

# A Novel Three-Step Technique for the Simple, Safe, and Efficient Complete Removal of Idiopathic Epiretinal Membrane

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**Purpose:** This study aimed to assess a new three-phase method's efficacy and safety in treating idiopathic macular epiretinal membrane (ERM).

**Methods:** The novel technique involved a precise sequence: flap creation - wide margin- extensive peeling. Following the pars plana vitrectomy (PPV), to locate the epiretinal membrane, we stained the internal limiting membrane (ILM) with indocyanine green (ICG), using the stained ILM beneath as a guide to initiate the ERM flap. To minimize the force required for membrane peeling and traction on the underlying retina, we utilized a curved DSP scraper to form a wide-margin parallel arc along the inner aspect of the vascular arcade from the nasal to temporal side. Subsequently, the wide margin of the ERM was grasped tightly with ILM forceps, and traction was applied towards the central macular area to peel off the entire membrane. Finally, ICG staining was applied to ensure that the ERM was completely removed. The technique requires precise mastery of the three-step surgical skills and proficient use of specialized instruments.

**Results:** In a sample of 55 cases, the surgery achieved significant treatment outcomes. All surgeries were successfully performed with an average duration of  $4.23 \pm 0.34$  minutes for ERM peeling. At the 12-month postoperative follow-up, the mean logarithm of the minimum angle of resolution best-corrected visual acuity (BCVA) significantly improved from  $4.74 \pm 0.30$  to  $4.27 \pm 0.34$ . The average central macular thickness (CMT) significantly decreased from  $503.64 \pm 111.88 \mu\text{m}$  to  $353.38 \pm 72.64 \mu\text{m}$ . There are no intraoperative or postoperative complications and there was no recurrence.

**Conclusion:** The novel technique is a fast, simple, effective and safe surgical technique for treating idiopathic ERM. It significantly improves visual outcomes and reduces the occurrence of complications and recurrence.

**Plain Language Summary:** The new three-step technique is a fast, simple, and effective surgical method for treating idiopathic ERM. It significantly improves visual outcomes and reduces the occurrence of complications and recurrence.

**Keywords:** idiopathic epiretinal membrane, internal limiting membrane peeling, surgical technique

## Introduction

Idiopathic epiretinal membrane (ERM) is a fibrocellular proliferation that occurs in the macular area on the inner side of the retina.<sup>1,2</sup> As the condition progresses, symptoms such as vision decrease and visual distortion may develop in some patients.<sup>3-5</sup> Pars plana vitrectomy and ERM removal are considered both effective and safe therapeutic methods.<sup>6</sup>

At present, direct surgical removal of ERM is performed, but because the ERM is transparent and fragile, and the absence of a pre-staining method for the membrane this can provoke retinal hemorrhage, macular holes (MH), and an increased likelihood of recurrence due to insufficient removal.<sup>3–5</sup> Consequently, many surgeons now employ indocyanine green (ICG) staining of the internal limiting membrane (ILM) to aid in the piecemeal peeling and concurrent removal of the ILM and ERM.<sup>7–9</sup> Peeling of the ILM has been proven to assist in the complete removal of ERM.<sup>10–12</sup> However, this piecemeal peeling approach has made the total and thorough removal of ERM more challenging and has increased the risk of traction-related iatrogenic retinal tears, retinal hemorrhage, and the formation of MH.<sup>13</sup>

Professor Qiu Qinghua from our research team has developed a simple and effective technique based on mechanical principles: the larger and more complete the membrane peeling, the smaller the forces of traction on the membrane and the stress on the retina. This technique enables wide-scale and large-scale cohesive peeling of the central fovea and has been validated in the treatment of highly myopic macular schisis, demonstrating clear safety and efficacy.<sup>14</sup> Based on this, our study has applied this approach, as an adapted ILM removal technique, to the treatment of idiopathic ERM. We outline this refined method as a three-step procedure: flap creation - wide margin- extensive peeling. Additionally, we confirm that this innovative method is not only quick, efficient, and easy to master but also lowers the incidence of iatrogenic complications and recurrences.

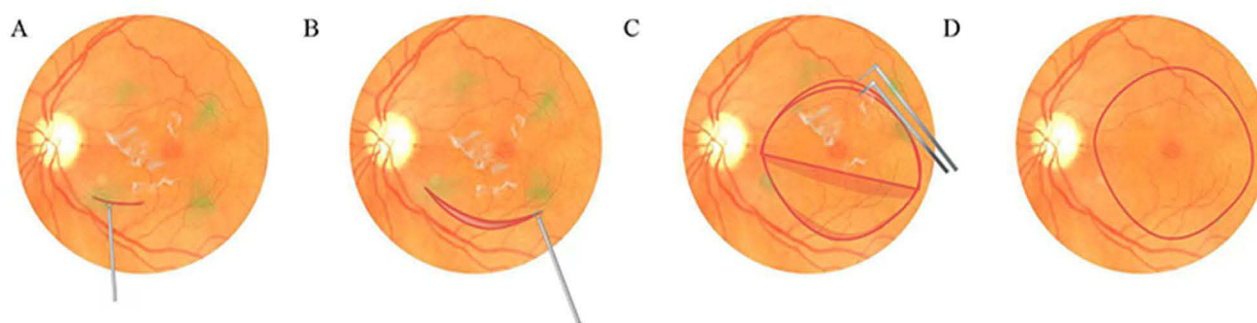
## Materials and Methods

### Subjects

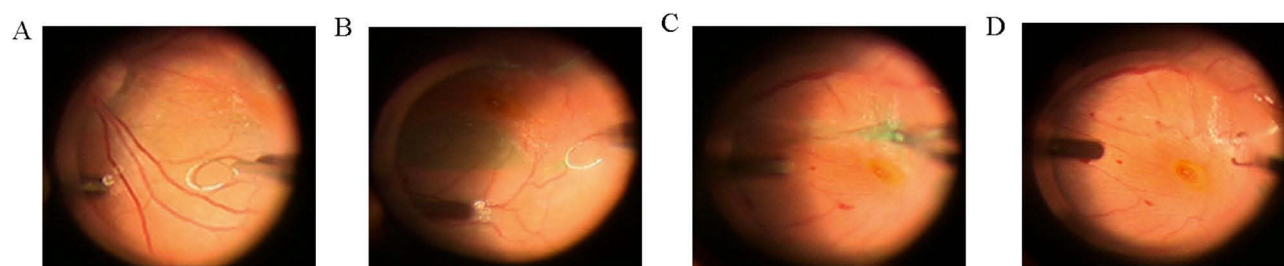
This retrospective study included 55 patients who underwent surgery for primary idiopathic ERM between November 2021 and October 2022. All were followed up for 12 months after being enrolled in this study. The surgery of the above 55 cases was performed by a skillful surgeon (Qiu QH) at the department of ophthalmology of Shanghai Tong Ren Hospital, the affiliated hospital of Shanghai Jiao Tong University School of Medicine. Exclusion criteria included age <18 years, secondary ERM, and the presence of glaucoma, retinal degenerative, or optic nerve neuropathy. The ERM has several grades: cellophane maculopathy (grade 1), crinkle cellophane maculopathy (grade 2), and macular pucker (grade 3). Grades 2 and 3 were indicated for surgery. This study was approved by the Medical Ethics Committee of Tong Ren Hospital, Shanghai Jiao Tong University School of Medicine (Approval No: 2021–012). All patients who participated in the examinations and procedures signed informed consent documents.

### Epiretinal Membrane Surgery

All patients underwent a vitreoretinal procedure with retrobulbar anesthesia, performed utilizing the Alcon Constellation® vitrectomy system (Alcon, Fort Worth, Texas, USA) equipped with 23-gauge instrumentation. The surgical intervention commenced with the core vitrectomy followed by the cortical vitreous removal, exposing the posterior hyaloid which was then segregated by an injection of triamcinolone acetonide (TA). Given the innate transparency and tight adhesion to the retina of the epiretinal membrane (ERM), which makes it difficult to stain, visual identification during surgery has proven to be challenging. To address this, a 0.5 mL solution of diluted 0.25% ICG was delivered into the vitreous chamber for the purpose of staining the ILM, thus facilitating the visualization and delineation of the ERM. The procedure was initiated at the stained ILM, which served as a landmark for developing the ERM flap. To minimize tractional forces during the membrane peeling, a Flex Finesse Loop (DSP) microspatula was employed to craft a wide, parallel arcuate border along the perivascular inner margin, extending from the nasal to the temporal side. The ERM margin was grasped with ILM forceps and gentle traction was exerted radially towards the center, achieving a release spanning approximately one-third to one-half of the disc diameter (DD). This maneuver was iteratively executed until the peeling extended to an approximate width of two-thirds to one DD to sufficiently expedite the removal of the substantial ERM portion. The ILM was intermittently restained with ICG to confirm the thorough excision of the ERM manifest over the macular territory. Meticulous attention was dedicated to the symmetric and gradual delineation of the fovea to ensure an equitable force distribution across its entirety. In culmination, the ILM forceps apprehended the delineated perifoveal region, applying traction to meticulously excise the ERM complex in its entirety (Figures 1 and 2). The entire surgical protocol had an estimated duration of 20–30 minutes.



**Figure 1** The surgical schematic of continuous full-block peeling of ERM. **(A)** Flap creation: utilize the stained ILM below as a guide to initiate the ERM flap; **(B)** Wide margin: use a curved scraper (DSP) to create a wide marginal parallel arc from the nasal side to the temporal side, along the inner side of the vascular arches; **(C)** Extensive peeling: grasp the ERM's wide margin with ILM forceps and apply traction towards the central surrounding areas to quickly and completely remove the large piece of ERM; **(D)** Stain the ILM again with indocyanine green (ICG) to confirm the complete removal of the ERM.



**Figure 2** The surgical procedure of the continuous full-block peeling of ERM. **(A)** Flap creation: utilize the stained ILM below as a guide to initiate the ERM flap; **(B)** Wide margin: use a curved scraper (DSP) to create a wide marginal parallel arc from the nasal side to the temporal side, along the inner side of the vascular arches; **(C)** Extensive peeling: grasp the ERM's wide margin with ILM forceps and apply traction towards the central surrounding areas to quickly and completely remove the large piece of ERM; **(D)** Stain the ILM again with indocyanine green (ICG) to confirm the complete removal of the ERM.

## Outcome Measures

The duration of ERM peeling procedure was recorded. BCVA was assessed before and at 1, 6, and 12 months following epiretinal membrane peeling surgery, and converted to logarithm of the minimum angle of resolution (logMAR). Optical coherence tomography (OCT) was used to detect changes in macular morphology, and central macular thickness (CMT) was measured before and at 1, 6, and 12 months following the epiretinal membrane peeling surgery.

## Statistic

All data were analyzed using SPSS 23.0 statistical software (SPSS Inc., Chicago, IL, USA). All continuous data are expressed as the mean  $\pm$  standard deviation. Statistical analysis of the data was performed using adopting the paired *t*-test.  $P < 0.05$  was considered statistically significant.

## Results

This study consisted of 55 patients with idiopathic ERM, which included 37 females and 18 males with 30 right eyes and 25 left eyes. The mean age of the patients was  $65.29 \pm 6.70$  y (range: 50–82 y). All surgeries were successfully performed, with an average duration of  $4.23 \pm 0.34$  minutes for ERM peeling. There no intraoperative or postoperative complications such as vitreous hemorrhage, retinal detachment and iatrogenic MH occurred. At the last visit, the central fovea of the macula returned to its normal form to varying degrees with the removal of the macular membrane. In addition, during the follow-up period, there was no recurrence among all patients (Table 1).

The average preoperative logMAR BCVA was  $0.23 \pm 0.13$ , and significantly improved to  $0.41 \pm 0.23$  ( $P < 0.001$ ),  $0.53 \pm 0.24$  ( $P < 0.001$ ) and  $0.65 \pm 0.27$  ( $P < 0.001$ ) at 1, 6, and 12 months postoperatively. The average preoperative CMT was  $503.64 \pm 111.88$   $\mu$ m (range: 293–816  $\mu$ m), and significantly decreased to  $413.44 \pm 89.70$   $\mu$ m (range: 253–590  $\mu$ m) ( $P < 0.001$ ),  $375.16 \pm 80.85$   $\mu$ m (range: 240–520  $\mu$ m) ( $P < 0.001$ ) and  $353.38 \pm 72.64$   $\mu$ m (range: 213–464  $\mu$ m) ( $P < 0.001$ ) at 1,

**Table 1** Clinical Characteristics of the Patients

	Preoperative		Postoperative		P1, P2, P3
		1 Months	6 Months	12 Months	
BCVA (logMAR)	0.23±0.13	0.41±0.23	0.53±0.24	0.65±0.27	< 0.001
CMT (μm)	503.64±111.88	413.44±89.70	375.16±80.8	353.38±72.64	<0.001
Vitreoretinal condition, no.					
Vitreous haemorrhage	0	0	0	0	–
RD	0	0	0	0	–
Iatrogenic MH	0	0	0	0	–
Recurrence	0	0	0	0	–

**Notes:** The data are presented as the mean±SD;  $p < 0.05$  was considered statistically significant. P1: Preoperative VS 1 months Postoperative; P2: Preoperative VS 6 months Postoperative; P3: Preoperative VS 12 months Postoperative.

**Abbreviations:** BCVA, best corrected visual acuity; CMT, central macular thickness; logMAR, logarithm of the minimum angle of resolution; RD, retinal detachment; MH, macular hole.

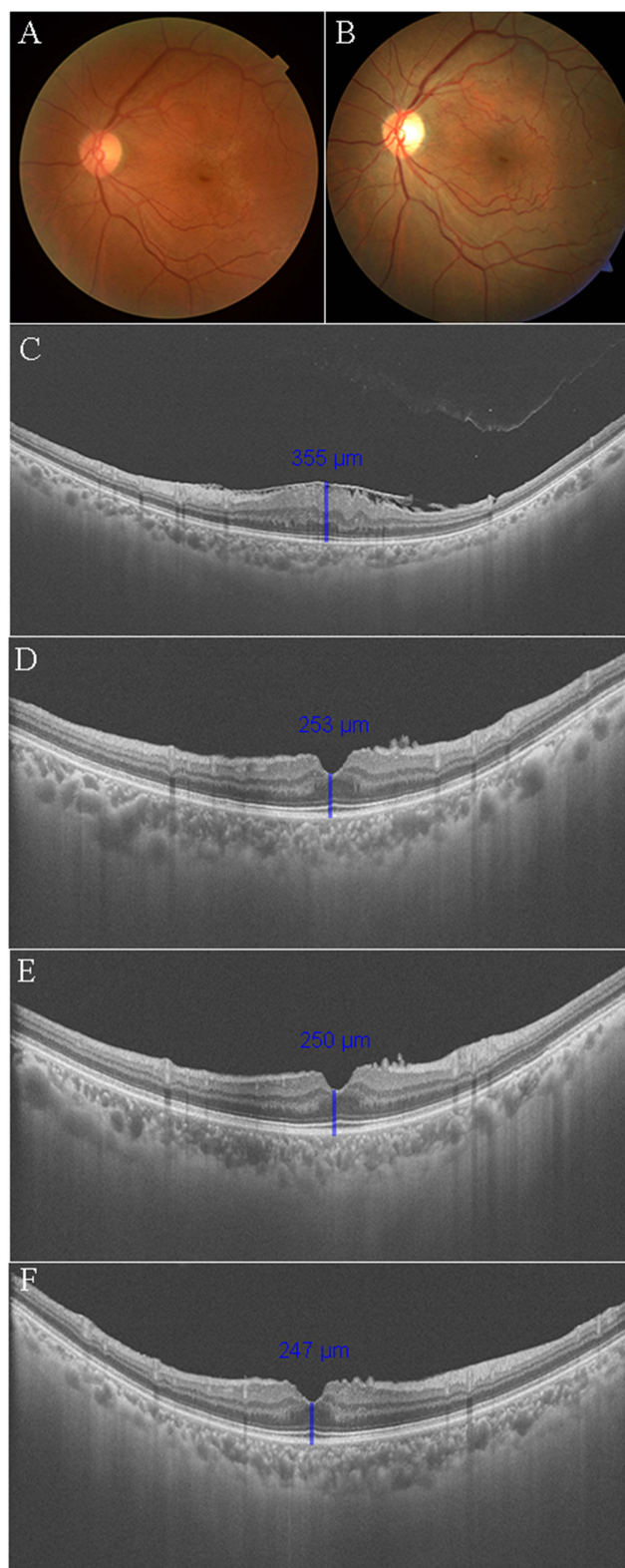
6, and 12 months postoperatively (Table 1). A representative case of the CMT reduction of a patient with IEM to a wide range of whole piece consecutive ILM peeling without preservation of the epi-fovea therapy, as documented by fundus photography, OCT is shown in Figure 3.

# Discussion

We introduce a novel method for the removal of the epiretinal membrane (ERM). Across all 55 cases, the ERM was removed en bloc in a very short amount of surgical time. Postoperative BCVA increased, and CMT decreased. Based on the study's findings, the statistical power for detecting significant improvements in BCVA and reductions in CMT at 1 month, 6 months, and 12 months postoperatively is approximately 0.99. This suggests that, at a significance level of 0.05, the study has a high probability of detecting the observed enhancements in BCVA and decreases in CMT as statistically significant outcomes of the surgical intervention. There were no complications observed either intraoperatively or postoperatively. Moreover, there was no recurrence in any of the patients during the follow-up period.

Surgical removal of the ERM is the primary treatment method for idiopathic ERM.<sup>12,15,16</sup> However, ERMs are transparent, fragile, and tightly adherent to the retina, with a difficulty in staining, making them prone to causing retinal tears, retinal bleeding, and MH during surgery.<sup>17,18</sup> The transparency of ERMs also makes complete removal during surgery challenging, leading to possible recurrence.<sup>17,18</sup> Therefore, effectively and safely removing the ERM poses a technical challenge. We have innovatively utilized ICG staining to locate the ERM for initiating flap creation, which significantly reduces the time spent searching for the membrane, and is both simple and safe.

Enhancing the visibility of ERM may aid in its complete removal. Thus, by staining the ILM with dyes and peeling the ILM, the ERM is concurrently removed.<sup>12,15,16</sup> Research has indicated that ERM/ILM dual peeling significantly reduces the recurrence rate of ERM compared to removing ERM alone, thereby decreasing the need for repeat surgery.<sup>17,18</sup> Therefore, effectively and safely performing a dual peeling of ERM/ILM presents a technical challenge. There are currently no detailed standards and guidelines for the dual peeling of ERM/ILM. Traditionally, the technique for peeling ILM was based on the individual surgeon's preference, done piecemeal. However, peeling off small parts of ILM each time increases the shearing force, therefore increasing the risk of traumatic retinal tears, retinal bleeding, and MH formation. Our three-step “flap creation - wide margin- extensive peeling” technique mainly uses ILM forceps and starts with a curved scraper, eliminating the need to switch between these two tools and providing significant convenience and operability. The main difference from previous ILM peeling methods is that the peeling is done in a large continuous manner rather than piece-by-piece. This significantly reduces the number of peels and the tension between the peeled and unpeeled flaps, avoiding traumatic retinal tears, bleeding, and the development of MH.<sup>13</sup> Our team's previous research has mechanically confirmed that this technique peels the membrane with minimal force and exerts the least traction on the retina. And we have previously demonstrated on a mechanical basis that our large-scale, continuous, full-block peeling method significantly reduces the occurrence of iatrogenic retinal tear, bleeding, and MH.<sup>14</sup>



**Figure 3** Fundus photos and OCT of a patient with idiopathic anterior retinal membrane before and after surgery. (A) Preoperative fundus photograph; (B) Postoperative fundus photograph; (C) Preoperative OCT at 1 week; (D) Postoperative OCT at 1 month; (E) Postoperative OCT at 6 months; (F) Postoperative OCT at 12 months.



In our study, this simple and feasible ILM removal technique was applied to patients with idiopathic ERM, with the ERM being extensive peeled in all 55 patients. Additionally, we limited our surgery time to within 30 minutes, with the average ERM peeling time being  $4.23 \pm 0.34$  minutes, and no intraoperative or postoperative complications such as retinal bleeding, MH, vitreous hemorrhage were observed.

This study has several limitations. Firstly, it is a single-center, retrospective study. Secondly, our innovative surgical technique has not yet been compared with other techniques. Moreover, our follow-up period was not very long. Therefore, a well-designed randomized controlled trial with a longer follow-up duration is urgently needed to confirm the efficacy of this innovative technique.

## Conclusion

In conclusion, the flap creation - wide margin- extensive peeling method is simple, fast, and safe to operate. At the same time, it effectively improves BCVA and reduces CMT. Additionally, it can also minimize iatrogenic complications and recurrence. Therefore, this technique can be considered an effective and applicable surgical approach. Further prospective, multicenter, and comparative studies should be conducted to evaluate the clinical outcomes and safety of this technique.

## Data Sharing Statement

The original contributions presented in the present study are included in the article material. Further inquiries can be directed to the corresponding authors.

## Ethics Approval and Consent to Participate

All procedures of this study were in accordance with the tenets of the Declaration of Helsinki and approved by the medical ethics committee.

## Patient Consent for Publication

All Patients declare that they consent for publication.

## Acknowledgments

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## Disclosure

The authors declare that they have no competing interests.

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