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EVALUATION OF THE MACULAR CHANGES AFTER SUCCESSFUL RETINAL DETACHMENT SURGERY USING OPTICAL COHERENCE TOMOGRAPHY

Mansour Hassan Ahmed*[1], Mohamed Yasser Sayed Saif[2], Bahaa Abdallah Hassan[3], Sherif Momtaz Hegazy[4] and Mohamed Sayed Taha[5]

[1]MD, Professor, Department of Ophthalmology, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt.
[2]MD, Professor, Department of Ophthalmology, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt.
[3]MD, Professor, Department of Ophthalmology, Research Institute of Ophthalmology, Giza, Egypt.
[4]MD, Lecturer, Department of Ophthalmology, Research Institute of Ophthalmology, Giza, Egypt.
[5]M.Sc, Associate Lecturer, Department of Ophthalmology, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt.

Corresponding Author: Mansour Hassan Ahmed

MD, Professor, Department of Ophthalmology, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt.

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ABSTRACT

Background: Incomplete visual recovery, color vision defects, or persistent metamorphopsia may persist even after successful surgery for rhegmatogenous retinal detachment (RRD), especially in cases of RD with macula off, suggesting microstructural macular damage that standard fundus biomicroscopy could not detect. **Methods**: We compared swept-source optical coherence tomography imaging with preoperative and postoperative visual acuity to evaluate the relationship between morphological changes in the outer retina and visual outcome and also to detect the changes in the subfoveal choroid thickness after successful repair of RRD with macula off. We enrolled 40 patients (40 eyes) with successful repair of RRD. The mean postoperative follow-up duration at the time of the initial and the final swept-source optical coherence tomography scan was 1.6 and 5.7 months respectively. **Results**: The mean age of the patients was 59.2± 13.4 years (range: 24-82 years). The mean visual acuity (logarithm of minimal angle of resolution) before surgery was 1.14± 0.64. Disrupted ellipsoid zone was noted in 17 eyes (42.5%). Disrupted external limiting membrane (ELM) was noted in 4 eyes (10%). The mean postoperative visual acuity was 0.85± 0.56. The difference between the visual acuity before and after surgery was statistically significant. Patients with integrity of the ellipsoid zone and ELM were associated with significant visual improvement than patients with disruption of the ellipsoid zone or ELM. There were no statistically significant differences in the mean subfoveal choroidal thickness between the fellow eyes and the operated eyes at the initial and the final swept-source optical coherence tomography scan. **Conclusion**: the presence of ellipsoid zone or external limiting membrane disruptions seems to correlate with visual acuity outcome after rhegmatogenous retinal detachment repair. The presence of subretinal fluid on the early postoperative swept-source optical coherence tomography images may lead to transient decrease in visual acuity, but subretinal fluid usually seems to resolve spontaneously with long-term follow-up. Retinal detachment surgeries don't affect the subfoveal choroidal thickness.

KEYWORDS: Ellipsoid zone; External limiting membrane; Swept-source optical coherence tomography; Macula off rhegmatogenous retinal detachment; Subfoveal choroidal thickness.

1. INTRODUCTION

Inadequate visual recovery, color vision defects, or tireless metamorphopsia may hold on even after successful surgery for rhegmatogenous retinal detachment (RRD) particularly in cases of RD with macula off, proposing the presence of microstructural macular changes that standard fundus biomicroscopy can't recognize.[1] There were only 42% of all RRD eyes accomplishing 20/40 vision or better, and just 37% accomplishing 20/50 vision or better in macula-off detachment.[2] Optical coherence tomography (OCT) is a noninvasive continuous framework that is progressively utilized for diagnosing macular microstructure and assessing the reaction to different treatment modalities.[3,4,5,6] In previous studies, OCT data were used to describe the diverse morphological patterns for diagnosis, direction, and treatment of retinal pathology.[3,4,5,7,8] Late advances in retinal imaging have utilized OCT to assess poor visual recovery after retinal detachment surgery.[9-11] The swept-source optical coherence tomography (SS-OCT) utilizes a short pit swept laser with a tunable wavelength of task rather than the diode laser utilized in spectral-domain OCT.[12] The SS-OCT has enhanced image penetration utilizing a wavelength of 1050 nm and has an axial resolution of 5.3 μm and an axial scan rate of 100.000 scans for each second. Model models could achieve quicker sweep rates of something beyond than 400.000 scans for each second.[13,14] The 12 × 9 mm filter empowers synchronous imaging of the macula, the peripapillary region, the optic nerve head and the choroidal thickness. The 12 × 9 mm filter involves 256 B-scans each involving 512 A-scans with an aggregate obtaining time of 1.3 s.[15] SS-OCT additionally gives the ability of a wide field up to 12 × 12 mm pictures.[16]

SS-OCT empowers clear concurrent visualization of the vitreous and the pre-cortical vitreous pockets furthermore, the choroid and the sclera.[17] The financially accessible SS-OCT Triton (Topcon, Tokyo, Japan) measures the choroidal thickness (CT) with mechanized division utilizing a viewer programming where every segment can be estimated independently. This element has a promising role on the sectoral examination and follow-up of retinal pathologies including the choroid.[18]

Regardless of effective anatomical repair, visual acuity more often does not come back to standard when the RRD includes the macula preoperatively. This has been ascribed to different factors, for example, epiretinal membrane (ERM), existance of residual subretinal fluid (SRF), cystoid macular edema, macular hole, retinal folds, pigment migration, and duration of retinal detachment before surgical repair.[19-23] Minimal changes after RRD, for example, disruption of the ellipsoid zone [this band was previously known as the photoreceptor inner and outer segment (IS/OS) junction] and interruption of the external limiting membrane (ELM) have been recognized by OCT imaging and were connected to diminished postoperative visual recovery.[24-26]

2. MATERIALS AND METHODS

Patients

All patients were enrolled at the outpatient department of ophthalmology, Research Institute of Ophthalmology (Giza, Egypt). This study is a prospective observational follow-up study of 40 patients (40 eyes) with successful repair of RRD and a mean postoperative follow-up duration of 1.6 and 5.7 months for the initial and the final swept-source OCT scan respectively. The 40 patients were selected after a chart review of patients between December 2015 and November 2017 for primary macula-off RRD. We defined successful repair of RRD as the patient continuing to have the retina attached after 5 months following surgery. Inclusion criteria were: primary macula-off RRD; mean follow up of 5.7 months postoperatively; and a written informed consent. Exclusion criteria were history of detachment longer than 7 days, patients with other ocular diseases, previous macular lesions, exudative or tractional retinal detachment, history of amblyopia, and macular structural abnormalities in the fellow eye. Patients accepted best corrected visual acuity examination preoperatively and postoperatively and swept-source OCT imaging postoperatively for data analysis. The best-corrected visual acuity was determined from Snellen chart and converted to the logarithm of minimal angle of resolution (log MAR) equivalents to perform the appropriate statistical manipulation. Counting fingers, and hand movements at 1 m were converted to 1.6 and 1.9, respectively. The following data were also collected: age, sex, time from the onset of symptoms to surgery, characteristics of RRD including the number of quadrants involved, proliferative vitreoretinopathy grade, and type of surgery. The macula had detached from the retinal pigment epithelium, so it was known as macula-off RD. The Institutional Review Board Committee of Beni-Suef University Hospital approved the study.

Surgical procedure

Pars plana vitrectomy(PPV): PPV with silicone oil or gas tamponade was performed under sterile conditions in the ophthalmologic operating room using an operation microscope. We used the silicone oil tamponade mainly in cases of lower retinal detachment with inferior retinal breaks,cases with PVR (proliferative vitreoretinopathy) grade A ,cases with giant retinal tear and elderly patients who cannot posture. We used the gas tamponade (C_2F_6) mainly in cases of upper retinal detachment with one or two upper retinal breaks. The patients accepted standard three-port pars plana vitrectomy using a constellation vitrectomy machine. Initially, the vitreous was removed (core vitrectomy) followed by induction of PVD (posterior vitreous detachment). Next, we released the traction area followed by shaving of the vitreous base. A drainage retinotomy was performed if needed using endodiathermy, and a subretinal fluid was aspirated using a flute needle through the retinotomy. After fluid air exchange, we checked whether the entire retina was completely flattened against the retinal pigment epithelium and, if this was not done, additional retinectomy was performed to relax the remaining traction points, and a new drainage of subretinal fluid was made. After the retina was totally attached, photocoagulation was applied, surrounding all retinal breaks and along the entire edge of the drainage retinotomies. Finally, the silicone oil or C_2F_6 tamponade was injected into the eye. In cases with silicone oil tamponade, we removed the silicone oil after a mean time interval of 5.2 months when a stable retinal situation has been achieved.

Scleral buckling surgery (SBS): SBS was performed in the ophthalmologic operating room under sterile conditions. We administered eye drops to the patients to dilate the pupil to allow better approach to the eye before the procedure. Surgical access is best when the orbital rim is horizontal. We did 360 degrees periotomy, exposing the sclera followed by slinging the rectus muscles. A careful indented examination under anesthesia of the whole peripheral retina is now carried out to confirm the location of the retinal breaks, the location of each break is marked on the sclera. If a retinal break is highly elevated as in a bullous detachment parallax errors may make the break seem more posterior than it truly is, these errors may be avoided by draining subretinal fluid and then reforming the globe with air (the DACE operation) then we performed cryopexy to freeze the outer surface of the eye over the tear or detachment and then made trans-scleral drainage of subretinal fluid. After the fluid was drained, we sutured the buckle into place and then covered it with the conjunctiva. Silicone tires are usually oriented circumferentially but sponges may be oriented either circumferentially or radially. While the choice between tires and sponges is to some extent a matter of surgeon preference their different physical properties favor their use in different situations depending on the number, size and location of retinal breaks, this can be illustrated by some examples. Example 1: A detachment with a single elevated equatorial tractional tear may be closed using a single radial sponge without drainage of subretinal fluid. Example 2: A detachment due to a series of round retinal holes, the holes are anterior to the equator at various distances from the ora, they may be treated with a circumferential explants, as the distances from the ora varies the broader indentation from a tire can close all the breaks. Example 3: Three tractional tears can be treated with separate radial sponges or with a single circumferential buckle. We applied laser photocoagulation around the retinal breaks several days to weeks postoperatively once the retina has reattached.

OCT

Microstructural imaging of the macula was performed using SS-OCT (Swept-Source Optical Coherence Tomography). Scans were obtained at horizontal cross sections through the fovea; the scan showed three distinct lines, indicating reflection from the ELM, ellipsoid zone, and retinal pigment epithelium (RPE)/Bruch's membrane, respectively. Foveal microstructural changes in the photoreceptor layer were defined as disruption of the ellipsoid zone or ELM. Each of the OCT images was interpreted by two investigators. If there was any disagreement, a third investigator was consulted.

Statistical analysis

Visual acuity values were converted into the logMAR for statistical analysis. Statistical analyses were conducted using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). The possible correlation between the foveal microstructural changes (ellipsoid zone defects. ELM signals or other abnormalities) and the visual acuity outcomes was investigated using the independent-samples t test. A p value < 0.05 indicated Statistical significance.

3. RESULTS

Forty patients (19 right eyes and 21 left eyes) agreed to participate in the study. All Patients(16 men and 24 women) presented with acute macula-off retinal detachment and underwent retinal detachment repair surgeries with successful anatomical repositioning of the retina. The time between the occurrence of the RRD, assessed according to the symptoms the patient reported, and the surgical treatment ranged between 3 and 7 days (mean time 5.08 ± 1.56). All patients showed spontaneous RRD with one or more retinal breaks. Baseline characteristics are displayed in Table 1.The mean age of the patients was 59.2± 13.4 years (range: 24-82 years). The mean visual acuity (logMAR) before surgery was 1.14± 0.64. An intact ellipsoid zone was observed in 23 patients (57.5%), and 17 (42.5%) patients had a disrupted ellipsoid zone. An intact ELM was observed in 36 patients (90%), and 4 (10%) patients had a disrupted ELM. During the follow-up period, the mean postoperative visual acuity (logMAR) was 0.85± 0.56. Then difference between the visual acuity (logMAR) before and after surgery was statistically significant (p= 0.011). 8 eyes (20%) accepted pars plana vitrectomy with silicone oil, 6 eyes (15%) accepted pars plana vitrectomy with C2F6 tamponade and 26 eyes (65%) received segmental scleral buckles. The mean postoperative follow-up duration at the time of the initial and the final swept-source OCT (SS-OCT) scan for these 40 subjects was 1.6 months and 5.7 months respectively. Patients with integrity of the ellipsoid zone were associated with significant visual improvement postoperatively compared with the cases with disruption of the ellipsoid zone ($p < 0.05$, $p = 0.038$; Table 2). Patients with intact ELM showed significant visual improvement postoperatively compared with the cases with disruption of ELM (p=0.001; Table 3).

Table 1: Demographic and clinical data of patients with primary rhegmatogenous retinal detachment.

Item	Number	Percent (%)
No. of eyes	40	(100)
No. of right eyes	19	(47.5)
No. of left eyes	21	(52.5)
sex		
Male patients	16	(40)
Female patients	24	(60)
Age (y)	59.2 ± 13.4 (24-82)	
Duration of symptoms(d)	5.08 ± 1.56 (3-7)	
Extent of retinal detachment		
1 quadrant	8	(20)

2 quadrants	24	(60)
3 quadrants	4	(10)
4 quadrants	4	(10)
Initial pseudophakic eyes	6	(15)
Proliferative vitreoretinopathy (Grade A)	5	12.5
Preoperative visual acuity (LogMAR)	1.14 ± 0.64	
Retinal surgery		
Scleral buckling	26	(65)
PPV + silicone oil	8	(20)
PPV + C2F6 tamponade	6	(15)
Postoperative visual acuity (LogMAR)	0.85	0.56

- *Data are presented as n (%), mean ±SD, or mean ±SD (range).*
- *LogMAR = logarithm of minimal angle of resolution; PPV = pars plana vitrectomy; SD=standard deviation.*

Table 2: Intergroup comparison of patients with and without disrupted ellipsoid zone.

Ellipsoid zone disruption	*Yes*	*No*
No. of eyes	*17 (42.5%)*	*23 (57.5%)*
Pre-op LogMAR	*1.32 ± 0.6*	*0.88 ± 0.62*
Post-op LogMAR	*1.19 ± 0.38*	*0.3 ± 0.33*
VA change	*-0.13 ± 0.65*	*-0.58 ± 0.45*
P	*0.039*	

- *Data are presented as mean ± SD.*
- *Patients with integrity of the ellipsoid zone were associated with significant visual improvement postoperatively than were the cases with disruption of the ellipsoid zone (p <0.05, p = 0.039).*
- *logMAR = logarithm of minimal angle of resolution; Post-op = postoperative; Pre-op = preoperative; SD = standard deviation; VA change =logMAR after surgery - logMAR before surgery.*

Table 3: Intergroup comparison of patients with and without disrupted ELM.

ELM disruption	*Yes*	*No*
No. of eyes	4 (10%)	36 (90%)
Pre-op LogMAR	1.21 ± 0.62	1.11 ± 0.67
Post-op LogMAR	1.37 ± 0.21	0.55 ± 0.48
VA change	0.15 ± 0.65	-0.56 ± 0.42
P	0.001	

- *Data are presented as mean ± SD.*
- *Patients with intact ELM showed significant visual improvement postoperatively than the cases with disruption of ELM (p =0.001).*
- *ELM =external limiting membrane; logMAR =logarithm of minimal angle of resolution; Post-op =postoperative; Pre-op =preoperative; SD =standard deviation; VA change =logMAR after surgery -logMAR before surgery.*

We listed abnormalities detected by OCT other than disruption of the ellipsoid zone and ELM (Table 4). Subretinal fluid was present in 7 patients(17.5%) on the first follow up swept-source OCT image, but completely resolved in 5 patients (12.5%) on the final follow up swept-source OCT image. From the 4 cases(10%) with macular cysts, 2 cases showed single or few macular cysts with preserved foveal contour and 2 cases with elevated central retinal thickness with classic picture of cystoid macular edema. In all of the four cases cysts detected in the 1st follow up and disappeared in the final visit. The change in visual acuity of the seven eyes with residual subretinal fluid (SRF) was -0.33± 0.16 logMAR units, which was not significantly different from the change of visual acuity (-0.31± 0.12 logMAR units) among eyes without SRF (p = 0.40). The change of visual acuity of the four eyes with cystoid macular edema was -0.43 ±0.05 logMAR units, which was not significantly different from the change of visual acuity (-0.30 ±0.12 logMAR units) among eyes without cystoid macular edema (p=0.11). The change of visual acuity of the three eyes with epiretinal membrane (ERM) was -0.20 ±0.30 logMAR units, which was not significantly different from the change of visual acuity (-0.32± 0.11 logMAR units) among eyes without ERM (p = 0.714). Statistical analysis showed that the significant factors associated with postoperative visual improvement were ellipsoid zone disruption and ELM disruption. The mean time interval for silicone oil removal in 8 siliconized eyes was 5.2 months(range between 4.3 -6.6 months). No patients received subsequent ERM peeling because ERM condition did not obviously disturb the postoperative visual acuity.

Table 4: Other abnormalities detected by optical coherence tomography.

Macular changes by OCT	Number (percent)
Residual SRF	7 (17.5%)
Macular cysts	4 (10%)
Epiretinal membrane	3 (7.5%)

OCT= optical coherence tomography; SRF= subretinal fluid.

As regard measurement of the postoperative subfoveal choroidal thickness(SCT) at the initial and the final swept-source OCT scan ,it was found that the mean SCT of operated eyes were 262.2 ± 45.3 and 256.4 ± 46.5 µm respectively and that of fellow eyes was 256.9 ± 46.2 µm. There were no statistically significant differences in the mean subfoveal choroidal thickness between the fellow eyes and the operated eyes at the initial and the final swept-source OCT scan as in Table5.

Table 5: differences in the mean subfoveal choroidal thickness between the operated eyes and the fellow eyes.

SCT in µm	Operated eyes at the initial OCT scan	Operated eyes at the final OCT scan	Fellow eyes	total
mean ±SD	262.2±45.3	256.4±46.5	256.9±46.2	40
p-value	0.083			

SCT= subfoveal choroidal thickness, OCT= optical coherence tomography, SD= standard deviation.

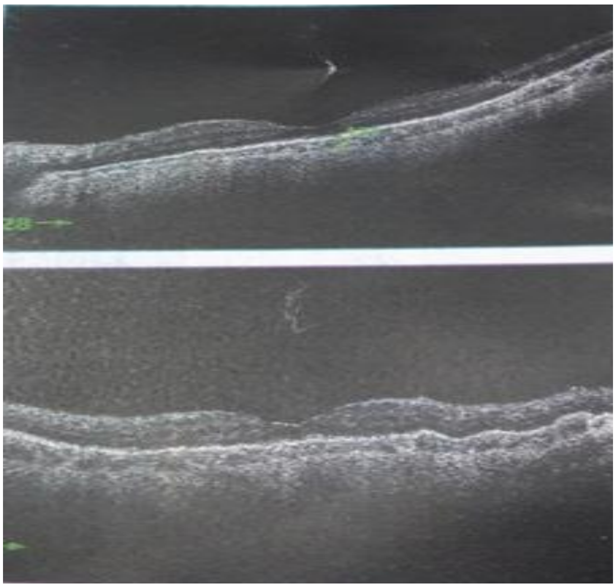

Figure 1: Postoperative SS-OCT images after successful repair of RRD of patient 17:preoperative LogMAR=1.34,postoperative LogMAR=1.19 show diffuse disruption of the ellipsoid zone with an intact external limiting membrane.

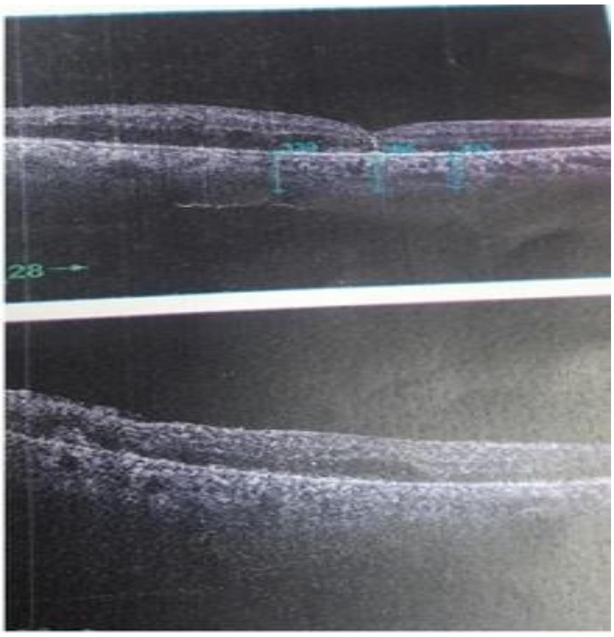

Figure 2: Postoperative initial SS-OCT images after successful repair of RRD of patient 8:preoperative LogMAR=1.28,postoperative LogMAR=0.95 show residual subretinal fluid.

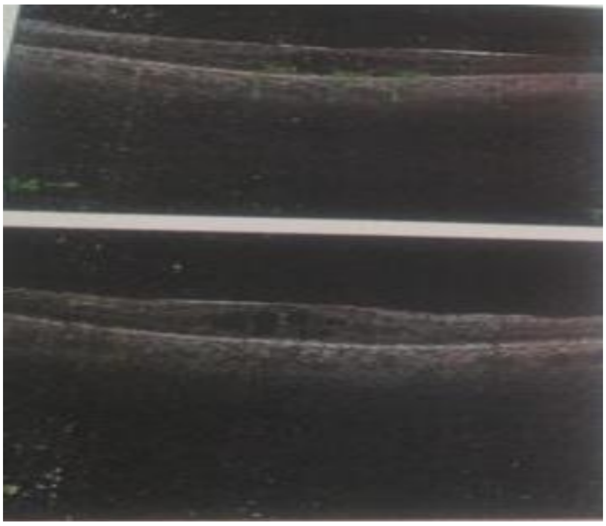

Figure 3: Postoperative initial SS-OCT images after successful repair of RRD of patient 12:preoperative LogMAR=1.26,postoperative LogMAR=0.83 show cystoid macular edema.

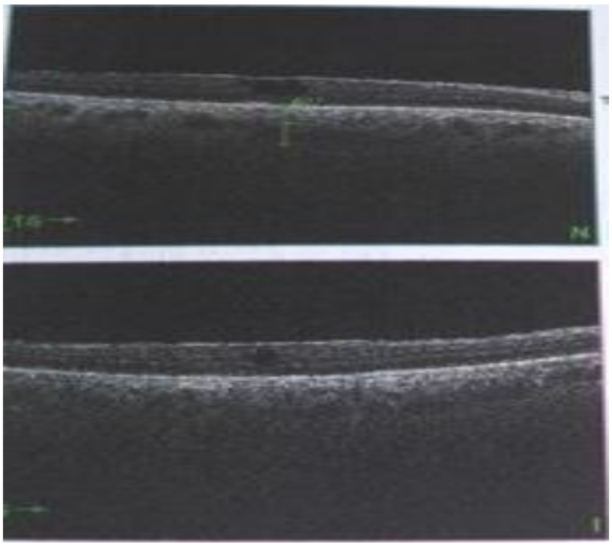

Figure 4: Postoperative SS-OCT images after successful repair of RRD of patient 23:preoperative LogMAR=1.20, postoperative LogMAR=0.98 show an epiretinal membrane.

4. DISCUSSION

These results demonstrate that the integrity of the ellipsoid zone and ELM, studied by SS-OCT, has a statistically significant improvement of postoperative visual acuity in patients with successful surgery for RRD. It is well known that some patients who undergo surgery for RRD have incomplete visual recovery. Several factors influencing postoperative visual acuity have been discussed that are important points of concern for retinal surgeons. Kitaya et al.[27] have suggested that using OCT to evaluate the appearance of the photoreceptor layer is correlated with postoperative visual acuity. Several studies[28,29] have reported that the use of SD-OCT has a higher resolution and better correlation with actual retinal anatomy and evaluation of the ellipsoid zone. Cobos et al.[29] reported that the presence of an intact ellipsoid zone on the preoperative SD-OCT scan was an important predictor of better visual recovery after ERM surgery. Lai et al.[30] revealed that abnormalities among the ELM or the ellipsoid zone were associated with poor visual outcomes in eyes after anatomically successful repair of RRD. In our study, ellipsoid zone lesions were detected in 42.5% of eyes and disrupted ELMs were found in 10% of eyes. Disruption in the ellipsoid zone or ELM was significantly correlated with less postoperative visual improvement. Intact ellipsoid zone and ELM after surgery may be related to better visual outcomes. Disrupted ellipsoid zone or ELM could be a marker of poor prognosis for visual recovery. The main limitations of our study were small sample size and inadequate follow up duration. Large prospective clinical trials with long follow up duration are necessary to provide significant anatomical and functional parameters of the visual recovery over time. The swept-source OCT instrument used in this study provides a somewhat higher axial image resolution than the currently commercially available FD OCT (spectral domain OCT) instruments.

The disruption of photoreceptor IS/OS is found to be the most important correlate of visual acuity and function in the early postoperative period and long-term follow-up. A previous study using serial FD OCT scan from 1 month to 25 months after surgical repair also found that the photoreceptor IS/OS junction integrity was an important factor correlation in visual restoration in eyes after repair of macula-involving RRD.[31] The mean postoperative follow up period for our current study was much shorter at 5.7 months (range, 5.2–6.4 months).

The back reflection arising from the IS/OS junction represents the abrupt boundary between the IS structures and highly organized OS of the photoreceptor layer. One hypothesis suggests that the hyper reflective IS/OS line is because of back reflection of the perpendicular photoreceptor stack, and hence, the disruption of IS/OS junction may represent photoreceptor misalignment or swelling of the photoreceptors. Spaide and Curcio[32] suggested that the band often attributed to the boundary between the IS and OS of the photoreceptors may actually align with ellipsoid portion of the inner segments.

External limiting membrane is formed by the junction of photoreceptor nuclei and Muller cells.[33] Loss of ELM on SS- OCT may be indicative of damage or loss of the photoreceptor nuclear body and Muller cells, which may lead to irreversible photoreceptor and vision loss at long-term follow-up.[34] Because histopathological studies of fovea centralis have shown that the inner half of the foveola is composed of inverted cone shaped zone of Muller cells in human retina, damage to foveal Muller cells may also play a role in long-term gradual degeneration of the foveal photoreceptor. Human Muller cells can differentiate into rod photoreceptors when transplanted into mouse retina, suggesting that Muller cells may have some plasticity to act as photoreceptor progenitor cells under certain conditions.[35,36]

Based on the previous studies, repair of macula-off RRD may be delayed up to 1 week after development of macula-off RRD without significant adverse effect on visual outcome.[20] However, visual recovery with further delay in repair is generally poorer.[21] In our study, The time between the occurrence of the RRD, assessed according to the symptoms the patient reported, and the surgical treatment ranged between 3 and 7 days (mean time 5.08 ± 1.56).Delay in repair of RRD may lead to failure of restoration of the IS/OS junction even after several years after successful repair, likely because of irreversible loss of photoreceptors via apoptosis which may have occurred before RRD repair.[37,38]

Subfoveal fluid was present in 7 eyes at the initial SS-OCT imaging. All these patients had RRD repaired via scleral buckling surgery combined with retinal cryopexy. Five patients had complete resolution of the SRF on follow-up SS- OCT 5.7 months later. Concurrent with resolution of SRF was improvement in foveal IS/OS disruption and visual acuity observed in these eyes. Historically, persistent SRF has been thought to be responsible for persistently decreased BCVA shortly after RRD repair.[22,39] However, studies with longer follow-up have shown complete resolution of SRF at 6 months to 24 months after sclera buckle surgery with no influence on the final visual acuity.[23,31]

Gama et al.[40] observed that the subfoveal choroidal thickness(SCT) of the eyes in the encircling scleral buckling(ESB) + pars plana vitrectomy (PPV) group was significantly increased compared to their fellow eyes(FE).The SCT of the PPV group was similar to their FE.The SCT of the ESB + PPV group was significantly increased compared to SCT of the PPV group.Akkoyun et al.[41] reported that no significant difference in SCT was observed between the group of ESB and the group of PPV or when comparing the operated eye with the fellow eye 1 and 6 months postoperatively.Sayman Muslubas et al.[42] revealed that vitrectomy didn't affect choroidal thickness.In our study we didn't combine ESB + PPV but we observed that neither ESB nor PPV affected SCT during the initial and the final SS-OCT imaging.

Our present study has some obvious limitations. The sample size is small because only 40 patients could be contacted and agreed to participate in this follow-up study. Thus, our impressions are based on the limited observations. Second, these results are based on a cohort of patients with favorable preoperative factors such as shorter duration of retinal detachment before repair. Many patients who underwent RRD repair at the Research institute of ophthalmology had complex RRDs requiring multiple repairs or had significant postoperative changes in the macula that did not qualify them for the study. Nevertheless, this study is a follow-up report using serial SS- OCT to study the macular morphologic changes after successful macula-off RRD repair and provides new insights regarding possible mechanisms for visual recovery and visual loss after RRD repair.

In conclusion, the presence of foveal IS-OS photoreceptor disruptions seems to correlate with visual acuity outcome after RRD repair both short-term and long-term. The presence of ELM disruptions in the early postoperative SS- OCT image may be a poorer prognostic sign, potentially leading to progressive photoreceptors damage and vision loss. The presence of SRF on the early postoperative SS- OCT images may lead to transient decrease in visual acuity, but SRF usually seems to resolve spontaneously with long-term follow-up. Thus, draining trace amounts of residual SRF seen postoperatively on SS- OCT may not be necessary unless it increases or is associated with worsening vision, also RD surgeries don’t affect the subfoveal choroidal thickness.

5. REFERENCES

1. **Nork TM, Millecchia LL, Strickland BD, Linberg JV. Chao G-m**. Selective loss of blue cones and rods in human retinal detachment. Arch Ophthalmol, 1995; 113: 1066e73.
2. **Pastor J, Ferna´ndez I, de la Ru´a ER, Coco R, Colmenares MS-R, Sa´nchez-Chicharro D, et al**. Surgical outcomes for primary rhegmatogenous retinal detachments in phakic and pseudophakic patients: the Retina 1 Projectdreport 2. Br J Ophthalmol, 2008; 92: 378e82.
3. **Markomichelakis NN, Halkiadakis I, Pantelia E, Georgalas E, Anthi K, Theodossiadis P, et al**. Course of macular edema in uveitis under medical treatment. Ocular Immunol Inflam, 2007; 15: 71e9.
4. **Puliafito CA, Hee MR, Lin CP, Reichel E, Schuman JS, Duker JS, et al.** Imaging of macular diseases with optical coherence tomography. Ophthalmology, 1995; 102: 217e29.
5. **Domalpally A, Altaweel MM, Kempen JH, Myers D, Davis JL, Foster CS, et al.** Optical coherence tomography evaluation in the Multicenter Uveitis Steroid Treatment (MUST) trial. Ocular Immunol Inflam, 2012; 20: 443e7.
6. **Onal S, Tugal-Tutkun I, Neri P, Herbort CP.** Optical coherence tomography imaging in uveitis. Int Ophthalmol, 2014; 34: 401e35.
7. **Iannetti L, Spinucci G, Abbouda A, De Geronimo D, Tortorella P, Accorinti M.** Spectral-domain optical coherence tomography in uveitic macular edema: morphological features and prognostic factors. Int J Ophthalmol, 2011; 228: 13e8.
8. **Iannetti L, Accorinti M, Liverani M, Caggiano C, Abdulaziz R, Pivetti-Pezzi P.** Optical coherence tomography for classification and clinical evaluation of macular edema in patients with uveitis. Ocular Immunol Inflam, 2008; 16: 155e60.
9. **Wolfensberger TJ, Gonvers M.** Optical coherence tomography in the evaluation of incomplete visual acuity recovery after macula-off retinal detachments. Graefe Arch Clin Exp Ophthalmol, 2002; 240: 85e9.
10. **Benson SE, Schlottmann PG, Bunce C, Xing W, Charteris DG**. Optical coherence tomography analysis of the macula after vitrectomy surgery for retinal detachment. Ophthalmology, 2006; 113: 1179e83.
11. **Benson SE, Schlottmann PG, Bunce C, Xing W, Charteris DG.** Optical coherence tomography analysis of the macula after scleral buckle surgery for retinal detachment. Ophthalmology, 2007; 114: 108-12.
12. **Yang Z, Tatham AJ, Zangwill LM, Weinreb RN, Zhang C, Medeiros FA.** Diagnostic ability of retinal nerve fiber layer imaging by swept source optical coherence tomography in glaucoma. Am J Ophthalmol, 2015; 159: 193–201.
13. **Postaid B, Baumann B, Huang D, Barry S, Cable AE, Shchuman JS, Duker JS, Fujimoto JG**. Ultrahigh speed 1050 nm swept source/fourier domain OCT retinal and anterior segment imaging at 100,000 to 400,000 axial scans per second. Opt Express, 2010; 18(19): 200029–48.
14. **Mohler KJ, Draxinger W, Klein T, Kolb JP, Wieser W, Haritoglou C, Kamplik A, Fujimoto JG, Neubauer AS, Huber R, Wolf A**.Combined 60 degrees wide-field choroidal thickness maps and high-definition en face vasculature visualization using swept-source megahertz OCT at 1050nm. Invest Ophthalmol Vis Sci, 2015; 55(11): 6284–93.
15. **Zhang C, Tatham AJ, Medeiros FA, Zangwill LM, Yang Z, et al**. Assessment of choroidal thickness in healthy and glaucomatous eyes using swept source optical coherence tomography. PLoS One, 2014; 9(10): e109683.
16. **De Carlo TE, Romano A, Waheed NK, Duker JS**. A review of optical coherence tomography angiography. Int J Retin Vitr, 2015; 1: 5. doi:10.1186/ s40942-0005-8.
17. **Ikakura H, Kishi S, Li D, Akayma H.** Observation of posterior precortical vitreous pocket using swept-source optical coherence tomography. Invest Ophthalmol Vis Sci, 2013; 54: 3102–7.
18. **Capuano V, Souied EH, Miere A, Jung C, Constanzo E, Querques G.**, Choroidal maps in non-exudative age-related macular degeneration. Br J Ophthalmol, 2015; 100(5): 677–82.
19. **Shimoda Y, Sano M, Hashimoto H, et al.** Restoration of photoreceptor outer segment after vitrectomy for retinal detachment. Am J Ophthalmol, 2010; 149: 284–290. [PubMed: 19939346].

20. **Ross WH, Kozy DW**. Visual recovery in macula-off rhegmatogenous retinal detachments. Ophthalmology, 1998; 105: 2149–2153. [PubMed: 9818620].
21. **Burton TC.** Recovery of visual acuity after retinal detachment involving the macula. Trans Am Ophthalmol Soc, 1982; 80: 475. [PubMed: 6763802].
22. **Wolfensberger TJ, Gonvers M.** Optical coherence tomography in the evaluation of incomplete visual acuity recovery after maculaoff retinal detachments. Graefes Arch Clin Exp Ophthalmol, 2002; 240: 85–89. [PubMed: 11931084].
23. **Ricker LJ, Noordzij LJ, Goezinne F, et al**. Persistent subfoveal fluid and increased preoperative foveal thickness impair visual outcome after macula-off retinal detachment repair. Retina, 2011; 31: 1505–1512. [PubMed: 21522038].
24. **Smith AJ, Telander DG, Zawadzki RJ, Choi SS, Morse LS, Werner JS, et al**. High-resolution Fourier-domain optical coherence tomography and microperimetric findings after macula-off retinal detachment repair. Ophthalmology, 2008; 115: 1923e9.
25. **Nakanishi H, Hangai M, Unoki N, Sakamoto A, Tsujikawa A, Kita M, et al.** Spectral-domain optical coherence tomography imaging of the detached macula in rhegmatogenous retinal detachment. Retina, 2009; 29: 232e42.
26. **Wakabayashi T, Oshima Y, Fujimoto H, Murakami Y, Sakaguchi H, Kusaka S, et al.** Foveal microstructure and visual acuity after retinal detachment repair: imaging analysis by Fourier-domain optical coherence tomography. Ophthalmology, 2009; 116: 519e28.
27. **Kitaya N, Hikichi T, Kagokawa H, Takamiya A, Takahashi A, Yoshida A.** Irregularity of photoreceptor layer after successful macular hole surgery prevents visual acuity improvement. Am J Ophthalmol, 2004; 138: 308e10.
28. **Schmidt-Erfurth U, Leitgeb RA, Michels S, Pova_zay B, Sacu S, Hermann B, et al.** Three-dimensional ultrahigh-resolution optical coherence tomography of macular diseases. Invest Ophthalmol Visual Sci, 2005; 46: 3393e402.
29. **Cobos E, Arias L, Ruiz-Moreno J, Rubio M, Garcia-Bru P, Caminal J, et al.** Preoperative study of the inner segment/outer segment junction of photoreceptors by spectral-domain optical coherence tomography as a prognostic factor in patients with epiretinal membranes. Clin Ophthalmol, 2013; 7: 1467.
30. **Lai WW, Leung GY, Chan CW, Yeung IY, Wong D.** Simultaneous spectral domain OCT and fundus autofluorescence imaging of the macula and microperimetric correspondence after successful repair of rhegmatogenous retinal detachment. Br J Ophthalmol, 2010; 94: 311-8.
31. **Wakabayashi T, Oshima Y, Fujimoto H, et al**. Foveal microstructure and visual acuity after retinal detachment repair: imaging analysis by Fourier-domain optical coherence tomography. Ophthalmology, 2009; 116: 519–528. [PubMed: 19147231].
32. **Spaide RF, Curcio CA**. Anatomical correlates to the bands seen in the outer retina by optical coherence tomography. Retina, 2011; 31: 1609 1619. [PubMed: 21844839].
33. **Spitznas M.** The fine structure of the so-called outer limiting membrane in the human retina. Albrecht Von Graefes Arch Klin Exp Ophthalmol, 1970; 180: 44–56. [PubMed: 4911298].
34. **Romano MR, Vinciguerra P, Radice P, et al.** Outer retinal layers. Ophthalmology, 2011; 118: 1006.e2. [PubMed: 21539987].
35. **Xia X, Li Y, Huang D, et al.** Oncostatin M protects rod and cone photoreceptors and promotes regeneration of cone outer segment in a rat model of retinal degeneration. PLoS One, 2011; 6: e18282. [PubMed: 21479182].
36. **Giannelli SG, Demontis GC, Pertile G, et al.** Adult human Müller glia cells are a highly efficient source of rod photoreceptors. Stem Cells, 2011; 29: 344–356. [PubMed: 21732491].
37. **Lewis GP, Charteris DG, Sethi CS, et al.** The ability of rapid retinal reattachment to stop or reverse the cellular and molecular events initiated by detachment. Invest Ophthalmol Vis Sci, 2002; 43: 2412–2420. [PubMed: 12091445].
38. **Cook B, Lewis GP, Fisher SK, Adler R.** Apoptotic photoreceptor degeneration in experimental retinal detachment. Invest Ophthalmol Vis Sci, 1995; 36: 990–996. [PubMed: 7730033].
39. **Benson SE, Schlottmann PG, Bunce C, et al**. Optical coherence tomography analysis of the macula after scleral buckle surgery for retinal detachment. Ophthalmology, 2007; 114: 108–112. [PubMed: 17095091].
40. **Gama I, Proença H, Gonçalves A, Faria M, Almeida L, Bernardo T**. Macular choroidal thickness after vitreoretinal surgery: Long-term effect of pars plana vitrectomy with and without encircling scleral buckling surgery. This paper was submitted to the 91st Congress of the Ophthalmology Society of Spain on September 25, 2015 in Seville, Spain, as a free communication.
41. **Akkoyun I, Yilmaz G.** Choroidal thickness after scleral buckling surgery versus pars plana vitrectomy in macula-off rhegmatogenous retinal detachment.Article in German cited by www.ncbi.nlm.nih.gov/pubmed/24901425. Klin Monbl Augenheilkd, 2014 Oct; 231(10): 1029-33. doi: 10.1055/s-0034-1368375. Epub 2014 Jun 5.
42. **Sayman Muslubas I, Karacorlu M, Hocaoglu M, Arf S, Uysal O**. Subfoveal choroidal thickness changes after pars plana vitrectomy in recent onset rhegmatogenous retinal detachment cited by https://www.ncbi.nlm.nih.gov/pubmed/27579730. Retina, 2016 Dec; 36(12): 2371-2376.