Evaluation of macular structure and vasculature after postoperative period of retinal detachment surgery using optical coherence tomography angiography.

Mehmet Demir, Cetin Akpolat*

Department of Ophthalmology, University of Health Science, Istanbul, Turkey

Received: *12-Feb-2023, Manuscript No. AACOVS-23-89255;* ***Editor assigned:*** *14-Feb-2023, AACOVS-23-89255 (PQ);* ***Reviewed:*** *28-Feb-2023, QC No. AACOVS-23-89255;* ***Revised:*** *03-May-2023, Manuscript No. AACOVS-23-89255 (R);* ***Published:*** *10-May-2023, DOI:10.35841/aacovs.7.3.653-657*

Abstract

Purpose: This study aimed to evaluate the macular structure after Rhegmatogenous Retinal Detachment (RRD) surgery using Optical Coherence Tomography Angiography (OCTA).

Methods: This study analyzed the results of 66 eyes of 33 patients who were treated for unilateral Rhegmatogenous Retinal Detachment (RRD). The eyes that had RRD surgery were included in the study group (n=33) and fellow eyes served as the control group (n=33). The subgroups of the study group were defined according to the type of surgery. Best Corrected Visual Acuity (BCVA, in decimal), Central Macular Thickness (CMT, µm), superficial and deep retinal Vessel Density (VD, %), choriocapillaris VD, Foveal Avascular Zone (FAZ) area (mm^2) and FAZ Perimeter (PERIM, mm) were evaluated using OCTA.

Results: Mean BCVA was poor in the study group when compared to the control group (0.54 ± 0.1 *vs.* 0.01 ± 0.01; p<0.001). Mean CMT values were similar in the study and control groups (p=0.468). All superficial segment VD measurements were lower in the study group than in the fellow eyes (p<0.001 for all). Whereas, no significant deep segment VD measurement differences were observed between the study and control groups as well as mean FAZ area and PERIM values (p>0.05 for all).

Conclusion: Eyes that underwent RRD surgery had lower superficial VD measurements. Patients in the SBC+gas+laser group had better results than the other subgroups. Visual functions were not similar in the groups despite similar mean CMT measurements.

Keywords: Microvascular density, Optical, Retinal detachment, Tomography, Visual acuity, Vitrectomy

Introduction

Rhegmatogenous Retinal Detachment (RRD) is secondary to retinal break or breaks and subsequently the accumulation of subretinal fluid in the subretinal area. This pathology, the separation of the neurosensory retina from the Retinal Pigment Epithelium (RPE), causes loss of Visual Acuity (VA) and needs surgical intervention [1].

The surgical treatment for RRD had been 360 degree scleral buckling until 1971. Then, Pars Plana Vitrectomy (PPV) has been used as another choice for the treatment of RRD. In some cases of RRD, PPV combined Silicon Band Cerclage (SBC) has been performed. SBC, Silicon Oil (SO) or sulfur hexafluoride/perfluoropropan (SF_6/C_3F_8) gas tamponade injection accompanied by laser photocoagulation are other modalities for RRD treatment that are used frequently [2-4].

Post-surgical visual outcomes could be affected by many parameters, including preoperative visual acuity, the status of the attached or detached macula, involvement of optic nerve, lens and cornea, age of the patient, duration and extension of detachment, degree of proliferative vitreoretinopathy and integrity of the macular structure.

OCTA is a novel non-invasive vascular imaging technique used to display retinal and choroidal vessels by detecting red blood cell movement. OCTA can detect superficial, deep and choroidal plexus and measure the FAZ area [5]. The purpose of the present study was to evaluate the alterations in vision, macular structural and vascular parameters in the post-vitreoretinal surgical period. This study aimed to evaluate the macular structure after Rhegmatogenous Retinal Detachment (RRD) surgery using Optical Coherence Tomography Angiography (OCTA).

Materials and Methods

This present study analyzed the results of 66 eyes of 33 patients, who had unilateral vitreoretinal surgery due to RRD. This study adhered to the tenets of the declaration of Helsinki and was approved by the local ethics committee.

Patients

The patients with anatomically successful surgical results were consecutively selected for enrollment in the study. The eyes that underwent RRD surgery were included in the study group (n=33) and fellow eyes were enrolled in the control group

(n=33). In addition, the study group was divided into subgroups 1, 2, 3 and 4 according to the type of surgery. Subgroup 1 included patients who underwent PPV+SBC+SO tamponade, subgroup 2 included patients who underwent PPV+SF_6/C_3F_8 tamponade, subgroup 3 included patients who underwent PPV +SO tamponade and subgroup 4 included patients who underwent SBC+SF_6/C_3F_8+laser photocoagulation.

All patients underwent a complete ophthalmic examination, including Best Corrected Visual Acuity (BCVA, in decimal); Intraocular Pressure (IOP, mmHg) measured with Goldmann applanation tonometry, slit lamp biomicroscopic and fundoscopic assessments. Structural and vascular images of the macula were obtained by using spectral domain OCTA (RTVue XR Avanti, Optovue, Fremont, CA, USA). Patients with any cardiovascular or other systemic conditions, high refractive error (spherical equivalent more than ± 6 dioptres), keratopathy, re-detached retina, axial length ≥ 26 mm, glaucoma, uveitis, traumatic maculopathy or traumatic retinal detachment, diabetic retinopathy, retinal vein occlusion, previous neovascularization membranes, severe senile macular degeneration, proliferative vitreoretinopathy, macular hole, presence of SO at last visit and poor OCTA scan quality (<7/10) were excluded.

Standard three port 23 gauge PPV was performed using the Alcon constellation system (Alcon laboratories, Inc., Fort Worth, TX, USA) under retrobulbar or general anesthesia. During PPV, triamcinolone acetonide was used to visualize the remnants of the vitreous. The SBC surgery was performed under general anesthesia: Firstly 360 degrees conjunctival peritomy was performed then SBC was implanted and sutured with a 5/0 non-absorbable suture and the silicon band were tightened following subretinal fluid drainage. Laser application was performed at postoperative 1-3 days following SBC surgery+gas injection.

OCTA measurement

OCTA centered in the macular area was performed in both eyes after pupillary dilatation in the last visit of the postoperative period. A fovea centered scan of 3 mm × 3 mm OCTA was performed for each eye. OCTA scans included Central Macular Thickness (CMT, um), superficial (fovea, parafovea, superior and inferior hemifield) VD (%), deep (fovea, parafovea superior and inferior hemifield) VD, choriocapillaris VD and Foveal Avascular Zone area (FAZ, mm^2) and FAZ Perimeter (PERIM, mm) measurements. VD measurements were analyzed with Optovue's angioanalytics software program. Each image was evaluated by two different masked authors.

Statistics

Statistical analysis was performed using SPSS V.27.0 software for Windows. Demographic and clinical characteristics were summarized by standard descriptive statistics e.g. Mean ± Standard Deviation (SD). Independent student's t-test and one way Analysis of Variance (ANOVA) tests were used in case of normal distribution, otherwise non-parametric Kruskal-Wallis test was used to compare variables between the groups and subgroups. A p-value of <0.05 was considered statistically significant.

Results

A total of 66 eyes of 33 patients who underwent unilateral vitreoretinal surgery due to RRD were evaluated in two main (study and control) groups and four subgroups of the study group. The results of the last visit were evaluated. Demographic characteristics and follow-up durations were represented in Table 1.

Table 1. *Demographics of the patients.*

Feature	Mean ± SD	P*
Mean age (years)	58.4 ± 10.31	-
Male	59.2 ± 9.30	-
Female	57.6 ± 10.11	-
Subgroup 1-4	57.9 ± 10.00/58.50 ± 10.21/57.30 ± 9.40/58.7 ± 10.41	0.448
Male/female (numbers)	19/14	-
Follow-up duration (months)	25.8 ± 12.41 (24-30)	-
Subgroups 1-4 (24-30)	25.3 ± 12.21/24.9 ± 11.60/25.5 ± 12.01/26.1 ± 12.70	0.305
Note: SD: Standard Deviation, *p<0.05 was considered statistically significant.		

The mean BCVA in the study group was lower than in the control group (p<0.001). The mean postoperative IOP and CMT values in the study and control groups were similar (p=0.791 and p=0.468), respectively.

All mean superficial VD measurements including superficial fovea, superficial parafovea, superficial superior hemifield and superficial inferior hemifield (p<0.001 for all) were lower in the study group when compared to the control group. Whereas, all mean deep VD measurements were similar in the study and control groups (p>0.05 for all). Mean VD measurements of choriocapillaris in the study and control groups were also similar (p=0.402). Meanwhile, the mean FAZ area and PERIM measurements were similar in both groups (p=0.590 and 0.234, respectively) (Table 2).

Table 2. *Comparison of mean OCTA parameters between the study and control groups.*

Parameter	Study group (n=33) Mean ± SD	Control group (n=33) Mean ± SD	p*
BCVA (in decimal)	0.54 ± 0.111	0.88 ± 0.212	<0.001
IOP (mmHg)	16.7 ± 6.20	15.9 ± 7.10	0.791
CMT (um)	273.4 ± 60.21	264.8 ± 38.32	0.468
Superficial foveal VD (%)	17.7 ± 8.11	23.6 ± 7.62	<0.001
Superficial parafoveal VD	40.2 ± 5.60	47.8 ± 6.31	<0.001
Superficial superior hemifield VD	38.5 ± 6.42	46.6 ± 5.31	<0.001
Superficial inferior hemifield VD	37.2 ± 9.01	45.8 ± 5.80	<0.001
Deep foveal VD (%)	33.3 ± 9.80	35.0 ± 8.31	0.124
Deep parafoveal VD	50.3 ± 7.40	52.5 ± 6.60	0.192
Deep superior hemifield VD	48.0 ± 6.41	49.7 ± 7.11	0.258
Deep inferior hemifield VD	47.1 ± 6.60	48.8 ± 6.91	0.305
Choriocapillaris VD	2.1 ± 0.10	2.2 ± 0.11	0.402
FAZ area (mm^2)	0.29 ± 0.11	0.26 ± 0.10	0.59
PERIM (mm)	2.2 ± 0.71	2.1 ± 0.40	0.234

Note: OCTA: Optical Coherence Tomography/Angiography; BCVA: Best Corrected Visual Acuity; IOP: Intraocular Pressure; CMT: Central Macular Thickness; VD: Vessel Density; FAZ: Foveal Avascular Zone; PERIM: FAZ Perimeter; *p<0.05 was considered statistically significant (independent t test)

Mean BCVA was better in group 4 (SBC+SF_6/C_3F_8+laser) than in the other subgroups (p=0.038). Mean IOP values were similar in all subgroups 1-4 (p=0.242). The mean CMT value was lower in subgroup 1 (PPV+SBC+SO) than in the other subgroups (p=0.028) (Table 3).

Table 3. *Comparison of mean OCTA parameters between the subgroups.*

Parameters	Subgroup 1 (n=10)	Subgroup 2 (n=6)	Subgroup 3 (n=10)	Subgroup 4 (n=10)	p*
BCVA (in decimal)	0.30 ± 0.11	0.35 ± 0.10	0.31 ± 0.11	0.44 ± 0.10	0.038
IOP (mmHg)	17.4 ± 6.11	15.8 ± 5.20	17.7 ± 6.31	14.7 ± 5.50	0.242
CMT (um)	239 ± 46.10	277.4 ± 70.50	273.7 ± 60.50	275.6 ± 48.81	0.028
Superficial foveal VD (%)	16.2 ± 6.61	16.1 ± 6.70	18.5 ± 7.01	23.2 ± 6.70	0.018
Superficial parafoveal VD	36.1 ± 8.51	37.2 ± 4.30	38.2 ± 7.50	42.8 ± 6.30	0.033
Superficial superior hemifield VD	40.2 ± 7.81	38.4 ± 3.70	40.1 ± 6.30	40.7 ± 6.11	0.253
Superficial inferior hemifield VD	36.0 ± 4.51	37.2 ± 3.91	37.1 ± 5.70	41.6 ± 6.50	0.040
Deep foveal VD (%)	27.0 ± 8.90	33.6 ± 10.31	33.2 ± 7.41	35.37 ± 8.20	0.016
Deep parafovealVD	48.3 ± 8.20	50.0 ± 5.21	47.6 ± 7.31	50.3 ± 8.20	0.429
Deep superior hemifield VD	47.0 ± 6.50	46.7 ± 8.10	45.8 ±7.90	47.9 ± 6.11	0.488
Deep inferior hemifield VD	46.5 ± 6.10	45.8 ± 7.21	46.3 ± 7.41	47.3 ± 6.30	0.303
Choriocapillaris	2.0 ± 0.10	1.8 ± 0.11	1.8 ± 0.20	1.9 ± 0.30	0.246

FAZ area (mm^2)	0.31 ± 0.10	0.30 ± 0.10	0.28 ± 0.10	0.32 ± 0.10	0.232
PERIM (mm)	2.4 ± 0.80	2.2 ± 0.40	2.0 ± 0.70	2.3 ± 0.70	0.502

Note: OCTA: Optical Coherence Tomography/Angiography; BCVA: Best Corrected Visual Acuity; IOP: Intraocular Pressure; CMT: Central Macular Thickness; VD: Vessel Density; FAZ: Foveal Avascular Zone; PERIM: FAZ Perimeter; *p<0.05 was considered statistically significant (Kruskal-Wallis).

Mean superficial VD measurements in the superficial fovea (p=0.018), superficial parafovea (p=0.033) and superficial inferior hemifield (p=0.040) were higher in subgroup 4. However, superficial superior hemifield VD measurements were similar in all subgroups (p=0.253). Mean deep foveal VD measurement was lower (p=0.016) in subgroup 1 than in the other subgroups. Mean deep parafoveal, deep superior hemifield and deep inferior hemifield VD measurements were similar in all subgroups (p=0.429, p=0.488 and p=0303, respectively). Mean VD measurements of choriocapillaris in all subgroups were also similar (p=0.246). Meanwhile, the mean FAZ area and PERIM measurements were similar in all subgroups (p=0.232 and 0.502, respectively).

Discussion

In this study, we compared the eyes that had RRD surgery with fellow eyes in terms of BCVA, CMT, IOP, VD, FAZ area and PERIM measurements using OCTA. To the best of our knowledge, limited studies have been reported in the literature about examining the macular micro circulation with OCTA after RRD surgery. Our study may be unique in the literature regarding subgroup analysis and a good follow-up time.

In our study, as expected, the mean BCVA was poor in the study group than in the control group. Mean BCVA was better in subgroup 4 (SBC+SF_6/C_3F_8+laser subgroup) than in the other subgroups. The mean CMT of the study group was similar to the fellow eyes, but subgroup 1 (PPV+SBC+SO subgroup) had a lower mean CMT than the other subgroups. A significant reduction of VD in all superficial segments was observed in the study group, but all deep VD measurements were similar. Almost all superficial segments and only deep VD measurements were higher in subgroup 4 than in the other subgroups. Mean FAZ area and PERIM measurements were similar in the study and control groups as well as in the subgroups.

Consistent with our results, short term results of a study revealed significantly lower blood flow in both Superficial Capillary Plexus (SCP) and Deep Capillary Plexus (DCP) of the eyes with vitrectomy and scleral buckling than in the fellow eyes [6]. Another study reported lower VD values in both SCP and DCP of the patients who underwent PPV+SO tamponade compared to the fellow eyes [7]. The same study found that FAZ was larger in the study group than the fellow eyes, which was in contrast to our results.

A study reported a reduction in peripapillary VD after RRD surgery in patients who underwent PPV+SO or air/gas tamponade, but no significant difference was observed in SCP, DCP and FAZ when compared to the controls in the postoperative 3rd month [8]. In contrast to our results, another study showed that patients who underwent PPV+SO tamponade or SBC surgery had no significant effect on macular VD and FAZ changes after RRD surgery within a 6 months follow-up [9]. Several studies concluded that mean VD in both SCP and DCP of the eyes that had PPV+SO tamponade and PPV+gas tamponade surgeries were lower than the fellow eyes and FAZ area measurements were larger than the controls [10-13]. Some studies found similar mean FAZ measurements between the eyes that had vitreoretinal surgery and fellow eyes, supporting our results [14,15]. Results of a study showed that SO tamponade had a more negative effect on the retinal vasculature when compared to gas tamponades, which was inconsistent with our results [16]. The results of this study showed a reduction of macular vascular density which was agreement with the results of another study.

Previous studies and our results showed that RRD surgery can result in some changes in the macular VD. We observed a decrease in all superficial segmental VD measurements of the study group. Our findings revealed that the SBC+SF_6/C_3F_8+laser technique seems to be associated with minimum changes in the macular VD. One of the most notable observations from our study was that mean CMT did not show statistically significant differences between the study and control groups. Despite the anatomical success, BCVA was poor in the study group. OCTA scans may be necessary to understand the cause of functional failure but not always enough. Our results suggest that OCTA methods may be extremely useful for an easy and non-invasive evaluation of the eyes of the patients who underwent RRD surgery. In our study, superficial VD of the macula was the most affected than deep and choriocapillaris, which may be due to being the first vascular layer of the retina. This study has limitations including retrospective design and relatively sample size, especially in the subgroups.

Conclusion

In conclusion, eyes that underwent RRD surgery had lower values in superficial VD measurements than the control eyes. Patients in the SBC+gas+laser subgroup had better results than the other subgroups. Visual functions were not similar in the groups despite the similar mean CMT measurements. It may be postulated that visual function is more closely related to VD than CMT measurements.

Acknowledgments

There is no financial supporting for this study.

Conflict of Interest

All authors have no conflict of interest in this study.

Author's Contribution

All authors contributed to the collection and interpretation of the data.

Ethics Approval

Local ethics committee approval was obtained for the study.

References

1. Mitry D, Charteris DG, Fleck BW, et al. The epidemiology of rhegmatogenous retinal detachment: Geographical variation and clinical associations. Br J Ophthalmol. 2009;94(6):678-84.
2. Machemer R, Buettner H, Norton EW, et al. Vitrectomy: A pars plana approach. Trans Am Acad Ophthalmol Otolaryngol. 1971;75(4):813-20.
3. Schepens CL, Okamura ID, Brockhurst RJ. The scleral buckling procedures. I. surgical techniques and management. AMA Arch Ophthalmol. 1957;58(6):797-811.
4. Jia Y, Tan O, Tokayer J, et al. Split spectrum amplitude decorrelation angiography with optical coherence tomography. Opt Express. 2012;20(4):4710-25.
5. Tsen CL, Sheu SJ, Chen SC, et al. Imaging analysis with optical coherence tomography angiography after primary repair of macula off rhegmatogenous retinal detachment. Graefes Arch Clin Exp Ophthalmol 2019;257(9):1847-55.
6. Lee JH, Park YG. Microvascular changes on optical coherence tomography angiography after rhegmatogenous retinal detachment vitrectomy with silicone tamponade. PLoS One. 2021;16(3):e0248433.
7. Lu B, Zhang P, Liu H, et al. Peripapillary vessel density in eyes with rhegmatogenous retinal detachment after pars plana vitrectomy. J Ophthalmol. 2021;2021:6621820.
8. Xiang W, Wei Y, Chi W, et al. Effect of silicone oil on macular capillary vessel density and thickness. Exp Ther Med. 2020;19(1):729-34.
9. Lee JH, Park YG. Microvascular changes on optical coherence tomography angiography after rhegmatogenous retinal detachment vitrectomy with silicone tamponade. PLoS One. 2021;16(3):e0248433.
10. Christou EE, Kalogeropoulos C, Georgalas I, et al. Assessment of anatomical and functional macular changes with optical coherence tomography angiography after macula-off rhegmatogenous retinal detachment repair. Semin Ophthalmol. 2021;36(3):119-27.
11. Wang H, Xu X, Sun X, et al. Macular perfusion changes assessed with optical coherence tomography angiography after vitrectomy for rhegmatogenous retinal detachment. Graefes Arch Clin Exp Ophthalmol. 2019;257(4):733-40.
12. Bonfiglio V, Ortisi E, Scollo D, et al. Vascular changes after vitrectomy for rhegmatogenous retinal detachment: Optical coherence tomography angiography study. Acta Ophthalmol. 2020;98(5):e563-9.
13. Hong EH, Cho H, Kim DR, et al. Changes in retinal vessel and retinal layer thickness after vitrectomy in retinal detachment via swept source OCT angiography. Invest Ophthalmol. 2020;61(2):35.
14. Maqsood S, Elalfy M, Hannon AA, et al. Functional and structural outcomes at the foveal avascular zone with optical coherence tomography following macula off retinal detachment repair. Clin Ophthalmol. 2020;14:3261-70.
15. Zhou Y, Zhang S, Zhou H, et al. Comparison of fundus changes following silicone oil and sterilized air tamponade for macular on retinal detachment patients. BMC Ophthalmol. 2020;20(1):249.
16. Matteo G. Long term macular vascular changes after primary rhegmatogenous retinal detachment surgery resolved with different tamponade or different surgical techniques. Life. 2022;12(10):1525.

*Correspondence to

Cetin Akpolat

Department of Ophthalmology,

University of Health Science,

Istanbul,

Turkey

E-mail: *drmehmetfe@hotmail.com*