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ORIGINAL ARTICLE

Obesity and Non-Valvular Atrial Fibrillation: An Unexpected Paradox

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ABSTRACT

Background: Optical coherent tomography (OCT) is a noninvasive technique that has the advantage of imaging and quantitatively analyzing retinal thickness, nerve fiber layer, and optic nerve structures with good reproducibility. With OCT, several studies reported that retinal microstructures are important to the visual prognosis after macula off RRD surgery. According to these studies, integrity of the ellipsoid zone (EZ) and external limiting membrane (ELM) and presence of foveal bulge are significantly correlated with postoperative best corrected visual acuity (BCVA). This study aims to find postoperative factors related to changes of visual acuity after macular-off RRD surgery by analyzing OCT findings. **Methods:** 74 patients who were planned to undergo pars plana vitrectomy to repair macula-off rhegmatogenous retinal detachment. After surgical clinical success, patients were divided according to postoperative BCVA at the 6th month after surgery into two groups: Group A (Poor visual acuity <6/60) and Group B (Good visual acuity ≥ 6/60).**Results:** At the 1st month after the surgery, BCVA, central macular thickness (CMT), residual subretinal fluid (SRF) and ELM and EZ integrity were significantly associated with the final visual acuity (p=0.002, 0.033, 0.007 and 0.013). At the 3rd month, BCVA, ELM and EZ integrity were associated with the final visual acuity (p=<0.001, 0.011 and 0.001 respectively). At the 6th month, ELM and EZ integrity was associated with the final visual acuity (p=0.002 and <0.001 respectively)**Conclusion:** ELM and EZ integrity significantly influenced the final visual acuity at the 6th month after the surgery.

Keywords: Rhegmatogenous detachment, BCVA, pars plana vitrectomy, ELM, EZ.

INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is a serious eye condition requiring surgical intervention to reattach the retina. The most frequent surgical methods for treating RRD include pars plana vitrectomy

(PPV), the use of a scleral buckle, pneumatic retinopexy, or a combination of PPV and scleral buckle, depending on various considerations. While a single surgical procedure may successfully reattach the retina in up to 94% of cases, vision restoration can often be inconsistent and take time [1].Indeed, those with macula off RRD can experience varied levels of visual clarity after successful surgery to reattach the retina. Some patients might still report issues with vision clarity and experience image distortions known as metamorphopsia[2].Even though the retina looks reattached when examined with an ophthalmoscope, the degree of visual improvement after treating retinal detachment can vary widely among patients. While many factors have been suggested to predict how well patients will see after surgery, there is still limited research on how the structure of the reattached retina, as seen through tomography, relates to visual clarity[3].After successful retinal reattachment surgery, individuals with macula-off rhegmatogenous retinal detachments (RRDs) might still experience inadequate visual improvement. Detecting minor alterations in the foveal region can be challenging using conventional clinical assessments [4]. Various findings can affect the final visual outcome after the surgery, including cystoid macular oedema (CME), residual subretinal fluid (SRF), epiretinal membrane (ERM) and macular displacement [5].Optical coherence tomography (OCT) is a non-invasive method that excels in producing images and offering quantitative assessments of retinal thickness, nerve fiber layers, and optic nerve formations with consistent reliability [6]. Many research findings have emphasized the significance of retinal microstructures in predicting visual outcomes after surgery for macula off RRD. These studies highlight that the integrity of the ellipsoid zone (EZ) and the external limiting membrane (ELM), as well as the presence of a foveal bulge, are closely linked to the post-surgery best corrected visual acuity (BCVA) [7].This research aimed to identify postoperative factors associated with variations in visual acuity following macula off RRD surgery. The analysis encompassed multiple parameters, integrating both clinical observations and OCT results.

METHODS

This was a prospective cohort study undertaken at the Ophthalmology Department of Zagazig University Hospitals. It received clearance from the Ethics Committee of Zagazig University Hospital and was conducted between June 2020 and December 2022. All participants provided written informed consent. The study adhered to the World Medical Association's Code of Ethics (Declaration of Helsinki) for research involving human subjects.The study included 74 eyes from 74 patients. Each of these patients was scheduled to have a primary pars plana vitrectomy as a treatment for their macula-off RRD in whom, Retinal re-attachment was achieved clinically within 1 month after the surgery and was maintained throughout the follow up visits and the ocular media was clear enough to allow sufficient high quality OCT imaging and auto-fluorescence of the macula.Those who had RRD with grade C2 or more proliferative vitreoretinopathy (PVR) according to Hilton et al. (1983)[8] classification system, recurrent retinal detachment, Macula on RRD, documented macular disease e.g., age related

macular degeneration, macular hole, pathological myopia, Patients with tractional or exudative retinal detachment and patients with concomitant ocular disease including glaucoma, and diabetic retinopathy were excluded.After surgical clinical success, patients were divided according to postoperative BCVA at the 6th month after surgery into two groups: Group A (Poor visual acuity)included 52 eyes with postoperative BCVA < 6/60[9, 10]. Group B (Good visual acuity) included 22 eyes with postoperative BCVA ≥ 6/60.All patients had the following before the surgery, history taking(Age, Sex, social and medical history, patients' expectations including the informed medical consent after explaining the scheduled study), BCVA was assessed using Snellen's charts. The obtained decimal VA values were then converted to logarithmic minimal angle of resolution (logMAR) values prior to any statistical evaluations.Post Operative outcomes were assessed as follows: BCVA (LogMAR), OCT findings, including central macular thickness (CMT), SRF, ELM integrity and EZ line integrity. CMT was identified as the thickness spanning from the surface of the internal limiting membrane to the outer boundary of the retinal pigment epithelium (RPE) at the central fovea. On OCT, CME was characterized as any distinct hyporeflective space with a vertical extent of ≥300 microns located within the retinal tissue [11, 12]. SRF was identified as any subfoveal neurosensory retinal detachment observed at any stage during the post-operative monitoring. The elevation of the SRF was determined by measuring the distance between the inner boundary of the RPE and the outer limit of the back reflection. The state of ELM and the EZ were both categorized as either being intact or disrupted.

STATISTICAL ANALYSIS

All data were organized, presented in tables, and subjected to statistical evaluation using IBM SPSS (Statistical Package for the Social Sciences) software for Windows, version 23.0, developed by IBM Corp., Armonk, NY, USA. Quantitative data were represented as Mean±SD or median (range) as appropriate. On the other hand, qualitative data were articulated in terms of numbers and percentages.To determine the normality of continuous data, the Shapiro Walk test was utilized. The Independent samples t-test was used to compare between numerical variables between two groups with normal distributions, whereas the Mann Whitney U test was chosen for comparisons between two groups of variables that weren't normally distributed. For categorical variables, the Chi-square test or, when suitable, the Fisher's exact test was applied.For linear regression analysis, BCVA was transformed from its decimal format into logMAR values. This linear regression was executed to discern the correlation between possible post-surgery influential factors and the BCVA recorded 6 months post macula off RRD surgery. The P-value was set significant at ≤ 0.05. all tests were two-tailed.

RESULTS

Statistical analysis of baseline characteristics of patients with RRD showed that age, sex, laterality, axial length, and lens status have no statistically significant association between poor and good visual acuity (p-value 0.126,0.613,1.00,0.311,0.309 respectively). **(Table 1)**

At postoperative month one, logMAR BCVA was notably elevated in patients who subsequently demonstrated suboptimal visual acuity, registering at 1.76 ± 0.17 (p=<0.001). Elevated CMT and residual SRF postoperatively were significantly correlated with inferior final BCVA (p<0.001). Additionally, A pronounced compromise of ELM was concomitant with deteriorating visual acuity (p<0.001). EZ line integrity was significantly associated with good BCVA at the 6th month after the surgery. **(Fig.1) (Table 2)**

Three months postoperatively, logMAR BCVA was notably elevated in patients who ultimately manifested suboptimal visual acuity, recording a value of 1.76±0.17 (p=<0.001). Such a trend underscores that visual outcomes in the immediate postoperative phase bear a positive association with the eventual visual prognosis. Contrarily, CMT and residual SRF observed three months postoperatively did not exhibit a significant association with the visual acuity outcomes present at the six-month postoperative (p=0.358 and 0.279, respectively). Notably, disruptions to ELM and EZ line, identified three months post-surgery, were concomitant with suboptimal final visual outcomes. **(Table 3)**

Six months postoperatively, both CMT and SRF did not display a significant association with the ultimate BCVA outcome (p-values 0.358 and 0.279, respectively) **(Fig. 2)**. However, disruptions to ELM observed six months post-surgery were intrinsically linked with suboptimal final visual acuity (p<0.001). Conversely, the integrity of EZ line was positively associated with superior visual acuity at the end of the observation period. **(Table 4)**

In the multivariate analysis conducted at the one-month post-operative evaluation, there were significant associations between BCVA, SRF, and the integrity of ELM and EZ with the eventual visual acuity outcomes (p-values of 0.002, 0.033, 0.007, and 0.013, respectively). At the three-month post-operative visit, the BCVA and the integrity of both ELM and EZ were significantly correlated with the final visual outcomes, with respective p-values of <0.001, 0.011, and 0.001. By the six-month post-operative evaluation, only the integrity of the ELM and EZ demonstrated a significant relationship with the final visual acuity (p-values 0.002 and <0.001, respectively). **(Table 5)**

DISCUSSION

RRD continues to be a major reason for visual impairment, occurring in roughly 1 out of every 10,000 individuals [13]. Established risk factors for RRD encompass conditions like high myopia, having a family or personal history of RRD, previous trauma, and previous intraocular procedures [14, 15]. In recent times, surgical treatment for macula off RRD has exhibited a notably high rate of anatomical success. However, when it comes to functional outcomes, there exists a considerable degree of variability and unpredictability [16]. The primary reason appears to be the damage to the macula due to the presence of SRF, although surgical complications can also contribute to this issue [17].Previous research has identified certain factors that can predict favorable visual outcomes, but there is ongoing debate regarding the reliability of these factors for surgeons as predictive tools [18].Previous

research has concentrated on factors linked to the anatomical failure of RRD repair. These factors include older age, macular condition, the duration of symptoms, the involvement of the inferior quadrants, the presence of preoperative PVR, the phakic status of the eye, choroidal detachment, the number and size of retinal breaks, and the preexistence of hypotony[19, 20, 21, 22, 23]. Nonetheless, despite receiving appropriate surgical treatment, patients may still not achieve the desired functional visual acuity outcomes[24]. In recent times, OCT has facilitated the objective and quantitative measurement of RRD height, enabling a more accurate assessment of the structural alterations in the detached retina. This data has provided fresh perspectives on comprehending the visual rehabilitation process after a successful surgery for macula off RRD and identifying potential factors that could predict functional recovery [25, 26].Spectral-domain optical coherence tomography (SD-OCT) devices typically highlights four distinct layers in the outer retina beyond the central fovea. The innermost layer is believed to correspond to ELM. Following this, the next layer signifies the ellipsoid zone. The subsequent layer is often termed as the tips of the outer segment or the Verhoeff membrane. Finally, the most exterior reflective layer is presumed to symbolize the RPE, Bruch membrane, and potentially the choriocapillaris [27].The current study revealed that the presence of residual SRF, CME, ELM and EZ line disruption in the first month after successful attachment surgery were significantly associated with poor final visual outcome. Three- and six months post-surgery, disturbances in the ELM and EZ line remain a significant predictor for diminished visual sharpness. In contrast, the persistence of CME and SRF did not demonstrate a notable connection to the eventual visual result.Consistent with the findings of the present study, research by Mete et al. also illustrated a correlation between improved mean BCVA and the restoration of the ELM and EZ line. A marked difference was evident six months post-surgery ($p = 0.04$), with BCVA at this time point directly linked to the recovery of the EZ line alone [28]. Conversely, a study by Chatziralli et al. indicated a significant correlation between ELM disruptions and deteriorated BCVA ($p < 0.001$). Contradicting the findings of the present study, however, no significant relationship was found between BCVA and the presence of SRF (SRF) ($p = 0.064$) [29].Taku Wakabayashi et al. [30] observed various foveal anatomical irregularities in the eyes they examined. Specifically, 86.6% of the eyes presented with these abnormalities. disruption in the photoreceptor EZ line were identified in 60.5% of these eyes, and out of this percentage, 23% exhibited a compromised ELM. Additionally, 15.7% had persistent SRF, 31.5% displayed ERM, and 5% showed evidence of CME. Compared to the research conducted by Wakabayashi et al. [30], the current study included 74 subjects with macula-off RRD, and the monitoring period was limited to 6 months post-surgery. As a result, the conclusion of this study arrives several months ahead of Wakabayashi's findings. The average visual acuity observed in this study was 6/60 during the 6^{th} postoperative month. In contrast, the Wakabayashi study reported an average visual acuity of 6/12 at the 10-month postoperative

mark. Nevertheless, the OCT observations between the two studies bear resemblance. In this study, SRF persisting after 6 months was found in a single case (1/74), whereas Wakabayashi et al. observed it in 6 out of 38 cases. Similarly, CME was identified in one case at the 6-month follow-up in the present study, compared to two instances in Wakabayashi's research.Clinical assessments might not always detect foveal detachment. Thus, Gibran et al. recommend using OCT as the preferred method for studying delayed post-surgery vision improvement [31]. Numerous research utilizing OCT have suggested that the presence of SRF at the fovea, persisting months after surgery, could be a reason for suboptimal post-surgery recovery in patients with macula off RRD [32].Earlier research using OCT has revealed that, following RD correction, a significant number of patients still experience undetected SRF, irrespective of the type of surgical procedure used. Certain studies have indicated a link between enduring SRF and diminished vision after surgery[33]. In a research conducted by Benson et al., it was found that 6 weeks post-surgery, 15% of the subjects showed SRF when assessed with OCT. This presence of SRF was notably linked to a decline in VA at the same 6-week mark (P = 0.033) [34].In another study performed by Seo et al. they studied the influence of persistent SRF on visual outcome after successful scleral bucking for macula-off RRD. They found that no significant differences in final BCVA were found among patients and concluded that final VA was not found to be associated with SRF extent or duration [35].In the current study, a single case of persistent SRF was detected in the final follow up visit at the 6th month after the surgery. BCVA in this case was 0.6 LogMAR (6/24) which was not significantly related to SRF.Kai-Chun et al. [36] conducted a study to assess macular alterations post-surgery for RRD using OCT. They included 32 eyes that had successful attachment of a macula off RRD and were observed for 6 months post-surgery. The average logMAR BCVA recorded before surgery was 0.87±0.70. About 59.4% of eyes in the macula-off group exhibited a disrupted EZ. Eyes maintaining the EZ and ELM integrity showed notably better vision compared to those where these zones were compromised. In contrast, the current study reported a pre-surgery mean logMAR BCVA of 2.29±0.25. A disrupted EZ was observed in 64.8% of the eyes. This data aligns with Kai-Chun's findings concerning the pronounced visual enhancement in patients with a preserved EZ in comparison to those with a disrupted one (p value<0.001). In the multivariate analysis of the current research, it was shown that the integrity of the ELM and EZ played a crucial role in determining the final visual results. Although residual SRF was a determining factor in the visual outcome a month post-surgery, its impact on the visual acuity wasn't notable in subsequent follow-ups. In agreement with these findings, Park et al. underscored that the integrity of the EZ significantly impacts the eventual visual outcome[2].Consistent with the findings of the present research, Geiger et al. [37]discovered through multivariable logistic regression that superior preoperative BCVA (logMAR) (p = 0.008) was a statistically significant predictor of a postoperative VA achieving 20/40 or even better. In a study by

Kobayashi et al. [25], it was observed that there wasn't a significant relationship between the final BCVA and the BCVA before surgery. No initial parameters showed a notable correlation with the concluding BCVA. However, when analyzing the final BCVA using multivariate regression, both the BCVA measured two weeks post-surgery (P = 0.017) and the integrity of the EZ were determined to be independent and significant determinants of the ultimate BCVA (P = 0.006).Based on the OCT results, the current research aligns with Wakabayashi's findings [31]. After a successful RRD repair, OCT proves to be an effective and non-invasive method to assess alterations in the foveal microstructure.Variations in key factors compared to the present study might stem from the restricted quantity and range of variables evaluated. Hence, it's vital to undertake a thorough analysis of potential variables that might impact the visual acuity after surgery.The present research was constrained by a few drawbacks, notably the limited number of participants and the brief duration of the follow-up. However, we were able to verify varying degrees of structural alterations and vision impairment. Our findings indicate that OCT could offer a dependable technique for evaluating cellular harm and the restructuring that takes place in the macula-off region during rhegmatogenous RD.

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Competing interests: None.

Table 1: Association of Patient Characteristics with Visual Acuity Outcomes Six Months Post-Surgery.

		Poor Visual acuity		Good Visual acuity		Test*	P value
		N =52	%	N =22	%		
Age(years)	≤47	28	53.8	7	31.8	3.009	0.126
	>47	24	46.2	15	68.2		
Sex	Male	24	46.2	12	54.5	0.436	0.613
	Female	28	53.8	10	45.5		
Eye	Right	24	46.2	10	45.5	0.003	1.00
	Left	28	53.8	12	54.5		
Axial length	<25.5	29	55.8	9	40.9	1.367	0.311
	≥25.5	23	44.2	13	59.1		
Lens	Phakic	28	53.8	15	68.2	1.305	0.309
	Pseudo Phakic	24	46.2	7	31.8		

(*) Chi square test, p value significant at ≤0.05

Table 2: Association between Postoperative Factors at Month One Post-Surgery and Final Visual Outcomes at Six Months Post-Surgery.

		Poor Visual acuity		Good Visual acuity		Test *	P value
		N=52	%	N=22	%		
BCVA (LogMAR)		1.76±0.17		1.21±0.40		6.169**	<0.001
CME (mean ±SD)		558.50±56.21		354.18±35.93		15.711**	<0.001
SRF (mean±SD)		212.00±49.72		71.68±12.19		19.044**	<0.001
ELM integrity	Disrupted	49	94.2	6	27.3	36.28	<0.001
	Not Disrupted	3	5.8	16	72.7		
EZ line integrity	Disrupted	52	100	4	18.2	56.22	<0.001
	Not disrupted	0	0	18	81.8		

(*) Chi square test, (**) Independent sample T test, p value significant at ≤0.05

Table 3: Association between Postoperative Factors at Month Three Post-Surgery and Final Visual Outcomes at Six Months Post-Surgery.

		Poor Visual acuity		Good Visual acuity		Test *	P value
		N=52	%	N=22	%		
BCVA (LogMAR)		1.76±0.17		0.91±0.23		17.68**	<0.001
CME (Mean±SD)		264.19±37.62		272.73±32.83		-0.925**	0.358
SRF(Mean±SD)		15.25±4.06		18.18±8.52		-1.091**	0.279
ELM integrity	**Disrupted**	52	100	0	0	74.00	<0.001
	Non disrupted	0	0	22	100		
EZ line integrity	**Disrupted**	50	96.2	2	9.1	56.092	<0.001
	Not disrupted	2	3.8	20	9.9		

(*) Chi square test, (**) Independent sample T test, p value significant at ≤0.05

Table 4: Association between Postoperative Factors at Month six Post-Surgery and Final Visual Outcomes**.**

		Poor Visual acuity		Good Visual acuity		Test *	P value
		N=52	%	N=22	%		
BCVA (LOGMAR)		1.76±0.17		0.91±0.23		17.68**	<0.001
CME (Mean±SD)		264.19±37.62		272.73±32.83		-0.925**	0.358
SRF (Mean±SD)		15.25±4.06		18.18±8.52		-1.091**	0.279
ELM integrity	**Disrupted**	52	100	0	0	74.00	<0.001
	Non-Disrupted	0	0	22	100		
EZ line integrity	**Disrupted**	50	96.2	2	9.1	56.092	<0.001
	Not disrupted	2	3.8	20	9.9		

(*) Chi square test, (**) Independent sample T test, p value significant at ≤0.05

Table 5: Multivariate Analysis Evaluating Postoperative Factors Correlated with Final BCVA.

		Unstandardized Coefficients		P value	95.0% Confidence Interval for B	
		B	SE		Lower Bound	Upper Bound
Influencing Factors at the 1st month after the surgery:	**BCVA**	-0.269	0.082	**0.002**	-.432	-.106
	CMT	.000	.000	0.190	.000	.001
	SRF	.001	.001	**0.033**	.000	.002
	ELM integrity	.065	.023	**0.007**	.018	.112
	EZ line integrity	-.199	.078	**0.013**	-.354	-.044
Influencing Factors at the 3rd month after the surgery	**BCVA**	-.343	.089	**<0.001**	-.519	-.166
	CMT	.001	.001	0.342	-.001	.002
	SRF	.000	.002	0.961	-.005	.005
	ELM integrity	.085	.033	**0.011**	.020	.150
	EZ line integrity	-.286	.080	**0.001**	-.445	-.127
	CMT	.001	.001	0.225	-.001	.002
Influencing Factors at the 6th month after the surgery	**SRF**	.001	.002	0.751	-.004	.005
	ELM integrity	.104	.033	**0.002**	.038	.170
	EZ line integrity	-.378	.077	**<0.001**	-.531	-.224

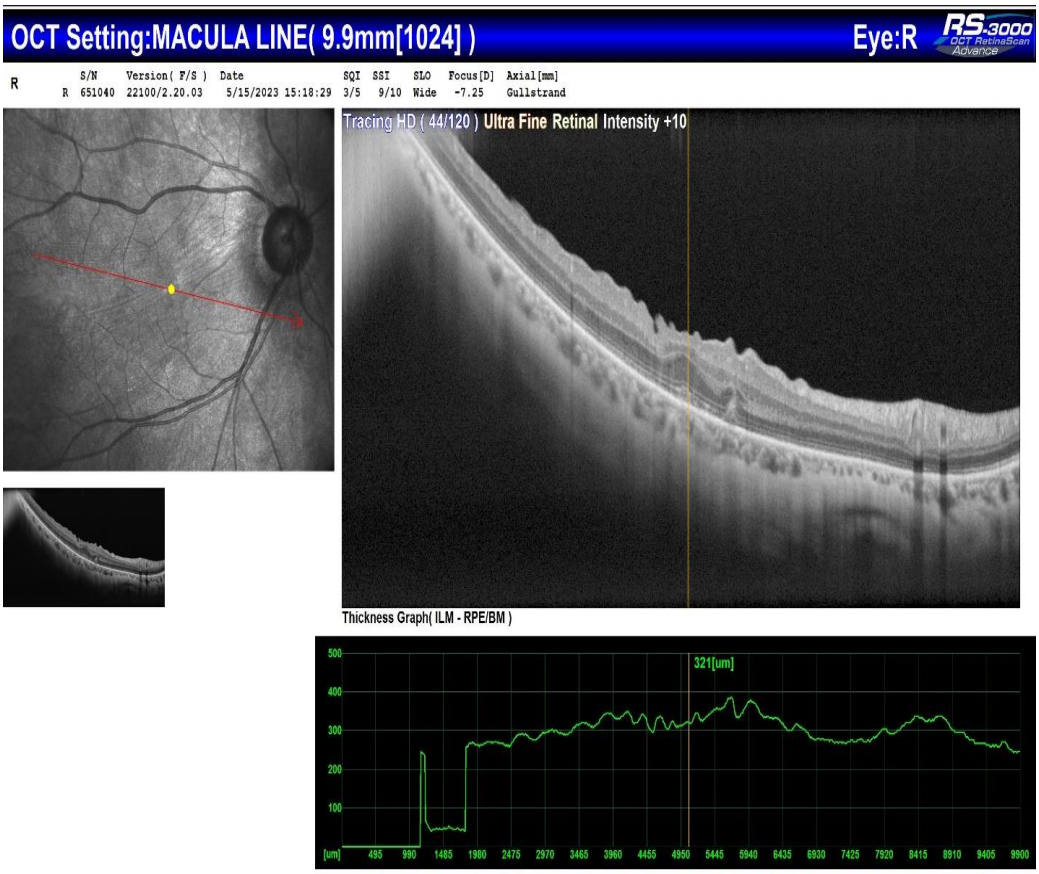
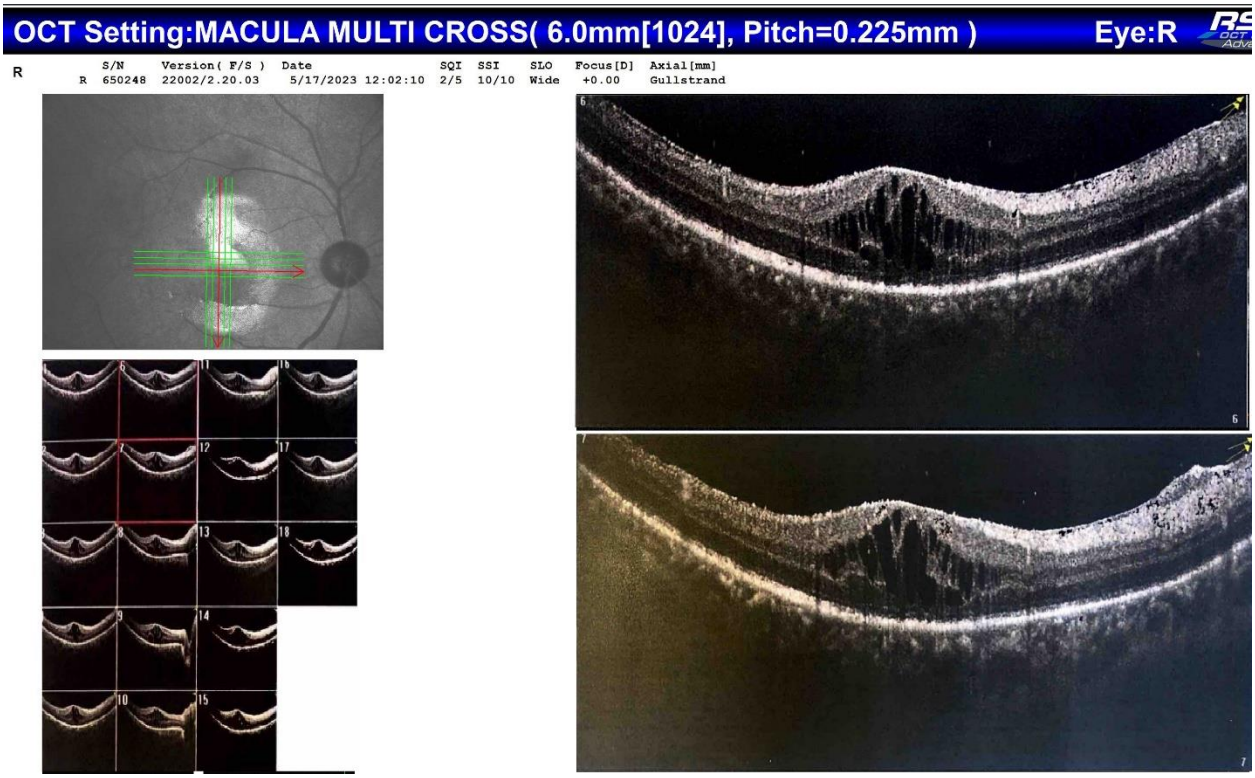


Fig. (1): Shows an intact outer foveal microstructure in a patient with macular displacement and a Snellen BCVA 6/18

Fig. (2) : Shows a patient with persistent cystoid macular edema at the 6th month postoperative with a final Snellen BCVA 0.2



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