after the surgical procedure [32].Because our patients underwent peripheral retinal screening after vitrectomy and received laser photocoagulation whenever a tear was detected, the incidence of RRD was quite low, and these patients were excluded from the study.

This study has several limitations. The retrospective design and the relatively small sample size, particularly in the ERM + macular hole group (n = 12), limited the statistical power to detect between-group differences and precluded further stratified analyses, such as separate comparisons according to hole diameter (e.g., <400 µm vs. ≥400 µm) or multivariable assessment of factors including cataract and glaucoma status; these analyses would require a larger cohort to be adequately powered and are planned for a future prospective study. Baseline symptom duration and patient age are reported above but were not analyzed as independent predictors of outcome in the present cohort. Finally, RNFL thickness was measured globally rather than by sector, which may have limited sensitivity to detect localized changes related to ILM peeling.

Conclusion

Epiretinal membrane coexistence is common in eyes with full-thickness macular holes, and its prevalence increases with both the severity and diameter of the hole. The effect of ERM on visual outcomes remains debated. In our series, visual acuity improvement was numerically greater in eyes without ERM, though this difference did not reach statistical significance. Further prospective studies with larger cohorts and longer follow-up are needed to clarify the influence of ERM on long-term functional and anatomical outcomes following macular hole surgery.

REFERENCES

1. Takahashi A, Yoshida A, Nagaoka T, Takamiya A, Sato E, Kagokawa H, Kameyama D, Sogawa K, Ishiko S, Hirokawa H. Idiopathic full-thickness macular holes and the vitreomacular interface: a high-resolution spectral-domain optical coherence tomography study. Am J Ophthalmol. 2012;154:881-892.

2. Aaberg TM, Blair CJ, Gass JD. Macular holes. Am J Ophthalmol. 1970;69:555-562.

3. Aaberg TM. Macular holes: a review. Surv Ophthalmol. 1970;15:139-162.

4. Gholam P, Stephen P, Mandi C. Vitreoretinal Surgical Techniques. UK: Informa; 2007.

5. Kwok AK, Lai TY, Yuen KS. Epiretinal membrane surgery with or without internal limiting membrane peeling. Clin Exp Ophthalmol. 2005;33:379-385. doi:10.1111/j.1442-9071.2005.01015.x

6. Department of Ophthalmology, Shiley Eye Center, University of California San Diego, La Jolla, California.

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8. Members of the Vitrectomy for Macular Hole Study Group are listed in the Appendix at the end of this article.

9. Messmer EM, Heidenkummer HP, Kampik A. Ultrastructure of epiretinal membranes associated with macular holes. Graefes Arch Clin Exp Ophthalmol. 1998;236:248-254.

10. 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;102:1702-1705.

11. Blain P, Paques M, Massin P, Erginay A, Spielmann AC, Santiago PY, Gaudric A. Epiretinal membranes surrounding idiopathic macular holes. Retina. 1998;18(4):316-321.

12. Meuer SM, Myers CE, Klein BE, Swift MK, Huang Y, Gangaputra S, et al. The epidemiology of vitreoretinal interface abnormalities as detected by spectral-domain optical coherence tomography: the Beaver Dam Eye Study. Ophthalmology. 2015;122:787-795. doi:10.1016/j.ophtha.2014.10.014

13. Bringmann A, Unterlauft JD, Barth T, et al. Different modes of full-thickness macular hole formation. Exp Eye Res. 2021;202:108393.

14. Gass JDM. Idiopathic senile macular hole: its early stages and pathogenesis. Arch Ophthalmol. 1988;106:629-639.

15. Smiddy WE, Green WR, Michels RG, de la Cruz Z. Ultrastructural studies of vitreomacular traction syndrome. Am J Ophthalmol. 1989;107:177-185.

16. Kelly NE, Wendel RT. Vitreous surgery for idiopathic macular holes: results of a pilot study. Arch Ophthalmol. 1991;109:654-659.

17. Olsen TW, Sternberg P Jr, Capone A Jr, et al. Macular hole surgery using thrombin-activated fibrinogen and selective removal of the internal limiting membrane. Retina. 1998;18:322-329.

18. Park DW, Sipperley JO, Sneed SR, et al. Macular hole surgery with internal-limiting membrane peeling and intravitreous air. Ophthalmology. 1999;106:1392-1397.

19. Taş MA, Şekeryapan Gediz B. Excentric Macular Hole Following Epiretinal Membrane Surgery: Two Case Reports. Ret-Vit 2025; 34: 55-58.

20. Grewal DS, Charles S, Parolini B, Kadonosono K, Mahmoud TH. Autologous retinal transplant for refractory macular holes: multicenter international collaborative study group. Ophthalmology. 2019;126:1399-1408. doi:10.1016/j.ophtha.2019.01.027

21. Steel DH, Donachie PHJ, Aylward GW, Laidlaw DA, Williamson TH, Yorston D, et al. Factors affecting anatomical and visual outcome after macular hole surgery: findings from a large prospective UK cohort. Eye (Lond). 2021;35:316-325. doi:10.1038/s41433-020-0844-x

22. Leonard RE 2nd, Smiddy WE, Flynn HW Jr, Feuer W. Long-term visual outcomes in patients with successful macular hole surgery. Ophthalmology. 1997;104:1648-1652.

23. Lansing MB, Glaser BM, Liss H, et al. The effect of pars plana vitrectomy and transforming growth factor-beta 2 without epiretinal membrane peeling on full-thickness macular holes. Ophthalmology. 1993;100:868-871.

24. Cheng L, Freeman WR, Ozerdem U, Song MK, Azen SP. Prevalence, correlates, and natural history of epiretinal membranes surrounding idiopathic macular holes. Ophthalmology. 2000;107(5):853-859.

25. Tadayoni R, Paques M, Massin P, Mouki-Benani S, Mikol J, Gaudric A. Dissociated optic nerve fiber layer appearance of the fundus after idiopathic epiretinal membrane removal. Ophthalmology. 2001;108:2279-2283.

26. Karahan E, Kartı Ö, Kaya M, et al. Evaluation of Outer Retinal Microstructure in Eyes with Epiretinal Membrane and Macular Hole. Ret-Vit 2018; 27: 259-264.

27. Essex RW, Hunyor AP, Moreno-Betancur M, Yek JTO, Kingston ZS, Campbell WG; Australian and New Zealand Society of Retinal Specialists Macular Hole Study Group. The visual outcomes of macular hole surgery: a registry-based study by the Australian and New Zealand Society of Retinal Specialists. Ophthalmol Retina. 2018;2:1143-1151. doi:10.1016/j.oret.2018.04.022

28. Jackson TL, Donachie PHJ, Sparrow JM, Johnston RL. United Kingdom National Ophthalmology Database study of vitreoretinal surgery: report 2, macular hole. Ophthalmology. 2013;120:629-634. doi:10.1016/j.ophtha.2012.09.003

29. Rizzo S, Belting C, Genovesi-Ebert F, di Bartolo E. Incidence of retinal detachment after small-incision, sutureless pars plana vitrectomy compared with conventional 20-gauge vitrectomy in macular hole and epiretinal membrane surgery. Retina . 2010;30(7):1065–1071

30. Ben Ghezala I, Mariet AS, Benzenine E, Gabrielle PH, Baudin F, Quantin C, Creuzot-Garcher C. Incidence of Rhegmatogenous Retinal Detachment Following Macular Surgery in France Between 2006 and 2016. Am J Ophthalmol. 2022 Nov;243:91-97. doi: 10.1016/j.ajo.2022.07.017.

31 Parke 3rd DW, Lum F. Return to the operating room af- ter macular surgery: IRIS registry analysis. Ophthalmology . 2018;125(8):1273–1278

32. Marie-Louise J, Philippakis E, Darugar A, Tadayoni R, Dupas B. Occurrence rate of retinal detachment after small gauge vitrectomy for idiopathic epiretinal membrane. Eye (Lond) . 2017;31(9):1259–1265