

## Research Article

# SD OCT Features of Macula and Silicon Oil–Retinal Interface in Eyes Status Post Vitrectomy for RRD

Manish Nagpal<sup>1</sup>, Navneet Mehrotra<sup>2</sup>, Rituraj Videkar<sup>3</sup>, and Rajen Mehta<sup>3</sup>

<sup>1</sup>MS, DO, FRCS, Retina Foundation, Near Shahibaug underbridge, Ahmedabad, Gujarat – 380004, India

<sup>2</sup>DNB, Retina Foundation, Near Shahibaug underbridge, Ahmedabad, Gujarat – 380004, India

<sup>3</sup>MS, Retina Foundation, Near Shahibaug underbridge, Ahmedabad, Gujarat – 380004, India

Corresponding Author: Navneet Mehrotra; email: navneetmeh@yahoo.com

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**Abstract.** *Aim:* To objectively document findings at the Silicon oil-Retinal interface, macular status and tamponade effect in Silicon Oil (SO) filled eyes using SD OCT. *Methods:* 104 eyes of 104 patients underwent SD OCT examination, horizontal and vertical macular scans, in silicone oil filled eyes which underwent silicone oil injection post vitrectomy for rhegmatogenous retinal detachment. Findings were divided into 3 Groups; Group A: Findings at silicon oil retinal interface, Group B: Macular pathology and Group C: Tamponade effect. Group C was further divided into two groups; Group 1: Complete tamponade and Group 2 : Incomplete tamponade. *Results:* Group A: subsilicon epiretinal membranes  $N = 17$  (16.3%), emulsified silicon oil  $N = 16$  (15.4%) Group B: foveal thickening  $N = 22$  (21.2%), foveal thinning  $N = 6$  (5.7%), subfoveal fluid  $N = 8$  (7.6%), macular hole  $N = 2$  (1.9%); Group C: Incomplete tamponade was noted in  $N = 12$  (11.5%), complete tamponade  $N = 92$  (88.5%). 10 out of 104 eyes (9.6%) had recurrent retinal detachment post silicon oil removal. 8 of these eyes had complete tamponade and 2 had incomplete tamponade. *Conclusion:* SD OCT is a useful tool to assess the SO–Retina interface, tamponade effect and macular pathology in SO filled eyes. There is lesser incidence of redetachment with incomplete tamponade in OCT.

**Keywords:** silicon oil; spectral domain OCT (SD OCT); tamponade; silicon oil interface; vitrectomy

## 1. Introduction

Silicone oil is an important postoperative tamponading tool used during vitreoretinal surgery, the most common indications being retinal detachment with proliferative vitreoretinopathy and complex retinal detachments [1–5].

Since silicone oil can lead to long term complications such as open-angle glaucoma secondary to accumulation of silicone oil in macrophages, progressive cataract, and corneal endothelial decompensation. it should be removed when it

is no longer required for the attachment of the retina [6–19].

The use of silicone oil is accompanied by an inflammatory reaction, primarily mediated by blood borne macrophages. This response can be observed within 1 month of silicone oil injection and continues even after silicone oil removal. Secondary effects of intraocular silicone oil could manifest in the form of epiretinal membranes, subsilicon membranes, macular hole etc. which could play a role in defining the visual outcome in such patients [20–23].

Table 1

S. no.	Findings at silicon oil interface	Number	Percentage
1	Subsilicon epiretinal membranes	17	16.3%
2	Emulsified silicon oil	16	15.4%

Table 2

S.no	Macular pathology	Number	Percentage
1	Macular edema	22	21.15%
2	Subfoveal fluid	8	7.6%
3	Foveal thinning	6	5.7%
4	Lamellar Macular hole	2	1.9%

Silicone oil acts as an internal tamponade by approximation of the neurosensory retina to the retinal pigment epithelium. Due to its higher surface tension, silicone oil does not enter the subretinal space; in fact it prevents the entry of fluid into the subretinal space [24]. It is due to the property of surface tension that the silicone oil globule maintains its singular nature. However, with decrease in the surface tension of the oil globule with time, silicone oil begins to emulsify. In this state of emulsification silicone oil does not serve the purpose of internal tamponade [25].

However there are limited ways to objectively note tamponade effect on the posterior pole. In B Scan the presence of silicone oil is an obstacle in the interpretation of findings and appropriate imaging, as it causes an apparent increase of the axial length of the eye, due to the lowered speed of sound in the medium [26, 27].

MRI and CTscan have been used to assess the retinal status and tamponade effect and can also differentiate silicon oil, gas and PFCL (perfluorocarbon liquid) [28–31]. But it is not practical to use these modalities in a routine clinical setting.

In this regard an OCT can be used to assess the silicon oil and its globule interface on the posterior pole in cases with clear media. The mechanism of operation of OCT is similar to ultrasound but overcomes the limitations of acoustic waves by replacing them with differing reflections of infrared light waves and is thus able to give good images even in the presence of silicon oil [31–35].

OCT is an excellent tool which depicts the macular status as well as vitreoretinal interface (VRI) even in silicon filled eye.

The vitreoretinal interface a complex composite structure, seat for various VRI-associated disorders such as posterior vitreous detachment, vitreomacular traction syndrome, idiopathic epiretinal membranes, lamellar holes, pseudoholes, and full thickness macular holes [36–38].

The increased axial resolution, the augmented signal/noise ratio, and the higher scan rate of new spectral domain-OCT (SD-OCT) compared to time domain OCT

Table 3

Tamponade	Number of patients	Percentage
INCOMPLETE	92	88.46%
COMPLETE	12	11.53%

Table 4

Re detachment	Number of patients
10 DAYS	1
15 DAYS	4
1 MONTH	5

have dramatically improved the ability to visualize the vitreomacular interface and posterior hyaloid membrane [36–38].

We have done a study to objectively assess the silicone oil retinal interface preoperatively before silicon oil removal and followed up these patients postoperatively for 3 months. The study aimed to objectively determine the findings on silicon oil interface, changes in macular morphology and tamponade effects of the silicon oil in vitrectomized eyes by SD-OCT.

## 2. Material and Methods

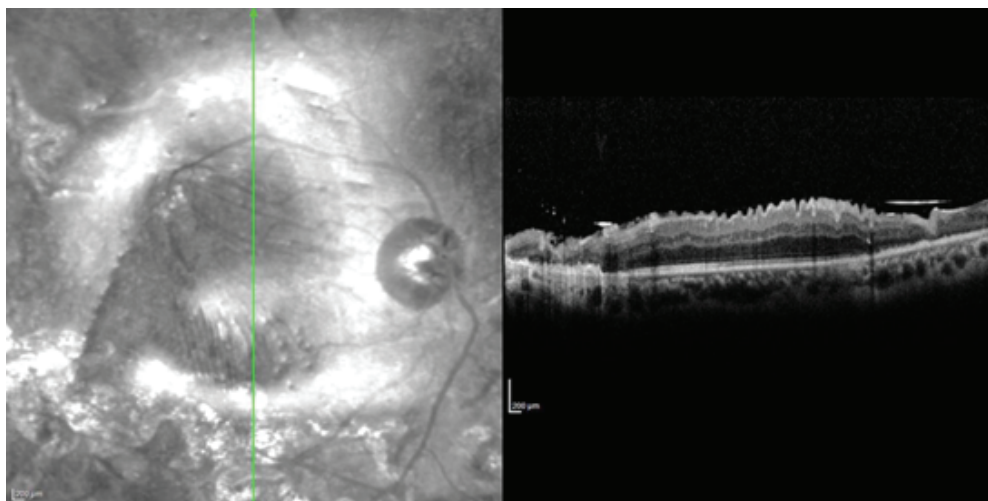
This was an observational case series of 104 eyes of 104 patients. Among 104 patients 87 were men and 17 were women, who underwent vitrectomy with silicon oil tamponade for rhegmatogenous retinal detachment (RRD). Spectral domain optical coherence tomography was done for all these patients.

The subjects with clear media enabling fundus visualization, undergone vitrectomy for rhegmatogenous retinal detachment and had received silicon oil tamponade and with settled retina on clinical examination were included. Patients with minimum 3 months of post silicon oil removal follow up were only included for the study.

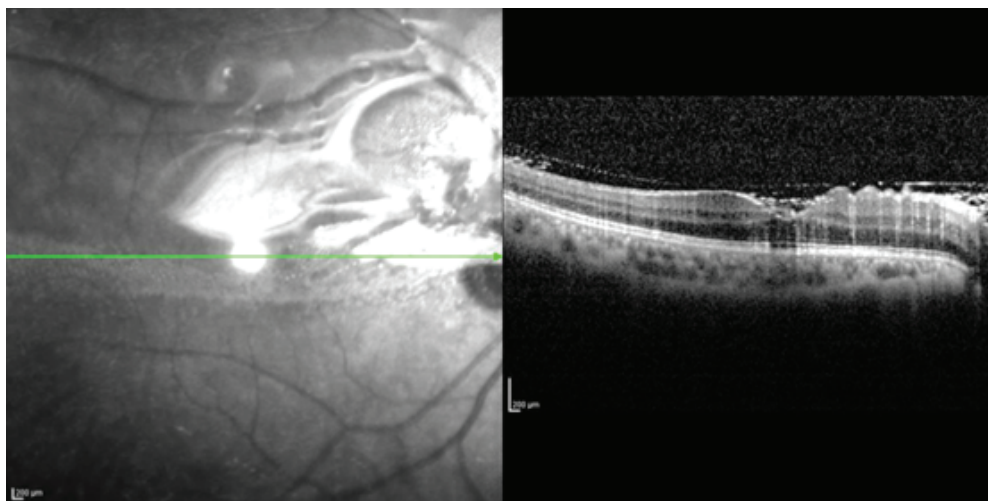
The subjects with corneal opacities or infiltration, any inflammation in anterior segment decreasing the signal strength of OCT, to the extent difficult to interpret, and patients with nystagmus where reliable OCT is not possible were excluded.

SD-OCT relies on a spectrometer and high-speed camera using the mathematical premise of Fourier transformation for analysis of the reflected light. These result in a significant increase in the amount of data acquired during each session while reducing motion artifacts with an increased signal-to-noise ratio when compared with time-domain OCT. Commercial available SD-OCT machines have a reported axial resolution of 5 to 7 microns.

SD-OCT examination was carried out with a Spectralis HRA+OCT device (Heidelberg Engineering, Heidelberg,



(a) Sub silicon oil membranes.



(b) Emulsified silicon oil.

**Figure 1:** Findings at silicon oil interface.

Table 5

Uniformity of tamponade in re-detachment patients ( <i>N</i> = 10)	Number of re-detachments
Complete tamponade	8
Incomplete tamponade	2

Germany) that was equipped with an eye-tracking system for the simultaneous acquisition of near-infrared reflectance ( $\lambda=815$  nm) and SD-OCT images. This simultaneous SD-OCT imaging was carried out with an illumination wavelength of 870 nm and an acquisition speed of 40 000 A-scans per second.

Horizontal, vertical lines as well as volume scans were performed in the morning before silicon oil removal by the physician. The patients were followed on first postoperative day, at the end of one month and 90 days postoperative visit.

For each eye, a standard protocol of SD-OCT imaging using a full block scan containing 19 B-scans ( $30^\circ \times 15^\circ$ ) distance between B-scans:  $240 \mu\text{m}$  was utilised.

The horizontal and vertical scans were standardized to 8mm length. The same areas were scanned through the software of the machine by taking progressive reference scan option at each visit so as to prevent any observer subjective bias. Tamponading effect of silicon oil could be assessed only in the macular region as it is difficult to pass the scan through the peripheral retina.

We labelled the eyes with complete tamponade in which on macular OCT, in both the horizontal and vertical scans, there was complete adherence of oil to retina along the complete course of OCT. Patients in which there was incomplete adherence of silicon oil to retina were labelled as incomplete tamponade.

The patients were evaluated and the findings were divided into three groups:

1. Group A: Findings at silicon oil - retinal interface
2. Group B: Macular pathology
3. Group C: Tamponade effect

In all patients silicon oil was identified and seen as bright hyper reflective surface.

### 3. Results

*3.1. Group A: Findings at silicon oil – retinal interface (Figure 1).* Sub silicon oil epiretinal membranes were noted in 17 patients (16.3%). Emulsified silicon oil globules were noted in fovea in sixteen patients (15.4%) (Table 1).

*3.2. Group B: Macular pathology (Figure 2).* Macular edema was noted in 22 patients (21.15%). Eight patients (7.6%) had subsensory fluid at the fovea. In 6 patients (5.7%) thinning at the fovea was noted on OCT. 2 patients (1.9%) developed lamellar macular hole. (Table 2)

*3.3. Group C: Uniformity of tamponade (Figure ??).* 92 patients (88.5%) had incomplete tamponade of silicon oil noted in OCT before silicon oil removal. Only 12 patients (11.5%) had complete tamponade on OCT (table 3).

10 patients (9.61%) had redetachment after silicon oil removal. 8 of these 10 patients had complete tamponade on OCT before silicone oil removal and 2 patients had incomplete tamponade (Table 4 and 5)

### 4. Discussion

It is clinically difficult to assess the silicone oil – retinal interface in silicone oil filled eyes. Ultrasonography used to assess silicone filled eyes has various limitations [26, 27]. The conduction velocity of ultrasound in silicone oil is drastically reduced (55–60% less than in the normal vitreous) producing distortion and linear magnification of the image. Imaging artifacts arise due to reflection from silicone oil interfaces and attenuation of sound waves due to the silicone oil<sup>26</sup>. It is not routinely used due to its complexity and difficult reproducibility.

Magnetic resonance imaging (MRI) has also been evaluated as a useful tool for detecting recurrent retinal detachment and evaluation of posterior segment of the eyes with silicone oil [28–31]. However, MRI as an imaging modality may not be in widespread use due to its high cost at all centres.

With SD OCT, the interface could be assessed with a better resolution and thus various findings such as fine deposits, pucker, tamponade effect etc are visualised better

which might help us to understand and objectively correlate functional visual status in vitrectomized eye with attached retina. Satchi et al. [33] and Hota K. [34] looked the interface with SD OCT in patients with macular hole.

This study shows the changes occurring at the silicon oil retinal interface and macular pathological changes occurring in the silicone oil filled eyes. A study by Wickham et al. [22] has shown that there is an intense inflammation at the interface leading to epiretinal membrane formation. This inflammatory response in silicon oil filled eyes is supposed to be mediated by bloodborne macrophages. It has been shown that macrophages often contained phagocytosed silicone oil and seemed to remain viable despite large volumes of silicone oil in the cell [18, 26]. The presence of multinucleated giant cells suggests a chronic granulomatous inflammatory response to intraocular silicone oil. Foveal deposits, we noticed, may also be due to this inflammatory reaction. Other macular pathologies like macular edema and lamellar macular hole may also be due to the inflammatory changes.

The formation of emulsified silicon oil globule is due to mechanical energy imparted by the saccadic movements and decrease in surface tension caused by inflammatory products and blood released during surgery. These emulsified silicone oil globules were also noticed at the interface during OCT.

After removal of silicon oil retina can undergo redetachment. Various redetachment rates were reported starting from 9% to 25% and even reaching 66% [19–22]. 10 out of 104 eyes (9.6%) had recurrent retinal detachment post silicon oil removal in our study. 8 of these eyes (66.67%) had complete tamponade and 2 (2.17%) had incomplete tamponade. It seems that if the retina is attached in the presence of emulsified oil i.e incomplete tamponade then it has a better chance of remaining attached when the emulsified oil is removed.

In one of our previous studies [41] also we have found that there is lesser incidence of recurrent retinal detachment following silicone oil removal (SOR) in presence of emulsified oil. In the same study we also observed that the duration of silicon oil tamponade did not correlate with the incidence of redetachment as has also been stated by some other studies [9, 12, 40].

There are no definite guidelines so as to make the decision of SOR in a way which will result in less incidence of redetachment. While the surgeons differ in approach on the decision for silicone oil removal, trying to understand the prognostic factor will help in counselling of the patient and increase the predictability of the retinal status post SOR. In the present study we tried to hypothesize that there is lesser incidence of redetachment if we find incomplete tamponade on OCT.

SD OCT is a useful tool to study the Silicon oil-Retinal interface, macular pathology and tamponade effect objectively and could help prognosticate functional outcomes

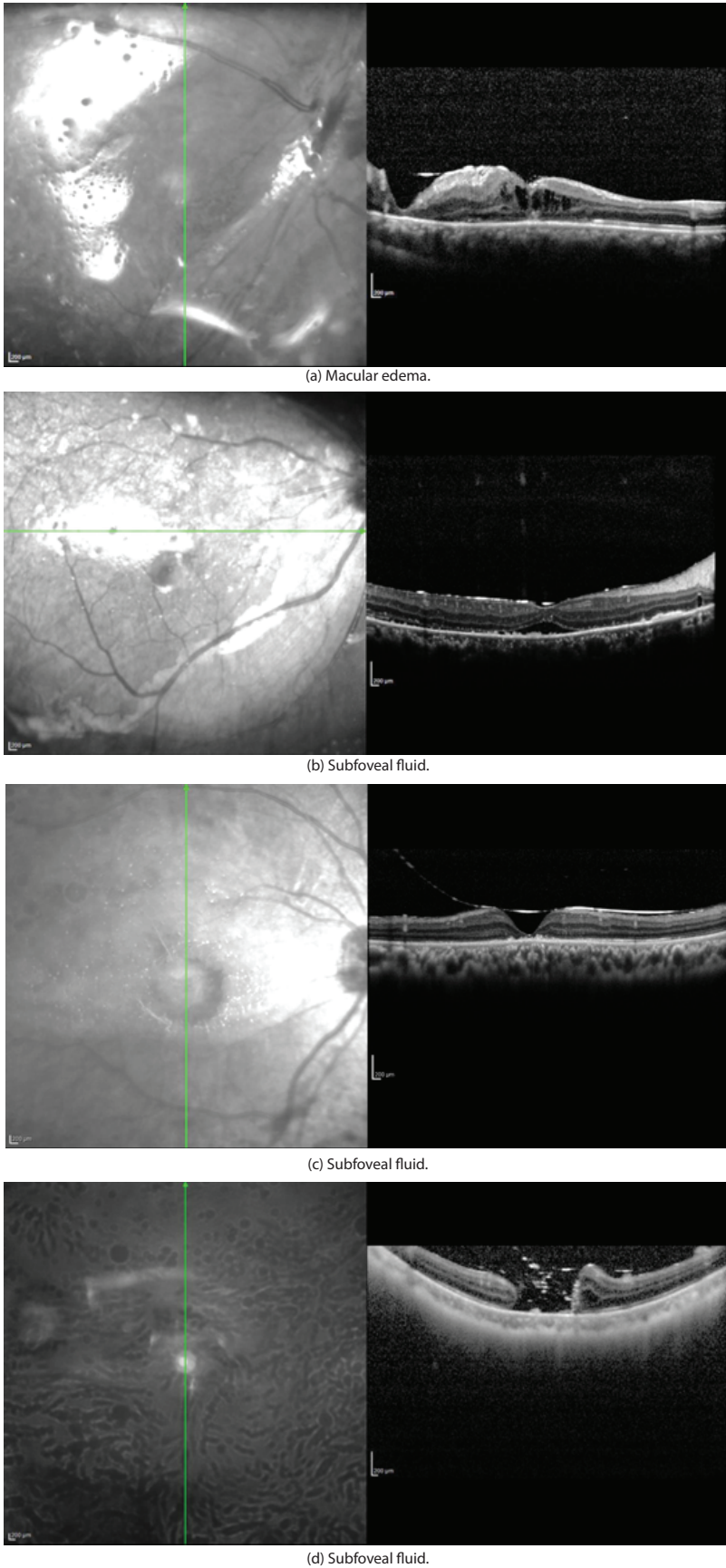
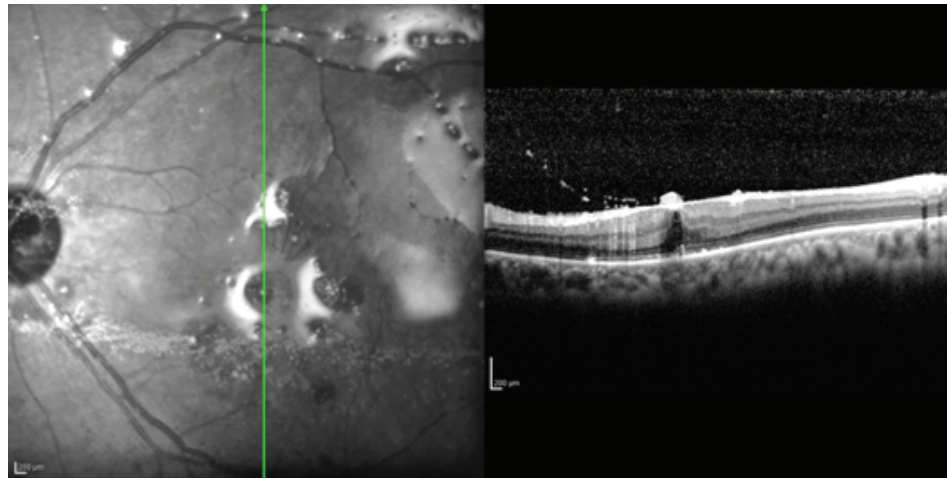
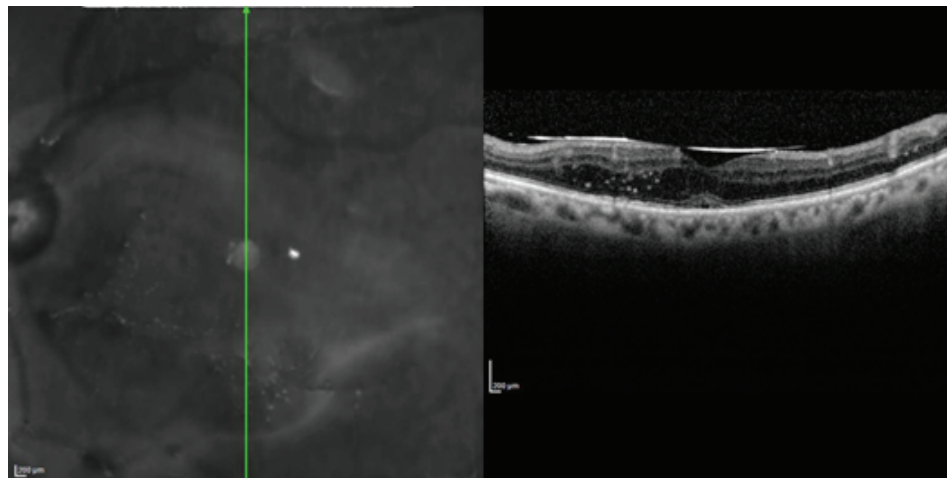


Figure 2: Macular pathology.



(a) Incomplete tamponade – Incomplete adherence of silicon oil to retina.



(b) Complete adherence – Complete adherence of silicon oil to retina.

**Figure 3:** Tamponade effect.

in silicon filled eyes and may help predict the risk of redetachments in certain situations.

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