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ORIGINAL PAPER

Subfoveal choroidal thickness change following pars plana vitrectomy with silicone oil endotamponade for rhegmatogenous retinal detachment

Enver Mirza · Günhal Şatırtav · Refik Oltulu · Hürkan Kerimoğlu · Mehmet Kemal Gündüz

Abstract

Purpose To report changes in subfoveal choroidal thickness (SFCT) using spectral-domain optical coherence tomography following pars plana vitrectomy (PPV) with silicone oil (SiO) endotamponade injection and subsequent removal.

Methods In this prospective study, 24 eyes of 24 patients with macula-off rhegmatogenous retinal detachment (RD) were included. These patients underwent PPV with SiO injection removal. SFCT measurements were taken 2 weeks and 3 months after PPV and SiO injection and 1 month after SiO removal. The contralateral eyes served as controls.

Results Mean SFCT values of the operated eyes were 294.1 ± 70.5 μm and 282.9 ± 80.6 μm 2 weeks and 3 months after PPV and 264.2 ± 63.3 μm 1 month after SiO removal. There was no significant change in SFCT between first and second measurements ($p = 0.96$). SFCT decrease was statistically significant when first and last measurements were compared ($p = 0.03$). SFCT percent change was correlated with duration of SiO in the eye and was not correlated with amount of endolaser photocoagulation performed during surgery. SFCT values of the fellow eyes were 317.1 ± 84.8 μm, 313.7 ± 79.8 μm and 306.1 ± 69.1 μm, at 2 weeks and 3 months after PPV and 1 month after SiO removal, respectively. There was no significant difference between the measurements of the control eyes taken at different time intervals ($p = 0.430, p = 0.085$, respectively).

Conclusion SFCT seems to decrease after the removal of the SiO which indicates that choroidal parameters should be taken into account during or after surgery for rhegmatogenous RD.

Introduction

Silicone oil (SiO) is a widely used intravitreal tamponade in the repair of retinal detachment (RD) where long-term tamponade is needed. Although its use resulted in promising anatomical and functional results, visual loss without any apparent explanation has been reported in several case series [1–5]. The etiology of this complication has been attributed to several factors in different studies, such as lesions of ganglion cells and horizontal-bipolar cell synaptic process in the outer plexiform layer causing generalized macular dysfunction [1–3], progressive thinning of inner retinal layers in the macular region [6, 7] and

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direct infiltration of optic nerve by SiO leading to optic nerve dysfunction [8]. To the best of our knowledge, the role of choroid related to this complication and the possible changes in its structure and thickness during or after the pars plana vitrectomy (PPV) and SiO injection and removal has not been studied to date.

The choroid has numerous functions in the eye including metabolic support to the retinal pigment epithelium (RPE) and the retina. The choroid contributes in blood supply to the prelaminar portion of the optic nerve, has melanocytes to absorb excess light penetrating the retina and RPE, and also acts as a heat dissipating mechanism of the macula [9–11]. It also plays an important role in the pathogenesis of many diseases of the posterior segment of the eye. Recent development of enhanced depth imaging (EDI) has made choroidal examination with spectral-domain optical coherence tomography (SD-OCT) possible. Short-term changes in human choroidal thickness have been reported, associated with the time of the day, smoking, coffee and caffeine intake [12–16]. In this study, we aimed to investigate any potential effect of PPV procedure and intraocular SiO endotamponade on subfoveal choroidal thickness (SFCT) in patients operated for macula-off rhegmatogenous RD.

Materials and methods

Twenty-four eyes of 24 patients who underwent PPV and SiO endotamponade injection and subsequent SiO removal for macula-off rhegmatogenous RD between January 2013 and March 2014 in our clinic were included in the study. Patients with a systemic disease or coexisting ocular pathology (central serous chorioretinopathy, age related macular degeneration, high myopia) or previous ocular surgery, and patients who developed RD before or during SiO removal were excluded from the study.

The preoperative and postoperative data included the medical history, measurement of the best corrected visual acuity (BCVA) using a Snellen chart, slit-lamp examination, intraocular pressure (IOP) measured by Goldman applanation tonometry, binocular fundoscopy, B-scan ultrasonography and fundus photographs.

The same vitreoretinal surgeon (HK) performed all surgeries using local subtenon anesthesia. All eyes were treated with 25-gauge PPV using a non-contact wide-angle viewing system (BIOM; Oculus GmbH, Wetzlar, Germany) and the ZEISS LUMERA 700 operating microscope (ZEISS GmbH, Oberkochen, Germany). The vitreous base was thoroughly shaved using 360° scleral depression. All retinal tears were treated with endolaser photocoagulation, which was performed under perfluorocarbon (PFC). A 360° endolaser treatment was performed. Retinotomy, retinectomy, and internal limiting membrane peeling were performed if necessary. The PFC liquid was aspirated completely with fluid–air exchange followed by injection of SiO under air. SiO with viscosity of 1000 centistokes (cSt) was used.

The criteria for SiO removal which was performed 3–6 months after the primary RD surgery included complete reattachment of the retina, absence of neovascular proliferations, at least 3 months duration of SiO in the eye, complications due to SiO such as IOP increase, decreased vision due to refractive changes and emulsification of SiO. SiO was removed through 25-gauge pars plana sclerotomy with active drainage followed by at least three fluid–air exchanges to remove as much residual SiO as possible.

SFCT measurements were taken with EDI, SD-OCT (Spectralis OCT, with software version 5.3: Heidelberg Engineering, Heidelberg, Germany) 2 weeks and 3 months after PPV and 1 month after SiO removal from both eyes of the patients. Choroidal thickness was defined as the distance from the outermost layer of the RPE to the inner scleral border and was measured manually using the caliper tools of the software. High-quality, 10.5-mm horizontal line scans through the fovea were obtained for each eye which were saved for analysis after 100 frames were averaged using the automatic averaging and eye tracking features of the device. The measurements were taken by two independent retinal specialists [HK (OBSERVER 1) and GS (OBSERVER 2)]. The observers were masked as to each other's measurements. Each session was performed at approximately 3 PM to avoid diurnal variations. Fellow healthy eyes served as controls.

The study adhered to the tenets of the Declaration of Helsinki and all federal laws. The ethics committee of our institution approved the study. All statistical analyses in our study were performed by SPSS 20.0 software, and for data editing or sketching some of the graphs MS Office Excel was used. The variables were investigated using analytical methods (Kolmogorov–

Smirnov and Shapiro–Wilk's tests) to determine whether or not they are normally distributed. Descriptive analyses were presented using mean ± standard deviation (SD) for normally distributed variables. Independent samples t test or Mann–Whitney U test was used to compare the measurement variables between operated and control groups. Related sample t test or Wilcoxon test was used to compare the repeated measurements. Also for the repeated measures, ANOVA test was used to investigate the within- and between-group values. The difference between the 2nd week and 3rd month measures of SFCT was calculated, and then percent change in SFCT was obtained. The Pearson and Spearman's rho correlations of these rates and some numerical variables were tabulated. The level of agreement between the two observers has been calculated using the intraclass correlation coefficient, coefficient of repeatability and coefficient of variation. The value of $p < 0.05$ was considered statistically significant in analyses.

Results

A total of 24 eyes of 24 subjects (17 males, 7 females) were analyzed in this study. Five eyes were excluded because of poor OCT image quality ($n = 2$) and obscure chorioscleral interface ($n = 3$). The demographic data and visual acuity values before PPV, 3 months after PPV and 1 month after SiO removal are given in Table 1. Mean age of the patients was 60.4 ± 11.4 years (range 35–77 years). Visual acuity after SiO removal increased in 23 patients and decreased in 1 patient (Patient #1) when compared to preoperative values. The decrease in visual acuity in one patient was attributed to the development of cystoid macular edema following SiO removal.

Mean SFCT values of the operated eyes were 294.1 ± 70.5 μm 2 weeks after PPV, 282.9 ± 80.6 μm 3 months after PPV and 264.2 ± 63.3 μm 1 month after SiO removal as shown in Table 2. When the mean values of the first and second measurements were compared, the difference was not statistically significant ($p = 0.96$, ANOVA). The decrease in SFCT was statistically significant when first and last measurements were compared ($p = 0.03$, ANOVA). The corresponding mean SFCT values of the healthy fellow eyes were 317.1 ± 84.8 μm, 313.7 ± 79.8 μm and 306.1 ± 69.1 μm, respectively. The difference

between these values was statistically insignificant ($p = 0.43$, $p = 0.09$, $p = 0.21$, respectively). No significant difference was found when corresponding mean SFCT values of operated and healthy eyes were compared ($p = 0.62$, $p = 0.48$, $p = 0.14$, respectively, Independent samples t test), (Table 2). Second and third SFCT measurements of the controls did not differ significantly when compared to first measurement ($p = 0.430$, $p = 0.085$, respectively).

The coefficient of agreement between the two observers concerning all the measurements is high. The coefficient of variation is under 5%. The coefficient of repeatability values for all the measurements are within 95% of confidence interval in the Bland–Altman graphics. Also, the scatter values are placed in the confidence limits in the graphics.

The mean duration of SiO in the operated eyes was calculated as 104 ± 27.7 days (range 92–156 days). The mean number of endophotocoagulation shots in the operated eyes was 2372 ± 901 shots (range 1187–4284 shots). The percentage of difference of SFCT in the first and last measurements ($- 0.076 \pm 0.142$) was correlated with the duration of SiO in the eye (rho = 0.537, $p = 0.032$), but was not correlated with the amount of endophotocoagulation (rho = 0.308, $p = 0.306$).

Discussion

A number of case series have been reported where profound central visual loss has been found in eyes after uncomplicated vitrectomy with SiO tamponade for RD in eyes with good visual potential [1–5]. To the best of our knowledge, choroidal thickness has not been evaluated as in relation to PPV and SiO endotamponade injection and removal procedures. In the present study, we evaluated changes in the SFCT after PPV with SiO injection and after removal of the SiO.

Comparing the SFCT values obtained at different time periods, we have found that the mean SFCT does not change significantly between second week and third month measurements after PPV. This result may represent a true stability of the choroidal morphology throughout the presence of intraocular SiO. However, the number of patients may not be sufficient for the change to reach a statistical significance. The mean SFCT tends to show a decrease when the values

Table 1 Demographic data and visual acuity values of the patients

Patient number	Age	Gender	Pre-PPV VA (Snellen)	Post-PPV VA (Snellen)	Post-SiO removal VA (Snellen)
1	74	M	0.2	0.05	0.05
2	39	M	hm	hm	0.05
3	52	M	hm	0.01	0.05
4	66	M	hm	0.1	0.7
5	37	M	0.4	0.05	0.5
6	66	M	hm	0.05	0.15
7	66	F	hm	0.4	0.5
8	35	M	0.3	0.2	0.6
9	77	M	0.4	0.2	0.5
10	72	M	0.01	0.1	0.4
11	59	F	0.01	0.01	0.1
12	65	M	0.15	0.3	0.5
13	49	F	hm	0.1	0.1
14	61	F	p+	0.1	0.5
15	63	F	hm	0.2	0.7
16	62	F	hm	0.2	0.3
17	61	M	hm	0.3	0.1
18	50	M	hm	0.5	0.5
19	63	M	hm	0.2	0.5
20	69	F	hm	0.3	0.5
21	65	M	hm	0.2	0.7
22	58	F	50cmCF	0.2	0.4
23	72	M	50cmCF	0.3	0.5
24	69	M	hm	0.1	0.9

Pre-PPV VA, visual acuity before PPV; post-PPV VA, visual acuity 2 weeks after PPV; Post-SiO VA, visual acuity 1 month after SiO removal; HM, hand motions; P + , light perception

Table 2 Mean SCFT of the operated and fellow eyes

	Operated eyes	Fellow eyes	p value*
SFCT 2 weeks after PPV	294.1 ± 70.5 μm	317.1 ± 84.8 μm	0.621
SFCT 3 months after PPV	282.9 ± 80.6 μm	313.7 ± 79.8 μm	0.476
SFCT 1 month after SiO removal	264.2 ± 63.3 μm	306.1 ± 69.1 μm	0.142

SFCT: Subfoveal choroidal thickness

*Independent samples t test

obtained before and after the SiO removal are compared ($p = 0.05$).

There is a statistically significant difference between the values obtained 2 weeks after PPV and 1 month after SiO removal ($p = 0.03$). This result may have been obtained due to several reasons. First of all,

the difference may be the result of a possible actual decrease in SFCT due to the presence of intraocular SiO, due to mechanical or pressure-related effects. However, the decrease could not have been documented between the first and second measurements due to an insufficient number of patients or the time

period. We have studied the SFCT 2 weeks and 3 months after PPV. Perhaps if this time interval were to be broader, the decrease in SFCT would have been more profound.

Secondly, the decrease may also be due to the effect of surgical procedure of SiO removal, instead of the effect of intraocular SiO. The effect of posterior segment surgical intervention on SFCT has not been studied in detail. The choroidal thickness has been shown to fluctuate after scleral buckling surgery by several studies. In a study by Kimura et al., the subfoveal choroidal thickness changed temporarily following segmental scleral buckling surgery [17]. Similar results are obtained in another study involving 11 patients who had been operated with scleral buckle by Miura et al. [18]. This was attributed to reversible subclinical microcirculatory dysfunction of the choroid in both studies. Moreover, inflammation and transient IOP decrease during the surgery is said to contribute to changes in SFCT. Nevertheless, the effect of intraocular surgery on choroidal morphology seeks further research.

It is reported that reproducibility of results for OCT measurement of retinal nerve fiber thickness is different in healthy eyes and SiO-filled eyes and that thickness measurement is not reliable in SiO-filled eyes [19]. In contrary, it has also been reported that the presence of SiO in the vitreus chamber does not change the reproducibility of OCT measurements of foveal thickness [20]. Whether the presence of intraocular SiO may have an effect on the measurement of choroidal thickness with SD-OCT is not known, resulting in misinterpretation of the images which ought to be further studied.

This study had several limitations, including a small sample size, short-term follow-up. Moreover, reproducibility of the choroidal thickness measurement in SiO-filled eyes using OCT is debatable. To partly overcome this limitation, we used two independent observers and, after evaluating inter-observer repeatability, took the average of the measurements. One other limitation of this study is the lack of preoperative data. These data could give us information on the effect of RD itself on changes in choroidal thickness in the foveal area. However, it is difficult to perform good-quality EDI-OCT in eyes where the macula was detached before the surgery. A control group with rhegmatogenous RD treated with PPV and an endotamponade other than SiO may have given valuable information in comprehending the results of this study.

In conclusion, intraocular SiO does not seem to affect the SFCT when SFCT is measured at 2 weeks and 3 months after PPV. SFCT decreases after the removal of the SiO which may be the result of the surgical procedure itself or preoperative misinterpretation of the measurement due to the presence of SiO in the ocular media. It might be prudent and necessary to integrate choroidal thickness measurements in management of patients with RD operated with PPV, SiO injection and removal. Further studies are needed to evaluate the accuracy and reliability of choroidal thickness measurements in the presence of intraocular SiO.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards." The study was approved by the Medical, Surgical and Drug Investigations Ethical Committee of Necmettin Erbakan University Meram Faculty of Medicine. The study adhered to the tenets of the Declaration of Helsinki.

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