Predictive value of ectopic inner foveal layer without internal limiting membrane peeling for idiopathic epiretinal membrane surgery

Bugra Karasu · Ali Rıza Cenk Celebi

Received: 7 August 2021 / Accepted: 18 December 2021 / Published online: 6 January 2022
© The Author(s), under exclusive licence to Springer Nature B.V. 2022

Abstract
Purpose To investigate the clinical importance of ectopic inner foveal layer (EIFL) grading (mild to severe) in patients diagnosed with idiopathic epiretinal membrane (iERM) and had pars plana vitrectomy (PPV) with solely ERM peeling.

Materials and methods Patients diagnosed with iERMs who had undergone PPV including only ERM peeling were enrolled in the study, and follow-up findings were recorded at baseline, and at 3, 6, 12 months and final examinations. EIFL was categorized into four grades, from mild to severe. Pre- and postoperative anatomical changes were measured using spectral domain optical coherence tomography (SD-OCT) imaging. The association between EIFL and other SD-OCT parameters with best-corrected visual acuity (BCVA) was assessed before and after PPV surgery.

Results One-hundred thirty-eight eyes of 106 patients with mild to severe EIFL were included in the study. Higher EIFL thickness was significantly correlated with lower baseline \( r=0.575, p=0.020 \) and final BCVA \( r=0.748, p=0.001 \). Although EIFLs continued in advanced-stage cases (stage 3 and 4) (64 eyes [82%]) at the final visit, it was observed in 8 eyes (23%) in the early stage (stage 2) of iERMs. A strong positive correlation was found between EIFL thickness and recurrence rate of ERM \( r=0.876, p<0.001 \). Recurrence of ERM was detected in 27 eyes; 2 (7%) at stage 1, 3 (9%) at stage 2, 10 (23%) in stage 3, and 12 (33%) in stage 4 \( p<0.001 \).

Conclusion A negative association was found between the severity of EIFL and postoperative anatomical and visual recovery. In terms of surgical timing, early stages (stages 1 and 2) may be preferred for providing good anatomical and visual recovery and a low recurrence rate following surgery.

Keywords Ectopic inner foveal layer · Epiretinal membrane · Membrane peeling · Pars plana vitrectomy · ERM recurrence

Introduction

Pars plana vitrectomy (PPV) with idiopathic epiretinal membrane (iERM) peeling is the most acceptable surgical procedure for symptomatic
epiretinal membranes (ERMs). Despite the superiority of anatomical achievements, visual prognosis is occasionally unpredictable following surgery [1–4]. Therefore, several studies have been undertaken to identify sensitive prognostic biomarkers that can visually estimate postoperative achievement.

Various biomarkers have been described in the literature as predictors of visual acuity following surgery in iERMs. These include the integrity and continuity of both the ellipsoid and interdigitation zones, and the length of the photoreceptor outer segment [3, 5, 6]. However, prognostic evaluation of such parameters remains controversial, because the assessment of outer retinal integrity may not be analyzed in some eyes with iERMs due to the artifacts present in SD-OCT [7]. Since analysis of outer retinal changes may be inadequate to predict postoperative visual results, studies of inner retinal layers, which are among the main regions affected by ERM-related mechanical stress, should be considered first [8–12].

In a recent study, the existence of ectopic inner foveal layers (EIFLs) in the central foveal zone in eyes with iERMs was characterized using SD-OCT. The formation of EIFL may represent a substantial part of ERM development, and is crucial for newly recommended SD-OCT staging diagrams in iERMs [13]. Although the presence of EIFL has been documented to be related to lower baseline best-corrected visual acuity (BCVA), the prognostic effect of EIFL on postoperative BCVA has not been elucidated due to the controversial results on this issue [12, 13].

In order to investigate the clinical importance of EIFL, in the present study, the outcomes of both visual and anatomical surgery were analyzed in a patient cohort diagnosed with iERMs and had PPV with solely ERM peeling.

Materials and methods

Between September 2013 and March 2019, the medical records of 106 iERM patients (138 eyes) who had undergone PPV in a tertiary hospital were procured. These were then screened by two independent evaluators (BK and AC) and reviewed retrospectively.

Patients were allocated to four stages in accordance with the ERM type:

Stage 1—26 eyes,
Stage 2—34 eyes,
Stage 3—42 eyes,
Stage 4—36 eyes.

The study protocol was conducted in accordance with the principles of the Helsinki Declaration and approved by the local ethics committee (approval number: 2019–06/10).

Inclusion criteria were the presence of iERM which was followed up regularly and treated with PPV and membrane peeling (only ERM), and a follow-up period of at least 13 months.

Exclusion Criteria were as follows:

Any history of intraocular surgery except for phacoemulsification surgery, previous retinal detachment history, all types of age-related macular degeneration, history of choroidal neovascularization (CNV), pachychoroid spectrum diseases and all subtypes, all forms of diabetic retinopathy that cause macular edema, retinal dystrophies, previous history of all types of retinal vein and artery occlusion, any history of advanced glaucoma and optic neuropathy, history of ocular trauma, history of endophthalmitis or any intraocular infection, macular telangiectasia, history of Irvine–Gass syndrome, or other reasons that may cause vision decrement other than ERM.

Ophthalmic assessment comprised of a comprehensive ophthalmologic examination including BCVA and intra-ocular pressure (IOP) assessment, slit lamp biomicroscopy, fundus examination, and SD-OCT imaging at baseline and at 3, 6, 12, and final visit following PPV surgery. BCVA was evaluated using the Snellen chart at each visit and subsequently converted to the logarithm of the minimum resolution angle (logMAR).

Ectopic inner foveal layers were characterized by SD-OCT scans in the fovea as follows: the presence of hyporeflective and hyperreflective bands spreading from the inner nuclear and the inner plexiform layer along with the fovea region was detected as shown in Fig. 1. The EIFL thickness in the central fovea region was manually measured using Heidelberg Spectralis as a vertical line between the outer edge of the inner
nuclear layer and the lower face of the central ERM (Fig. 1) [13].

Mean central macular thickness (CMT) was measured automatically using the Heidelberg program. In SD-OCT, ERM is generally described as a single, irregular line above the internal limiting membrane (ILM) underlying the retinal wrinkle and hyperreflective band among the ERM and ILM. In the present study, all ERMs (138 eyes) were based on a four-grade staging system, as in the ERM classification described by Govetto et al. [13], as shown in Fig. 1.

**Staging scheme of ERMs by SD-OCT (Fig. 1)**

**Stage 1.** This stage indicates a mild ERM with a few anatomical changes. The foveal depression and contour are maintained, and all retinal layers are well visualized. This stage has a thin cellophane-like membrane appearance.

**Stage 2.** There are several anatomical modifications associated with this stage. Though the foveal depression disappears, all retinal layers can be visualized.

**Stage 3.** Sustained EIFLs overlap with the entire foveal base (white arrows). Similar to grade 1 ERMs, the foveal depression has been lost, and all retinal layers are well displayed.

**Stage 4.** In this stage, irregularity and disorganization of ERM are seen in all layers of the fovea. Thick EIFLs entirely enclose the foveal area (white arrows), foveal depression is not observed, and the whole retinal layers are distorted.

Cystoid macular edema (CME) is characterized by the presence of multiple hyperreflective intraretinal cystoid spaces on OCT. The definition of pseudohole, as determined on the B-scan OCT image findings, was established as per the International Vitreomacular Traction Working Group [14].

The presence of a discontinuity in the ellipsoid band at the fovea was identified as an indicator of the ellipsoid zone disruption. Surgical procedures were performed as ERM peeling using a standard 3-port 23 gauge PPV system. A combination surgery with a simultaneous phacoemulsification was implemented in the event of advanced cataracts such as nuclear color/opalescence (N3), cortical (C3), posterior subcapsular (P3) or further lens opacity (LOCS III) [15].

**The surgical procedure**

Anterior and core vitrectomy were performed initially, following which the posterior hyaloid was detached with the aid of visualization using triamcinolone acetonide. ERM was then stained with membrane blue dual dye and peeled up to the vascular arcades. At the end of the surgery, partial air fluid exchange was performed in all patients. The operation was terminated by administering topical and subconjunctival antibiotics to the eyes.
Statistical analysis

Descriptive statistics were calculated for all variables. Mean and SD values were used to represent continuous variables; categorical variables were expressed as frequencies and percentages. The distribution of data was determined using the Kolmogorov–Smirnov test, and the Levene test was used to delineate variance homogeneity. The t test or ANOVA was employed to analyze inter-group data with a regular distribution and equal variance. Non-normally distributed and ranked data for inter-group analysis were implemented using the Mann–Whitney U test or Kruskal–Wallis test. Chi-square test was performed to compare ERM recurrence rates between the groups. The Friedman test was applied for data changes that did not conform to the normal distribution during the follow-up periods, and the MANOVA test was used for normally distributed data. Pearson’s correlation test was used to evaluate the association between continuous functional and anatomical variables. Generalized equation estimation analysis was used for statistical analysis, since both eyes were included in some patients. Baseline BCVA and CMT, as well as changes in CMT and EIFL thickness from baseline were included as variables for the univariate and multivariate models. Logistic regression analysis was used to evaluate the effect of EIFL on final visual acuity and recurrence rate of ERM. SPSS (version 22.0, SPSS Inc., Chicago, IL, USA) was used for undertaking the statistical analysis. p < 0.05 was considered as statistically significant.

Results

The mean age of the participants was 69.25 ± 7.81 years (range, 48–86 years), and fifty-one (48%) patients were male and 55 (52%) patients were female. The mean follow-up time was 26.18 ± 13.07 months (range, 13–68 months).

The surgical intervention criteria were BCVA > 0.20 logMAR (20/32 equivalent) at the time of diagnosis or metamorphopsia that compromised visual quality if BCVA was < 0.20 logMAR (20/32 equivalent). The combined procedure was implemented in 16 of 26 eyes (61.5%) in stage 1, 23 of 34 (67%) in stage 2, 26 of 42 (62%) in stage 3, and 23 of 36 (64%) in stage 4. There was no statistically significant difference between the groups in terms of performing combined surgical procedures (p = 0.067).

Twenty-one eyes were excluded from the study. While 17 eyes were excluded because of poor OCT image quality (n=12) and choriocapillary interface that could not be imaged (n=5), four were excluded due to macular diseases, such as CNV.

There were no statistically significant differences with respect to age (p = 0.952), follow-up time (p = 0.908), sex (p = 0.244), side (p = 0.994), anterior segment status (p = 0.219), baseline IOP (p = 0.673), baseline BCVA (p = 0.019), and the number of combined procedures (p = 0.067).

Recurrence ERM was detected in 27 of 138 eyes; 2 (7%) at stage 1, 3 (9%) at stage 2, 10 (23%) in stage 3, and 12 (33%) in stage 4 (p < 0.001). The clinical data of the participants are summarized in Table 1, and the baseline values of the study are presented in Table 2.

Stage 1

BCVA increased from baseline 0.46 ± 0.22 (20/57 equivalent) to 0.11 ± 0.12 logMAR (20/25 equivalent) at the final visit (p < 0.001). CMT decreased from baseline 312.08 ± 50.76 to 248.08 ± 41.63 μm at the final visit (p < 0.001). IOP decreased from baseline 14.66 ± 1.15 to 14.25 ± 2.45 mmHg at the final visit (p = 0.467).

Stage 2

BCVA increased from baseline 0.51 ± 0.24 (20/64 equivalent) to 0.15 ± 0.18 (20/28 equivalent) logMAR at the final visit (p = 0.021). CMT decreased from baseline 312.08 ± 50.76 to 248.08 ± 41.63 μm at the final visit (p < 0.001). IOP decreased from baseline 14.66 ± 1.15 to 14.25 ± 2.45 mmHg at the final visit (p = 0.467).

Stage 3

BCVA increased from baseline 0.68 ± 0.20 (20/93 equivalent) to 0.40 ± 0.38 logMAR (20/50 equivalent) at the final visit (p = 0.015). CMT decreased from baseline 419.84 ± 57.94 to 366.84 ± 60.09 μm at the final visit (p < 0.001). IOP decreased from baseline 14.76 ± 1.16 to 16.07 ± 5.28 mmHg at the final visit (p = 0.147).

Stage 4

BCVA increased from baseline 0.68 ± 0.20 (20/93 equivalent) to 0.40 ± 0.38 logMAR (20/50 equivalent) at the final visit (p = 0.015). CMT decreased from baseline 419.84 ± 57.94 to 366.84 ± 60.09 μm at the final visit (p < 0.001). IOP decreased from baseline 14.76 ± 1.16 to 16.07 ± 5.28 mmHg at the final visit (p = 0.147). Figure 2 shows SD-OCT
images of two patients who underwent PPV at the third and fourth stages during the follow-up period.

Stage 4

BCVA increased from baseline $0.71 \pm 0.25$ (20/100 equivalent) to $0.48 \pm 0.32$ logMAR (20/60 equivalent) at the final visit ($p < 0.001$). CMT decreased from baseline $545.61 \pm 40.34$ to $401.46 \pm 46.97 \mu m$ at the final visit ($p < 0.001$). IOP decreased from baseline $14.92 \pm 0.27$ to $15.38 \pm 2.75$ mmHg in the final visit ($p = 0.200$).

Comparison of each stage according to the follow-up period among patients revealed a significant change in stage 1 for CMT (month 3, $p < 0.001$; month 6, $p = 0.041$; month 12, $p = 0.001$; final visit, $p < 0.001$).

As for the BCVA, a significant change was observed in stage 1 for all follow-up visits as compared to those between other stages (month 3, $p = 0.012$; month 6, $p = 0.039$; month 12, $p = 0.043$; final visit, $p = 0.028$). The baseline and follow-up data of parameters are given in Table 3.

A correlation was seen between the lower baseline BCVA and both the higher baseline CMT and higher baseline EIFL thicknesses ($r=0.574$ vs. $r=0.575$, $p < 0.001$ and $p = 0.020$, respectively). It was also noted that a higher baseline EIFL thickness was correlated with a lower final BCVA ($r=0.748$, $p = 0.001$).

We also compared the individual regression coefficients of the study groups, as the EIFL had a clear change in effect on recurrence of ERM and final BCVA. A higher EIFL may possibly be associated with a lower final BCVA ($p < 0.001$, $R^2=0.719$). The increment of EIFL resulted in a positive probability of higher recurrence rate of the ERM ($p = 0.003$, $R^2=0.592$).

In addition, CMT was correlated with EIFL thickness ($r=0.476$, $p < 0.001$), which may be explained by the effect of these variables on visual acuity. Although EIFLs continued in advanced-stage cases (stages 3 and 4) in 64 of 78 eyes (82%) at the

---

**Table 1** The demographic and clinical data of patients

| Groups | Grade 1 | Grade 2 | Grade 3 | Grade 4 | $p$ values |
|--------|---------|---------|---------|---------|------------|
| Eyes   | 26      | 34      | 42      | 36      | 0.244*     |
| Gender | 12f14m  | 11f12m  | 15f17m  | 11f14m  |            |
| Age (mean±SD) | 67.58±9.41 | 68.76±6.31 | 69.62±8.18 | 70.84±7.69 | 0.952*     |
| Side   | 13r13l  | 14r20l  | 20r22l  | 14r22l  | 0.994*     |
| Follow-up (months) (mean±SD) | 25.33±10.36 | 26.23±13.48 | 28.81±17.40 | 27.53±8.83 | 0.908*     |
| Follow-up (months) (range) | 13–57 | 13–54 | 13–68 | 13–52 |            |
| Recurrences of ERM | 2/26 (7%) | 3/34 (9%) | 10/42 (23%) | 12/36 (33%) | <0.001†    |

* ANOVA test, † Chi square test

SD, standard deviation; f female, m male; r right, l left; ERM, epiretinal membrane; phakic, pseudophakic

**Table 2** Baseline findings of the study

| ERM (number) | Stage 1 ($n=26$) | Stage 2 ($n=34$) | Stage 3 ($n=42$) | Stage 4 ($n=36$) | $p$ value |
|--------------|------------------|------------------|------------------|------------------|------------|
| BCVA (log MAR) (Snellen) | (0.46±0.22) (20/57) | (0.51±0.24) (20/64) | (0.68±0.20) (20/93) | (0.71±0.25) (20/100) | 0.019*     |
| CMT (µm)     | 312.08±50.76     | 419.84±57.94     | 488.37±46.10     | 545.61±40.34     | <0.001*    |
| CME (%)      | 6/26 (23%)       | 7/34 (20%)       | 9/42 (21%)       | 8/36 (22%)       | 0.091†     |
| Pseudohole (%) | 4/26 (15%)       | 6/34 (17%)       | 7/42 (16%)       | 5/36 (13%)       | 0.284†     |
| Ellipsoid zone disruption (%) | 0 | 1/34 (2%) | 6/42 (14%) | 8/36 (22%) | 0.002†     |
| EIFL thickness(µm) | 0 | 161.49±34.79 | 189.78±47.84 | 254.18±54.74 | 0.021*     |

* $p$ value: ANOVA test. †$p$ value: chi-square test
**Fig. 2** The spectral domain-optical coherence tomography (SD-OCT) images of two patients who underwent pars plana vitrectomy (PPV) at the second and third stages during the follow-up period. The length between the red and yellow arrows shows the EIFL in the OCT images at stages 3 and 4.
At the final visit, it was observed in 8 of 34 (23%) eyes in the early stage (stage 2).

A positive correlation was seen between the baseline and final CMT \((r=0.575, p=0.020)\) as well as between EIFL thickness and the recurrence rate \((r=0.694, p<0.001)\). Figure 4 shows the ERM recurrence by EIFL thickness between the groups.

**Discussion**

This study investigated the clinical importance of EIFL grading (mild to severe) in a cohort of 138 eyes diagnosed with iERMs and exposed to PPV (solely ERM peeling), and found a significant relationship between higher baseline thickness of EIFL and high recurrence rate, as well as between lower baseline and final BCVA over long-term follow-up \((p<0.05)\).

There is no consensus on the timing of surgery in eyes with iERMs. Determining the severity of ERM and assessing the prognosis by surgical expulsion may be difficult [13]. The characterization of reliable prognostic biomarkers is therefore crucial among surgeons for predicting postoperative functional and anatomical outcomes in eyes with iERMs. Various studies have shown that ILM peeling with ERM does not provide an anatomical and visual benefit compared to ERM peeling alone in patients with iERM. It has also been reported that the rate of recurrent ERM and the need for repetition of ERM surgery are lower in eyes that are peeled up with ILM and ERM [16–18].

To date, numerous OCT studies have analyzed the prognostic role of inner retinal changes in the decrement of BCVA in iERMs. In fact, recent studies suggest that impairment of the external retinal layers...
**Fig. 3** The foveal contour formation in the fovea of a stage 2 ERM patient after surgery is shown. There is no EIFL tissue at this stage at baseline period. When traction is removed (white arrows), a thin and hyperreflective inner retinal tissue begins to form a connection on the outer nuclear layer 3 months following surgery. While increment of this tissue was detected during follow-up, the parafoveal inner nuclear layer approached the center of fovea (white arrows). The blue arrows indicate ERM shrinkage and EIFL is observed in OCT images.
may be inadequate to explain the vision deterioration precisely in ERM formation. However, the integrity of the photoreceptor and the outer retinal layer has an important prognostic value in final visual acuity during long-term follow-ups [8–13]. In this context, we have classified the presence of EIFL in a subset of iERMs and associated the incidence of anatomical findings with poor initial BCVA.

In a retrospective study of 12 months, Govetto et al. evaluated the effect of EIFL on anatomical and functional outcomes in 111 eyes of 107 patients with iERMs in which both ERM and ILM were peeled up [19]. Their study showed that the presence of EIFL had a considerable impact on the initial and final BCVA; it was also observed that higher EIFL correlated with lower initial BCVA. EIFLs were detected in 56 of 111 eyes (50.4%) before ERM and ILM peeling surgery. EIFLs continued to exist in 51 (91%) of 56 eyes after surgery due to the diagnosis of stage 3 and 4 iERMs. Although the thickness of the EIFL decreased after the surgery (p < 0.001), the reduction in EIFL in the postoperative period did not cause any change in the final BCVA. The authors suggested that the presence of EIFL may be a negative prognostic factor for postoperative anatomical and visual recovery. Predicting the prognostic efficacy of inner retinal changes on visual function may lead to a bias in the assessment of such analysis due to the strong correlation between inner retinal thickness and CMT. Previous studies have demonstrated independent relationships between inner retinal thickness and visual acuity in iERMs; however, automated software may usually perform analyses corresponding to the incorrect retinal layer rather than the inner retinal parameters [11, 20]. In our study, though EIFL was present at baseline in 98/138 (71%) patients which decreased in 72/138 (52%) post-surgery, it did not disappear completely. We speculate that an excess amount of EIFL probably had a negative prognostic effect in terms of ERM recurrence rate, visual acuity improvement, and restoration of the foveal anatomy.

In a recent study by Yildiz et al., both ERM and ILM were peeled up in 112 eyes of 112 patients, and less visual and anatomical gains were achieved in advanced stages (stages 3 and 4) [21]. In our study, after solely performing ERM peeling, though the number of recurrences was higher, the visual and anatomical gains were less for the advanced stage (stages 3 and 4).

It has been documented that EIFL thickness decreases during the postoperative follow-ups [22]. In the present study, following ERM surgery, this decrease was evident up to 6 months, with a minimum decrease seen between 6 and 12 months. However, postoperative EIFL thinning did not directly affect alterations in postoperative visual acuity. This outcome could raise new questions about EIFL-associated visual deterioration and limited functional and anatomical recovery following ERM surgery. In fact, recent studies have suggested that greater the thickness of the EIFL, the lower the final BCVA [20, 23]. It may be considered that ectopic retinal tissue can act as a physical barrier on image formation due to its location between afferent light and photoreceptors, which obstructs or distorts the visual image projected onto the foveal cones. The severity of this image distortion, in turn, may be directly proportional to the increase in the EIFL thickness [23].

In the presence of EIFL, several changes can take place in retinal microstructures. The displacement of chronic inner foveal may lead to damage and disruption of photoreceptors and other retinal cells, resulting in disturbances in normal neural conduction, visual deterioration, and metamorphosis in eyes with iERM [13, 20, 24]. This may be particularly associated with stage 4 iERMs, as this stage is involved in complete foveal irregularity and lower postoperative visual achievement. As stated in the study by Matthews et al., complete recovery of foveal depression in the long follow-up periods after surgery
gradually decreases with an increase in ERM grade [25]. Persistence of EIFL following ERM surgery in most eyes with stage 3 and 4 iERMs may explain the low postoperative anatomical gain and lower visual outcomes in these stages. It is probable that ellipsoid zone disruption and outer retinal layer changes in stage 4 might have affected the final visual acuity as seen in the present study.

The presence of EIFL in the absence of traction suggests that it may result in mechanical displacement of the inner retinal tissue, possibly as a result of other molecular reactions caused by Müller cells [13]. This cell activation may be responsible for inner retinal reorganization of the fovea in the postoperative period in eyes with stage 2 ERM and symbolize a reparative reaction following ERM surgery. Therefore, ILM peeling has a negligible effect on visual outcomes following ERM surgery. ERM recurrences are minimized by peeling of the ILM; nevertheless, most recurrences are clinically insignificant [17, 18]. In another study, better outcomes were found in terms of anatomical and functional recovery in patients with iERMs whose ILM was not peeled in the first month after PPV surgery. The authors concluded that in line with the visual outcome and photoreceptor integrity, supplementary ILM peeling may not be an obligatory procedure [26]. Recently, the development of microcystic macular edema without vascular leakage on fluorescein angiography with ganglion cell loss and thickening of the inner nuclear layer has been observed and termed as retrograde maculopathy. This condition is commonly seen in patients with iERMs who have undergone both ERM and ILM peeled up [27]. In our study, none of the patients developed retrograde maculopathy and the functional gains were not notably affected.

To the best of our knowledge, this is the first study to evaluate EIFL, recurrence rate, and anatomical and visual outcomes according to the SD-OCT-based ERM staging scheme before and after ERM peeling alone.

The limitations of the current study include its retrospective design and the absence of high-density macular scanning for all cases. Despite the use of high-intensity SD-OCT imaging in most of the involved eyes, the central fovea might have been overlooked by a standard macular raster or single high-definition horizontal B-scan, resulting in mismatched and overlooked classification of some iERMs. Nevertheless, the strengths of our study include convenient follow-ups and sample size, two blinded independent evaluators. Although longer follow-up periods also represent the strength of our study, it was seen that both visual acuity and SD-OCT parameters returned to normal within approximately 2 years after surgery, which supports that long-term follow-up provides greater opportunities for evaluation of postoperative anatomical and visual outcomes [28].

The existence of EIFL should not be the main factor in the surgical decision-making process when the ERM grading is assessed. However, based on the findings of this study, we suggest that the surgical intervention may be preferable in terms of visual improvement, postoperative anatomical gain, and lower recurrence rate in stages 2 and 1. Moreover, it may be stated that in an early grade of EIFL (stages 1 and 2), the outer retinal layers are not affected, and that the foveal cavity formation is higher in the postoperative period. The thickness of the EIFL correlated with both the baseline and final BCVAs. Furthermore, postoperative EIFL thinning and the severity indirectly affected the postoperative BCVA alterations. Therefore, the formation of EIFL may cause irreversible retinal damage, and the existence of EIFL may be associated with a negative prognostic factor for the postoperative anatomical and visual recovery. Additionally, supplementary clinicopathological studies are needed to better determine the pathophysiology of EIFL development before performing surgical procedures. Finally, automated segmentation of the inner retinal layers and further imaging methods are needed as these would be crucial toward improving the ability to identify and quantify EIFL. We hope that the outcomes of the current study will result in a spur in designing of future studies that will evolve the surgical management of these lesions.

**Funding** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**Declarations**

**Conflict of interest** Bugra Karasu and Ali Rıza Cenk Celebi declare that they have no conflict of interest.
Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained prior to every surgical procedure from all individual participants included in the study.

References

1. Asaria R, Garnham L, Gregor ZJ, Sloper JJ (2008) A prospective study of binocular visual function before and after successful surgery to remove a unilateral epiretinal membrane. Ophthalmology 115:1930–1937
2. Dawson SR, Shunmugam M, Williamson TH (2014) Visual acuity outcomes following surgery for idiopathic epiretinal membrane: an analysis of data from 2001 to 2011. Eye (Lond) 28:219–224
3. Falkner-Radler CI, Glittenberg C, Hagen S, Benesch T, Binder S (2010) Spectral domain optical coherence tomography for monitoring epiretinal membrane surgery. Ophthalmology 117:798–805
4. Michalewski J, Michalewski Z, Cisiecki S, Nawrocki J (2007) Morphologically functional correlations of macular pathology connected with epiretinal membrane formation in spectral optical coherence tomography (SOCT). Graefes Arch Clin Exp Ophthalmol 245:1623–1631
5. Hosoda Y, Ooto S, Hangai M, Oishi A, Yoshimura N (2015) Foveal photoreceptor deformation as a significant predictor of postoperative visual outcome in idiopathic epiretinal membrane surgery. Invest Ophthalmol Vis Sci 56:6387–6393
6. Shiono A, Kogo J, Klose G et al (2013) Photoreceptor outer segment length: a prognostic factor for idiopathic epiretinal membrane surgery. Ophthalmology 120:788–794
7. Rii T, Itoh Y, Inoue M, Hirakata A (2012) Foveal cone outer segment tips line and disruption artifacts in spectral-domain optical coherence tomographic images of normal eyes. Am J Ophthalmol 153:524–529
8. Cho KH, Park SJ, Cho JH, Woo SJ, Park KH (2016) Inner retinal irregularity index predicts postoperative visual prognosis in idiopathic epiretinal membrane. Am J Ophthalmol 168:139–149
9. Kim JH, Kang SW, Kong MG, Ha HS (2013) Assessment of retinal layers and visual rehabilitation after epiretinal membrane removal. Graefes Arch Clin Exp Ophthalmol 251:1055–1064
10. Okamoto F, Sugiura Y, Okamoto Y, Hiraoka T, Oshika T (2015) Inner nuclear layer thickness as a prognostic factor for metamorphopsia after epiretinal membrane surgery. Retina 35:2107–2114
11. Park SW, Byon IS, Kim HY, Lee JE, Oum BS (2015) Analysis of the ganglion cell layer and photoreceptor layer using optical coherence tomography after idiopathic epiretinal membrane surgery. Graefes Arch Clin Exp Ophthalmol 253:1829–1830
12. Yang SH, Kim JT, Joe SG, Lee JY, Yoon YH (2015) Postoperative restoration of foveal inner retinal configuration in patients with epiretinal membrane and abnormally thick inner retina. Retina 35:111–119
13. Govetto A, Lalane RA 3rd, Sarraf D, Figueroa MS, Huschman JP (2017) Insights into epiretinal membranes: presence of ectopic inner foveal layers and a new optical coherence tomography staging scheme. Am J Ophthalmol 175:99–113
14. Duker JS, Kaiser PK, Binder S et al (2013) The international vitreomacular traction study group classification of vitreomacular adhesion, traction, and macular hole. Ophthalmology 120(12):2611–2619
15. Chylack LT Jr, Wolfe JK, Singer DM et al (1993) The lens opacity classification system III: the longitudinal study of cataract study group. Arch Ophthalmol 111(6):831–836
16. Schechet SA, DeVience E, Thompson JT (2017) The effect of internal limiting membrane peeling on idiopathic epiretinal membrane surgery, with a review of the literature. Retina 37:873–880
17. Azuma K, Ueta T, Eguchi S, Aihara M (2017) Effects of internal limiting membrane peeling combined with removal of idiopathic epiretinal membrane: a systematic review of literature and meta-analysis. Retina 37(10):1813–1819
18. Díaz–Valverde A, Wu L (2018) To peel or not to peel the internal limiting membrane in idiopathic epiretinal membranes. Retina 38(Suppl 1):S5–S11
19. Govetto A, Virgili G, Rodriguez FJ, Figueroa MS, Sarraf D, Huschman JP (2019) Functional and anatomical significance of the ectopic inner foveal layers in eyes with idiopathic epiretinal membranes: surgical results at 12 months. Retina 39(2):347–357
20. Romano MR, Cennamo G, Cesarano I et al (2017) Changes of tangential traction after macular peeling: correlation between enface analysis and macular sensitivity. Curr Eye Res 42:780–788
21. Yildiz AM, Avci R, Yilmaz S (2021). The predictive value of ectopic inner retinal layer staging scheme for idiopathic epiretinal membrane: surgical results at 12 months. Eye (Lond). Fe 29
22. Kinoshita T, Kovacs KD, Wagley S, Arroyo JG (2011) Morphologic differences in epiretinal membranes on ocular coherence tomography as a predictive factor for surgical outcome. Retina 31(8):1692–1698
23. Marmor MF, Choi SS, Zawadzki RJ, Werner JS (2008) Visual insignificance of the foveal pit reassessment of foveal hypoplasia as fovea plana. Arch Ophthalmol 126:907–913
24. Joe SG, Lee KS, Lee JY, Hwang J-U, Kim J-G, Yoon YH (2013) Inner retinal layer thickness is the major determinant of visual acuity in patients with idiopathic epiretinal membrane. Acta Ophthalmol 91:242–243
25. Mathews NR, Tarima S, Kim DG, Kim J (2014) Foveal contour changes following surgery for idiopathic epiretinal membrane. Invest Ophthalmol Vis Sci 55:7754–7760
26. Ahn SJ, Ahn J, Woo SJ et al (2014) Photoreceptor change and visual outcome after idiopathic epiretinal membrane removal with or without additional internal limiting membrane peeling. Retina 34:172–181
27. Dysli M, Ebneter A, Menke MN et al (2019) Patients with epiretinal membranes display retrograde maculopathy after surgical peeling of the internal limiting membrane. Retina 39:2132–2140

28. Kinoshita T, Imaizumi H, Miyamoto H, Katome T, Semba K, Mitamura Y (2016) Two-year results of metamorphopsia, visual acuity, and optical coherence tomographic parameters after epiretinal membrane surgery. Graefes Arch Clin Exp Ophthalmol 254:1041–1049

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.