

MACULAR SURGERY: CURRENT AND INNOVATIVE TECHNIQUES

Novel surgical approaches are changing the way surgeons address macular traction and macular holes.

By Marcelo Zas, MD, PhD; Mariano Cotic, MD; and Marcos Mendaro, MD



The assessment of the vitreomacular interface has evolved significantly, and we can now accurately determine its histological

architecture like never before. OCT and OCT angiography are the most relevant tools available to help clinicians image and evaluate changes in the posterior pole. These imaging capabilities have given rise to improved macular surgery performance and better communication with the patient about their condition, both of which have improved care.

CONDITIONS WE TREAT

Epiretinal membranes (ERMs), vitreomacular traction, and full-thickness macular holes (FTMHs) are the most common disorders that can arise due to vitreoretinal interface changes. Currently, these conditions are treated with surgery.

ERMs and Vitreomacular Traction

In the past, ERMs were considered an epiretinal phenomenon caused by two vectors of traction: anteroposterior and tangential. This is now known as *vitreomacular traction syndrome* (VMTS), where 20% of the population is asymptomatic; some patients may experience spontaneous resolution, while others progress to a FTMH.¹⁻³

In 2016, the PACORES group published a retrospective multicenter study of 168 eyes, of which 21.4% (36 eyes) showed spontaneous resolution of VMTS after a mean follow-up of 11.4 ± 12.6 months. An unfavorable anatomic outcome occurred in 7.7% (13 eyes). In addition, the study found that the baseline spectral-domain OCT grade may predict the progression to FTMH.⁴

In 2017, Govetto et al published a new OCT staging scheme for ERMs, in which ERMs were classified based on foveal thickness measures and the identification of specific biomarkers, such as the presence of ectopic inner foveal layers. The ability to properly classify ERMs is crucial to

achieve optimal results in our everyday practice.⁵

The OCT-based staging scheme uses morphologic and functional characteristics to classify ERMs into four stages: presence of the foveal pit and well-defined retinal layers (stage 1); absence of the foveal pit and well-defined retinal layers (stage 2); absence of the foveal pit, well-defined retinal layers, and presence of ectopic inner foveal layers (stage 3); and absence of the foveal pit, disrupted retinal layers, and presence of ectopic inner foveal layers (stage 4).⁵

This classification is clinically relevant and has prognostic implications because higher stages correlate with worse visual acuity outcomes.

Macular Holes

To determine the appropriate treatment approach for FTMHs, we first measure the hole size and the baseline visual acuity. Based on these criteria, clinicians can decide to monitor, treat medically, or proceed to the OR. A surgical approach to FTMHs has three main objectives: lower the resistance to facilitate the closure with the maculorexis; decrease the size by drying with fluid-air exchange; and provide a gas tamponade (SF₆).⁶

AT A GLANCE

- Peeling the internal limiting membrane and epiretinal membranes has become the standard technique to address vitreomacular interface diseases.
- Human amniotic membrane transplant and autologous retinal transplant are recent approaches to the treatment of refractory macular holes.
- Retinal expansion is a valuable technique for macular holes, in which subretinal injection of balanced salt solution creates a macular detachment.

One of the most disruptive innovations in the field was made in 1997 by C. Eckardt, who published the results of macular holes that were treated with vitrectomy plus internal limiting membrane (ILM) peeling (Figure 1A).⁷ The procedure—novel at the time—led to an unprecedented 92% success rate, ushering in an era of ILM peeling as the standard for FTMHs.⁷

A few years later, Michalewska et al described the inverted ILM flap technique, which improved both functional and anatomic outcomes of vitrectomy for FTMHs with a diameter greater than 400 μm .⁸

More recently, Wiedemann provided insight into the mechanisms of ILM peeling, including improved retinal flexibility, better oxygen supply to the inner retina, and, potentially, retinal glial cell proliferation. These mechanisms lead to reduced foveal thickness and improved visual acuity, closure rates, and macular function.⁹

Despite this growing body of work, we have yet to find a definitive solution for macular holes. Many FTMHs that are refractory to conventional management may be less than 400 μm , requiring a revised classification scheme and novel treatment options.¹⁰ At the 2019 Retina World Congress, Tamer H. Mahmoud, MD, PhD, presented on autologous retinal transplantation (ART) for macular holes, adding to our growing armamentarium. Human amniotic membrane transplant (hAM) is yet another recent technique that has made the treatment of recurrent and refractory FTMHs possible.^{11,12} Both are equally valid and widely accepted.

With the capability to enhance epithelial cell growth, hAM is a well-known adjuvant used for the treatment of corneal and conjunctival defects. The initial technique, described by Rizzo et al, used bimanual manipulation to insert the graft into the subretinal space under perfluorocarbon liquid.¹¹ The restoration of the retinal layers observed in the postoperative period resembles a healthy eye, suggesting that the amniotic cells are inducing tissue remodeling.¹¹

A large retrospective case series of 130 patients undergoing ART for the repair of primary and refractory macular holes showed good anatomic and functional outcomes (Figure 1B). In the study, 89% of macular holes closed (78.5% complete; 10% small eccentric defect), visual acuity improved by at least 3 lines in 43% of eyes and at least 5 lines in 29% of eyes, and there were low complication rates.¹²

Several alternative surgical options may prove useful for certain refractory macular holes, such as various ILM flap techniques, retinal expansion, lens capsule transplantation, blood products, and macular buckling.

The CLOSE study group examined a total of 1,135 eyes and proposed a surgical classification for large FTMHs

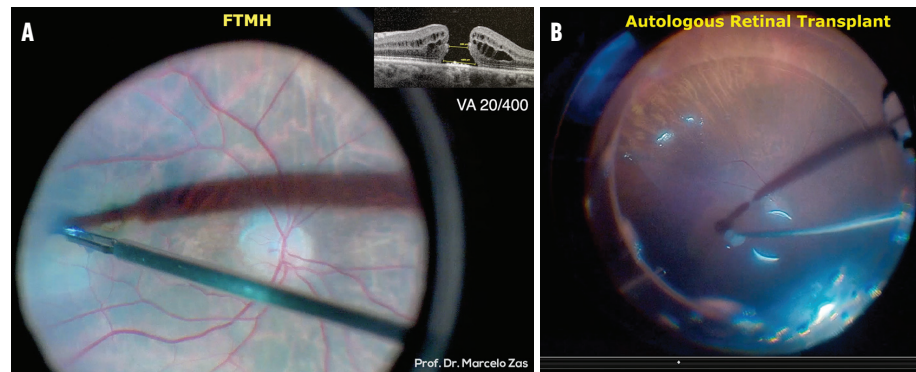


Figure 1. ILM peeling (A) became a standard surgical approach to FTMHs after C. Eckardt published on the technique in 1997. ART (B) may be a useful technique for refractory macular holes, leading to good anatomic and functional outcomes.

based on surgical techniques. The study found that large (400 μm – 550 μm) and X-large (550 μm – 800 μm) holes can be successfully treated with ILM peeling and ILM flap techniques, respectively. The team noted that further studies are necessary for XX-large ($\geq 800 \mu\text{m}$ – $< 1,000 \mu\text{m}$) and giant macular holes ($\geq 1,000 \mu\text{m}$) to determine which technique is best based on hole size and characteristics.¹³

Parolini et al published a classification and management system for patients with myopic traction maculopathy (MTM), which suggests that surgeons should observe early stages of MTM but address schisis and detachments with macular buckling. FTMHs should be treated with vitrectomy and ILM peeling to alleviate the tangential forces.¹⁴

The retinal expansion technique is another valuable alternative to macular hole closure. Subretinal injection of balanced salt solution creates a macular detachment, which may lead to hole closure. Our team recently published a retrospective interventional case series of two patients with chronic FTMHs who were treated with retinal expansion; one patient achieved complete hole closure.¹⁵

Alezzandrini et al published a study to compare the functional and anatomic outcomes at 24 months of eyes with a primary FTMH that failed to close after surgery and were treated with either an ART of ILM (ART-ILM) or the retinal expansion technique (Figure 2). Patients in the ART-ILM group ($n = 14$) experienced a statistically significantly improved BCVA (median 49.5, range 20–66 letters) compared with preoperative BCVA (median 39 letters). In contrast, patients in the retinal expansion group ($n = 14$) did not achieve a statistically significant improvement. At 24 months, 85.7% of patients in the ART-ILM group achieved closure compared with 57.1% in the retinal expansion group (Tables 1 and 2). The baseline macular hole size was not a significant preoperative factor that influenced closure rates.¹⁶

NOVEL TECHNIQUES ON THE RISE

Macular surgery has been a hot topic in retina for years, fostering the growth of many novel techniques. With advanced diagnostics and imaging we now embrace the fact

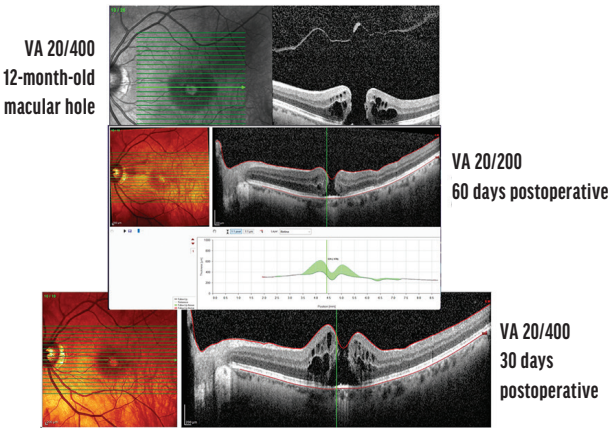


Figure 2. Although retinal expansion may help to close refractory FTMHs, recent research suggests patients may not experience significantly improved vision postoperatively.

that functional results are as equally relevant as anatomic outcomes. Thus, we must begin assessing the visual function of our patients using BCVA, microperimetry, mERG, and multimodal images. These postoperative evaluations could provide surgeons with significant insight into the true nature of our surgical results. ■

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TABLE 1. BASELINE CHARACTERISTICS OF PATIENTS			
Variable	Treatment		P Value
	ART-ILM (n = 14)	Retinal Expansion (n = 14)	
Male gender	50%	50%	.703
Hole size (µm)	640.79 ± 94.75	646.43 ± 99.15	.879
BCVA (ETDRS)	0.703	0.703	.563
Time between first and second surgery (months)	11.3 ± 3.2	11.3 ± 3.2	NA
Abbreviation: ART-ILM, autologous retinal transplant of internal limiting membrane			

TABLE 2. LINEAR REGRESSION MODEL WITH ANATOMIC STATUS OF MACULAR HOLE AND POSTOPERATIVE VISUAL ACUITY AS THE DEPENDENT VARIABLE								
Variable	Univariate Model				Multivariate Backward Model			
	Estimate (SE)		P value		Estimate (SE)		P value	
	Anatomic Status	Visual Acuity	Anatomic Status	Visual Acuity	Anatomic Status	Visual Acuity	Anatomic Status	Visual Acuity
Sex (male vs female)	- 0.511 (0.966)	9.188 (5.917)	.597	.133	NA	NA	NA	NA
Macular hole size (µm)	0.023 (0.009)	- 0.139 (0.018)	.009	< .001	0.023 (0.009)	- 0.087 (0.016)	.009	< .001
Baseline VA (ETDRS)	- 0.065 (0.043)	1.262 (0.163)	.136	< .001	NA	0.779 (0.140)	NA	< .001
Time between first and second vitrectomy (months)	0.704 (0.290)	- 3.217 (0.901)	.015	.001	NA	NA	NA	NA

Tables adapted from Alezzandrini A et al. *Int J Retina Vitreous*. 2021;7(1):57.¹⁶

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MARCELO ZAS, MD, PHD
■ Associate Professor of Ophthalmology, Head of Retina Section, Ophthalmology Department, School of Medicine, Hospital de Clínicas “José de San Martín,” University of Buenos Aires, Buenos Aires, Argentina
■ President, Argentine Society of Ophthalmology
■ Academic Secretary, Executive Committee, Pan-American Society of Retina and Vitreous
■ marcezas@gmail.com
■ Financial disclosure: Consultant/Speaker (Abbvie, Alcon, Bayer, Chengdu, Genentech/Roche, Novartis, Novo Nordisk, Ophthotech, Poen); Sub-investigator (Alcon, Allergan/Abbvie, Chengdu, Genentech/Roche, Ophthotech)

MARIANO COTIC, MD
■ Staff, Retina Section, Ophthalmology Department, School of Medicine, Hospital de Clínicas “José de San Martín,” University of Buenos Aires, Buenos Aires, Argentina
■ coticmariano@gmail.com
■ Financial disclosure: None

MARCOS MENDARO, MD
■ Staff Retina Section, Ophthalmology Department, School of Medicine, Hospital de Clínicas “José de San Martín,” University of Buenos Aires, Buenos Aires, Argentina
■ mendaromarcos@gmail.com
■ Financial disclosure: Speaker (Abbvie, Alcon, Genentech/Roche, Novartis)