Original Article

Detection of Occult Retinal Breaks Using Subretinal Dye in Recurrent Retinal Detachment Surgery

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Abstract

Objectives: To evaluate the results and effectiveness of the intraoperative subretinal dual dye-assisted technique in patients treated in our clinic for recurrent rhegmatogenous retinal detachment (RRD), where small hidden retinal tears could not be detected before or during surgery.

Materials and Methods: This retrospective observational study included 11 patients who underwent surgery in our clinic for recurrent RRD and in whom no retinal tears were detected during either preoperative or intraoperative examinations. Data from patients who underwent surgery using the modified subretinal MembraneBlue-Dual® (trypan blue 0.15% + Brilliant Blue G 0.025% + PEG 4%) dye method applied with a 41-gauge cannula were examined. Postoperative outcomes were analyzed.

Results: In 38.4% of patients, retinal tears were located at the posterior edge of a previous laser retinopexy scar. Dye leakage was seen from the edge of a previously lasered retinal tear in 30.7% and from a new tear in 30.7%. At 1-year follow-up, anatomical success and permanent retinal reattachment were achieved in all of the patients. At postoperative 1 year, best corrected visual acuity had increased from 2.0±0.3 logarithm of the minimum angle of resolution (logMAR) to 0.7±0.1 logMAR.

Conclusion: Occult small retinal tears that are undetectable in recurrent RRD can be successfully identified using the subretinal dye-assisted technique.

Keywords: Subretinal dye, retinal detachment, retinal tears, rhegmatogenous retinal detachment, vitrectomy

Cite this article as: Sül S, Tamer Kaderli S, Osmanlı E, Kaderli A. Detection of Occult Retinal Breaks Using Subretinal Dye in Recurrent Retinal Detachment Surgery. Turk J Ophthalmol. 2026;56:41-46

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Received: 29.06.2025
Revision Requested: 18.09.2025
Last Revision Received: 22.09.2025
Accepted: 17.11.2025
Publication Date: 18.02.2026

DOI: 10.4274/tjo.galenos.2025.91043

Introduction

Pars plana vitrectomy (PPV) is a commonly performed surgery for rhegmatogenous retinal detachment (RRD).[1,2] To prevent fluid re-entry and ensure retinal adhesion, tamponades such as gas and silicone oil are often used.[1,3,4] Despite these interventions, retinal detachment surgeries sometimes fail due to factors such as new or missed retinal breaks, reopening of original tears, or proliferative vitreoretinopathy (PVR).[5,6] Hence, identifying and addressing these issues are crucial for successful surgical outcomes.

The detection of retinal holes or breaks is critical for a successful retinal detachment repair. However, this goal can be challenging during redo surgery due to modifications made during previous surgeries. The dye-assisted technique for detecting occult retinal breaks offers a promising solution, simplifying the identification of previously undetected retinal breaks and improving anatomical and functional success. Previous case reports in the literature have demonstrated the effectiveness of an injection of subretinal dye, such as trypan blue or MembraneBlue-Dual®, with or without 180° endolaser retinopexy.[7,8]

The current study aimed to evaluate the efficacy and safety of the MembraneBlue-Dual® subretinal dye-assisted technique for detecting occult retinal tears in patients with RRD in whom retinal breaks could not be identified during either preoperative or intraoperative examinations.

Materials and Methods

This retrospective study included patients admitted to our department for recurrent RRD, in whom retinal breaks were not detected during preoperative and initial intraoperative examinations, and who subsequently underwent subretinal dye injection. The study was conducted in accordance with the principles of the Declaration of Helsinki, and ethics committee approval was obtained from Muğla Sıtkı Koçman University Medical Sciences Ethics Committee (protocol number: 241048, decision number: 127, date: 22.11.2024). A waiver of consent was granted as the study involved a retrospective review.

The medical records of patients who underwent PPV for recurrent RRD with unidentified tears between January 2018 and January 2023 were analyzed. The following data were collected: age at the time of surgery, sex, laterality, previous surgeries, type of previous surgery, concomitant ocular disorders, best corrected visual acuity (BCVA), intraocular pressure values, biomicroscopic anterior segment and fundus examination findings, optical coherence tomography (OCT), and ultra-widefield imaging using the Optos 200Tx system (Optos plc, Dunfermline, UK) before and at 6 months and 1 year post-PPV follow-up, findings at the last visit, complications, and disease course.

The inclusion criterion was RRD with no retinal breaks identified preoperatively or intraoperatively through scleral indentation. Exclusion criteria were primary retinal detachment, history of encircling scleral buckle surgery combined with vitrectomy, and detection of preoperative or intraoperative retinal tears.

The surgical procedures were performed by the same expert vitreoretinal surgeon (S.S.) and were similar in all patients (Figure 1). They began with the injection of perfluorocarbon heavy liquid to protect the posterior pole of the retina and optic disc from potential dye toxicity. MembraneBlue-Dual® (Trypan Blue 0.15% + Brilliant Blue G 0.025% + 4% PEG) was then injected into the subretinal space using a 41-gauge cannula. Additional perfluorocarbon heavy liquid was added to displace subretinal fluid toward the retinal periphery. The eye was rotated, allowing the dye to exit through the tiny break, facilitating its identification. Surgical success for PPV was defined as postoperative reattachment of the neurosensory retina for at least 1 year.

Statistical Analysis

Data analysis was performed using descriptive statistics to summarize the patient demographics, surgical history, and outcomes. Continuous variables such as age and duration between surgeries were expressed as the mean ± standard deviation (SD). Categorical variables, including the sex distribution and type of tamponade used, were presented as frequencies and percentages. Visual acuity outcomes at three and six months postoperatively were expressed as mean ± SD. Given the small sample size, no inferential statistical tests were applied, and the results were interpreted descriptively.

Results

A total of 11 patient files were included in the study. The mean age was 52.6±12.5 years. Eight patients (72.7%) were female and 3 (27.3%) were male. The mean duration between PPV surgeries was 65±11.3 days. In terms of procedures, 3 eyes (27.3%) underwent pneumatic retinopexy, 7 eyes (63.6%) underwent PPV with gas tamponade, and 1 eye underwent PPV with silicone oil. A history of trauma was present in 6 eyes (54.5%), while 5 (45.5%) had peripheral

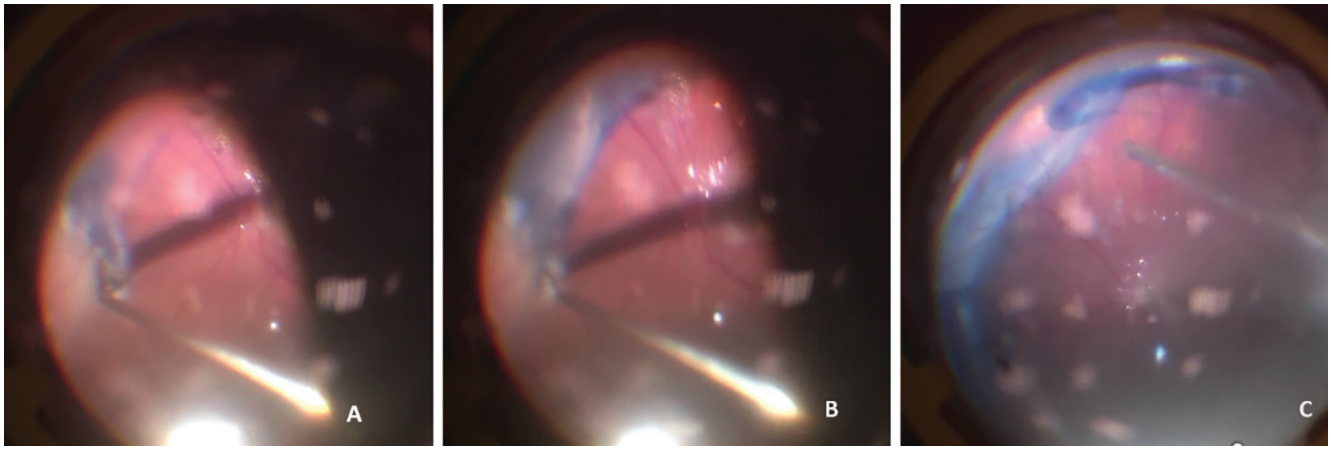

Figure 1. The surgical procedure: A) the dye was injected into the subretinal space using a 41-gauge cannula; B) the dye displaced the subretinal fluid toward the retina periphery; C) additional perfluorocarbon heavy liquid was then injected into the vitreous cavity until the dye was vented out of a very small break

degeneration. Only in one case, PVR was observed in the inferior quadrant around the remnant vitreous base. However, this area was attached and the previous laser spots were present in front of it, and the recurrent retinal tear was located away from that area. The new retinal tear, detected with dye, was located in a different quadrant, at the edge of previous laser retinopexy scar. There were no PVR-related detachments in our cohort, recurrent RRD was associated with occult tears in all cases. The demographic and baseline characteristics are summarized in Table 1.

At least one clinically unidentified retinal break was identified in each case using subretinal dye. Of these occult tears, 38.4% were located at the posterior edge of a previous laser retinopexy scar, 30.7% were at the edge of a previously lasered retinal tear, and 30.7% were new tears (Figure 2). Silicone oil was used in five cases, and C3F8 was used in six for tamponade. Persistent retinal attachment was achieved in all 11 patients.

After silicone oil removal and absorption of the gas tamponade, the retinas remained attached at the 1-year follow-up (Table 2). BCVA improved from 2.0±0.3 to 0.8±0.1 logarithm of the minimum angle of resolution (logMAR) at postoperative 3 months and 0.7±0.1 logMAR at postoperative 6 months.

At 6 months postoperatively, minimal cystoid macular edema (CME) was observed in two patients and we administered sub-Tenon triamcinolone acetonide. Three weeks after the sub-Tenon injection, CME had regressed in both patients. Only one patient had focal disruption of the external limiting membrane and ellipsoid zone in the temporal parafoveal area. The mean RNFL thickness was 94.2±9.7 and 91.9±7.6 µm, respectively, at 6 months and 1 year postoperatively. At the 1-year follow-up, the mean BCVA remained stable at 0.7±0.1 logMAR. No additional postoperative complications were observed.

Table 1. Baseline patient demographics and clinical findings (n=11)	
Age (years), mean ± SD	52.6±12.5
Sex (female/male), n	8/3
Laterality (R/L), n	7/4
IOP (mmHg), mean ± SD	7.2±1.2
Duration between PPV (days), mean ± SD	65.0±11.3
Previous treatment, n (%)	
Pneumatic retinopexy	3 (27.2)
PPV + gas tamponade	7 (63.6)
PPV + silicon oil	1 (9.1)
History of trauma, n (%)	6 (54.5)
Presence of peripheral degeneration, n (%)	5 (45.4)
Presence of PVR, n (%)	1 (9.1)
Location of RD (superior/inferior/total), n	3/4/4
Macula on/off RD, n	3/8
SD: Standard deviation, L: Left, R: Right, IOP: Intraocular pressure, PPV: Pars plana vitrectomy, PVR: Proliferative vitreoretinopathy, RD: Retinal detachment	

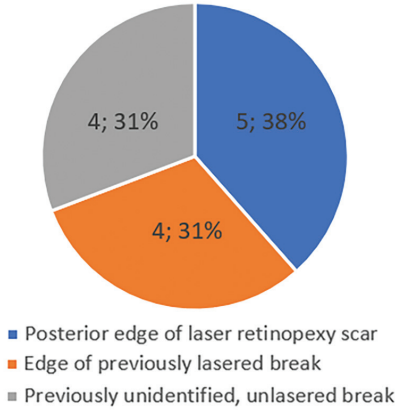

Figure 2. Locations of the detected occult breaks

Table 2. Postoperative clinical features (n=11)				
	Baseline	**Postoperative 3 months**	**Postoperative 6 months**	**Postoperative 1 year**
BCVA (logMAR), mean ± SD	2.0±0.3	0.8±0.1	0.7±0.1	0.7±0.1
IOP (mmHg), mean ± SD	7.2±1.2	14.0±3.2	13.5±2.3	12.5±1.8
CMT (μm), mean ± SD	-	342±45	321±52	311±48
RNFL (μm), mean ± SD	-	101.0±8.9	94.2±9.7	91.9±7.6
Presence of CME, n (%)	-	1 (9.1)	2 (18.1)	-
Presence of ELM disruption, n (%)	-	1 (9.1)	1 (9.1)	1 (9.1)
Presence of EZ disruption, n (%)	-	1 (9.1)	1 (9.1)	1 (9.1)

BCVA: Best corrected visual acuity, logMAR: Logarithm of the minimum angle of resolution, SD: Standard deviation, IOP: Intraocular pressure, CMT: Central macular thickness, RNFL: Retinal nerve fiber layer, CME: Cystoid macular edema, ELM: External limiting membrane, EZ: Ellipsoid zone

Discussion

This study evaluated the subretinal dye technique, as described in the literature, for identifying clinically undetectable retinal breaks and summarized the clinical results. This technique involves injecting dual blue dye under the retina, followed by the use of perfluorocarbon heavy liquids to reveal hidden retinal breaks. This approach successfully identified retinal breaks in all the patients.

The identification of retinal breaks is crucial in repairing RRD.[7,9] Typically, retinal breaks are identified using Lincoff's rules and careful examination before and during surgery. During surgery where liquid perfluorocarbon is used, the passage of subretinal fluid into the vitreous cavity may facilitate the detection of tears. However, small retinal breaks may still be overlooked despite thorough preoperative and intraoperative examination. If these tears are missed, they can lead to transretinal fluid flow into the subretinal space, causing redetachment and surgical failure.[7,8,9,10]

Previous studies have shown that undetected retinal tears can be identified using vital dyes, with various techniques showing high efficacy. Gupta et al.[9] utilized trans-scleral Vision Blue® injections targeting the site of greatest subretinal fluid depth. However, the use of this technique is limited because of potential complications such as hypotony and hemorrhage.[9,11] In case series by Jackson et al.[7] and Wong et al.,[12] MembraneBlue® successfully revealed hidden breaks in eyes with complex retinal detachment where traditional methods had failed. More recently, Khanduja et al.[13] reported that the modified subretinal dye extrusion technique (MORE-DETECH) (using trypan blue) effectively revealed occult retinal breaks in retinal detachment after silicone oil endotamponade removal. In their study, the technique achieved a success rate of 90.4% in detecting breaks, which were most commonly at the posterior edge of laser retinopexy scars. Berarducci et al.[14] similarly described chromophore-assisted detection (using MembraneBlue-Dual®) as a valuable surgical technique for detecting occult retinal breaks and managing challenging situations during retinal detachment surgery.

However, the use of dyes remains a topic of debate due to risks such as dye-related toxicity and the creation of iatrogenic retinal holes, and authors have emphasized the need for careful management to minimize these complications.[7,12,15,16,17,18] In the present study, perfluorocarbon heavy liquid was applied to protect the posterior pole before injecting the dual dye. Our findings aligned with reports supporting the effectiveness of subretinal dye,[7,17] and the lack of complications noted in earlier studies[7,12] suggests that this modified approach may offer a safer approach.

The choice of dye is important. Brilliant Blue is typically used to visualize the internal limiting membrane and appears safer due to lower toxicity.[18] However, we opted for MembraneBlue-Dual® in this research for improved visibility of any remaining vitreous or membrane. This decision was made despite research in rat models suggesting that trypan blue can cause dose-dependent neurotoxicity at concentrations above 0.04%.[18] Although we observed no retinal toxicity based on clinical findings and OCT data, definitive conclusions regarding subclinical toxicity could not be drawn, as we did not perform electrophysiological tests or microperimetry, which are effective in detecting subtle functional alterations following dye-assisted vitrectomy.[19,20,21]

Study Limitations

No serious adverse events were observed in the current study, and postoperative visual acuities improved as expected. However, the small sample size was a limitation, restricting the generalizability of the findings. Another limitation of our study is the absence of advanced assessments

such as electrophysiological testing and microperimetry. Additionally, collecting baseline data was challenging since the need for subretinal dye is often identified only during surgery. Future multicenter, prospective randomized controlled trials with larger patient populations are needed to provide more definitive outcomes on the efficacy and safety of subretinal dyes. Furthermore, animal studies are crucial to understanding potential long-term toxicity, which could aid in optimizing dye concentrations and application techniques.

Conclusion

The results herein demonstrate the benefit of using subretinal dye in challenging cases where retinal tears are undetectable during preoperative and intraoperative examinations. Although we do not recommend routine use, it may serve as a valuable tool for specific patient populations, such as those with recurrent retinal detachment or a history of failed retinal detachment surgeries. For patients at high risk of developing PVR, subretinal dye application could improve anatomical outcomes and should be considered in clinical decision-making. However, further research is needed to establish clear guidelines for its use in clinical practice.

Ethics

Ethics Committee Approval: The study was conducted in accordance with the principles of the Declaration of Helsinki, and ethics committee approval was obtained from Muğla Sıtkı Koçman University Medical Sciences Ethics Committee (protocol number: 241048, decision number: 127, date: 22.11.2024).

Informed Consent: Retrospective study.

Declarations

Authorship Contributions

Surgical and Medical Practices: S.S., S.T.K., Concept: S.S., S.T.K., A.K., E.O., Design: S.S., S.T.K., A.K., E.O., Data Collection or Processing: S.T.K., E.O., Analysis or Interpretation: S.T.K., S.S., E.O., Literature Search: S.T.K., A.K., S.S., Writing: E.O., S.T.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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