RESEARCH PAPER

Rate of Different Macular Pathologies Detected by Macular Optical Coherence Tomography before Silicone Oil Removal in Cases of Rhegmatogenous Retinal Detachment

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ABSTRACT
Purpose: To evaluate macular changes by optical coherence tomography (OCT) following pars plana vitrectomy (PPV) with silicone oil (SO) tamponade in primary rhegmatogenous retinal detachment (RRD). Methods: This prospective interventional study included 50 eyes with recent RRD treated at Beni Suef University Hospital. All patients underwent complete ophthalmological examination, PPV with SO tamponade, and OCT (Optovue RTVue 100 XR Avanti) within two weeks and again at three months postoperatively to assess central macular thickness (CMT) and structural changes. Results: Mean CMT decreased significantly from 261.5 ± 22.1 µm at two weeks to 245.1 ± 40.2 µm at three months (P=0.001). OCT findings included focal photoreceptor loss (12%), intraretinal cysts (10%), atrophic maculopathy (12%), attenuated IS/OS junction (4%), epiretinal membrane (6%), cystoid macular edema (4%), and macular hole (4%). Conclusion: PPV with SO tamponade is a safe and effective option for primary RRD, while OCT provides valuable detection of postoperative complications. Larger multicenter studies are needed to confirm these findings.
Keywords: Macular evaluation, optical coherence tomography, pars plana vitrectomy, silicone oil tamponade, primary rhegmatogenous retinal detachment
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INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is a potentially sight-threatening eye condition. The occurrence of RRD may range from 6.3 to 17.9 per 100,000 individuals, with the highest frequency observed in patients aged between 60 and 69 years [1]. In the early 20th century, Gonin conducted research on the disease process of RRD and determined it to be the most common cause of retinal detachment.

The primary objective of retinal reattachment surgery is to close all retinal breaks using laser photocoagulation or cryotherapy, alleviate abnormal vitreoretinal traction, and reattach the neurosensory retina to the retinal pigment epithelium. This can be achieved through external methods, such as applying a scleral buckle (SB), or internally through pneumo-retinopexy or pars plana vitrectomy (PPV) and tamponade [2].

The term "tamponade" refers to the use of a tampon, which is a plug or tent inserted tightly into a wound or orifice to stop bleeding. In the context of retinal detachment surgery, tamponade agents are utilized to create surface tension across the retinal breaks, preventing further fluid flow into the subretinal space until permanent sealing is achieved through retinopexy, which can be done using either photocoagulation or cryopexy. Gases and silicone oils are the two main categories of tamponade agents commonly employed in these procedures [3].

Silicone oil, unlike intraocular gas, is a liquid polymer that lacks expansile properties and is not absorbed by the body. It does not mix with water or perfluorocarbon liquid and forms a visible meniscus during surgery. While silicone oil has higher viscosity compared to gas, its buoyancy and surface tension are lower, resulting in less retinal tamponade [4].

After vitrectomy, silicone oil is used to internally tamponade and stabilize the retina. However, prolonged exposure to silicone oil can lead to complications such as cataracts, glaucoma, and keratopathy. Therefore, it is recommended to remove the silicone oil as soon as the retinal condition becomes stable [5].

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While silicone oil has been established as an effective substitute for vitreous humor, its prolonged use can lead to various complications. These complications commonly include corneal decompensation, progressive formation of cataracts, and an increase in intraocular pressure or secondary glaucoma. Additionally, if the silicone oil emulsifies over time, it can result in a decrease in visual acuity. Due to these complications, silicone oil is typically removed after a period of retinal stability. However, the repositioning of a mobile detached retina during removal can sometimes lead to redetachment [6].

Optical coherence tomography (OCT) is a noninvasive technique that provides high-resolution images of the layers in the macula. In SiO-filled eyes with clear media, OCT can be used to examine the posterior segments. This is important because certain complications, such as epiretinal membrane (ERM), macular holes, macular edema, sensory detachment, and thinning of the retinal layers, may not be easily detected through clinical examination alone. These complications have the potential to impact visual outcomes and may require modifications to the surgical procedure during the removal of silicone oil (Rashad et al. 2016) [7].

This study aims to assess the alterations in the macula using optical coherence tomography (OCT) following pars plana vitrectomy with silicone oil injection for primary rhegmatogenous retinal detachment cases.

MATERIALS AND METHODS

Patients:
This is a prospective, interventional study that was held at Beni Suef University Hospital in Egypt from May 2022 to July 2024. The Beni Suef University Ethical Committee approved the study protocol, with approval number FMBSUREC/10042022/Omar. We recruited 50 subjects (50 eyes), who all met our eligibility criteria.

Inclusion criteria:
To be included in our study, the patients have met the following criteria: a male or a female between 20-70 years old, with recent primary rhegmatogenous retinal detachment. Phakic or pseudophakic eyes, with clear-enough media to document macular changes by OCT, were included in the study.

Exclusion criteria:
Subjects with the following criteria have been excluded from our study: old retinal detachment, traction retinal detachment, aphakic retinal detachment, recurrent retinal detachment, diabetic retinopathy, known glaucoma patient, history of intraocular surgery rather than an uncomplicated phaco-operation, silicone oil total emulsification or hemorrhage opacifying the view, or unsuccessful RD surgery.

Methods:

All patients were subjected to the following:

Preoperative phase:
Before the operation, we obtained a detailed history and thorough ophthalmic examination to ensure they followed our selection criteria.

History:
We documented the demographic characteristics of all patients enrolled in the study, including age, sex, place of residence, occupation, and the presence of systemic diseases. In addition, we recorded each patient's ocular history, such as previous eye diseases, ocular trauma, use of topical medications (e.g., anti-glaucoma agents), and any prior ocular surgical procedures.

Ophthalmic examination:
Ophthalmologists at Beni Suef University Hospital performed a thorough ophthalmic examination to all of the subjects in the study. This included the following:

Assessment of uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) using Landolt's bracken ring chart and converted into logarithm of minimum angle of resolution (Decimal). Measurements were taken at 2 weeks following silicone oil injection and repeated after 3 months.

Cycloplegic refraction by autorefractometer.

Slit lamp examination of the anterior segment to assess: cornea to detect any opacity, iris and lens to detect any rubeosis iridis or cataract.

Posterior segment examination by indirect ophthalmoscope and slit lamp biomicroscopy using a non-contact +90D lens.

IOP measurement by applanation tonometer preoperatively and postoperatively at the 2nd week and 3rd month.

Operative phase: Pars plana vitrectomy with silicone oil (s1000) tamponade.
Pars plana vitrectomy with silicone oil (s1000) tamponade was performed. The procedure began with three 23-gauge sclerotomies. An infusion line was inserted through the sclerotomy in the inferotemporal quadrant, while the remaining two sclerotomies, positioned at approximately the 10 and 2 o'clock meridians, were used for the light pipe and vitrector, respectively.

To complete the core vitrectomy and induce posterior vitreous detachment, we performed anterior vitrectomy, core vitrectomy, and injected triamcinolone. Perfluorocarbon (PFC) was injected to achieve retinal flattening, followed by sequential air–fluid exchange and silicone–air exchange.

Postoperative phase:
All participants received postoperative care in the form of positioning and antibiotics. Good positioning was critical to make a good seal against retinal breaks. Topical antibiotics (moxiflox 0.5), cycloplegics (cyclopentolate1%), and

topical corticosteroid (prednisolone acetate) were used in a standard fashion and tapered accordingly over 4-6 week.

Follow up phase (Ophthalmic examination and Optical coherence tomography):
We performed complete ocular examination, including indirect ophthalmoscopy and slit lamb examination a day, a week, 2 weeks, and three months postoperatively. Optical coherence tomography (OCT) was the most important follow-up tool in our study.

All patients were investigated by cross-sectional OCT (Optovue RTVue 100 XR Avanti scanner system) within 2 weeks after injection of silicone, and after 3 months to assess the thickness of the macula, detect any macular changes. Using SS-OCT, macular thickness using retinal thickness was evaluated. The type of macular oedema, presence of subretinal fluid (SRF), and interruption of the outer retinal layer were also assessed.

Using SS-OCT, the choroid was defined as the space between the outer border of the RPE/Bruch's membrane complex and the inner border of the sclera. Using SS-OCT, choroidal thickness was measured subfovea 1mm away from the fovea nasally, temporally, superiorly, and inferiorly. Those readings were measured manually using a caliper.

Ethical Considerations:
Study protocol was submitted for approval by Institutional Review Board (IRB), faculty of medicine, Beni Suef university. The research objectives were explained to the participants individually and in groups. The researcher was available throughout the study. Informed written consent was obtained from each participant sharing in the study. Confidentiality and personal privacy were respected in all levels of the study. The relatives were ensured that the participation was completely voluntarily, and withdrawal from the study had no effect on their evaluation process. Collected data were used for any other purpose.

Statistical analysis:
Statistical analysis was performed using SPSS software version 27 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the baseline characteristics of the patients, including means and standard deviations (SD) for continuous variables and frequencies and percentages for categorical variables. Continuous data were tested for normality using the Shapiro-Wilk test. The relationship between age and ocular signs was assessed using the independent samples t-test for normally distributed data. Statistical significance was set at a p-value of less than 0.05.

RESULTS

Demographic data
A total of 50 eyes of 50 patients were included in our study. The mean age of them was 50.9 ± 13.1 years with a range of 20 – 72 years. According to their gender, 34 patients (68%) were males and 16 patients (32%) were females (**Error! Reference source not found.**).

Clinical data

Baseline clinical data
Regarding the comorbidities, 13 patients (26%) were hypertensive; however, no diabetic cases were included. According to the side of the disease, the left side represents 60% of the cases, and the right side represents 40% of the cases. In terms of the lens state, 30 patients (60%) were pseudophakic and 20 cases (40%) were phakic. According to the macular state, 19 patients (38%) had macula-on RRD. However, 31 cases (62%) were macula-off RRD.

Ophthalmological examination
In terms of the best corrected visual acuity (BCVA), the mean BCVA was 0.4 ± 0.09 (LogMar) at two weeks after vitrectomy, which decreased to 0.6 ± 0.2 at three months postoperatively (p =0.001). In terms of the intraocular pressure (IOP), we didn't report any elevation postoperatively, with the mean IOP at two weeks and at three months being 17.7 ± 2.1 and 16.3 ± 2.3, respectively (P=0.1) (**Error! Reference source not found.**).

Optical Coherence Tomography (OCT)

OCT findings:
According to the OCT findings, 12% of the cases had focal loss of photoreceptor, 12% of the cases had Atrophic maculopathy, 10% of the cases had intraretinal cysts, 4% had attenuated IS/OS and RPE, 6% had epiretinal membrane, 4% had CME, and 4% had macular hole (**Error! Reference source not found.**).

Central macular thickness (CMT)
According to the central macular thickness (CMT), it was 261.5 ± 22.1 (µm) at two weeks postoperatively, which decreased to 245.1 ± 40.2 (µm) at three months postoperatively (P=0.001) (**Error! Reference source not found.**)

Cases presentation

Case number 1:
58-year-old male patient, not diabetic, phakic, and underwent right PPV and SO injection (1000 cs) for right RRD with detached macula. Right macular OCT was performed within two weeks and again after three months, showing nearly no change in foveal thinning, with the retinal layers remaining normal as illustrated in **Error! Reference source not found.**.

Case number 2:
53-year-old male patient, not diabetic, phakic, and underwent left PPV and SO injection (1000 cs) for left traumatic RRD with detached macula. Left macular OCT was performed within two weeks and again after three months, showing a macular hole as illustrated in **Error! Reference source not found.**.

Case number 3:
46-year-old male patient, pseudophakic and underwent left PPV and SO injection (1000 cs) for left RRD with detached macula. Left macular OCT was performed within

two weeks and again after three months, showing epimacular membrane formation as illustrated in **Error! Reference source not found.**

Case number 4:
61-year-old female patient, pseudophakic, underwent Rt PPV and SO injection (1000 cs) for right RRD with detached macula. Left macular OCT was performed within two weeks and again after three months, showing macular atrophy as illustrated in **Error! Reference source not found.**.

DISCUSSION
Rhegmatogenous retinal detachment (RRD) is caused mainly by the subretinal accumulation of the vitreous fluid through a retinal tear or hole. This will lead to a separation between the retinal pigmented epithelium and the neurosensory retina [8].

Over the past decade, the approach of using pars plana vitrectomy (PPV) in managing rhegmatogenous retinal detachment (RRD) has advanced considerably due to the introduction of smaller transconjunctival incisions and faster vitreous cutting rates [9]. Warren et al. reported that the primary anatomical success rates for RRD repair via pars plana vitrectomy (PPV) range from 64% to 96%, while final visual acuity (VA) outcomes demonstrate a broader degree of variability [10].

Silicone oil (SO) is commonly used as a tamponade in vitreoretinal surgery for complicated rhegmatogenous retinal detachment (RRD) in patients with proliferative vitreoretinopathy, giant retinal tears, and trauma. Nevertheless, SO tamponade has the potential for long-term complications, including cataract, glaucoma, band keratopathy, and optic neuropathy [11].

Our study aimed to evaluate the macula in 50 eyes with recent rhegmatogenous retinal detachment by OCT before and after pars plana vitrectomy with silicone oil injection. Most of our patients were males (68%), which is consistent with Rabina et al. (2020), Fabian et al. (2012), and Christou et al. (2022), who reported similar percentages of males and females [12, 13, 14]. Our results showed that the mean age was 50.9 ± 13.1 years, with a range of 20 – 72 years, which is supported by Antoun et al. (2016) and Rabina et al. (2020), who reported that the age at the time of intervention was 57.6 ± 10.5 and 56.1 ± 15.2 years, respectively [15, 12]. In contrast to our findings, Christou et al. (2022) reported a higher mean patient age of 62.6 years (SD ± 7.2) [14].

In terms of the baseline clinical data, 13 patients (26%) had Hypertension, and no cases of diabetes mellitus. The lens was phakic in 30 patients (60%), and pseudophakic in 20 patients (40%). 31 patients (62%) had macula off RRD, while 19 patients (38%) had macula on RRD. These findings were aligned with Antoun et al. (2016) who observed hypertension in 29% of cases, phakic lenses in 54.8%, pseudophakic in 40.3%, aphakic in 4.8%, and macula-on in 22.6% versus macula-off in 77.4%, whereas Horozoglu et al. (2022) reported phakic status in 40% and pseudophakic in 60%, in agreement with our results [15, 16].

The mean BCVA in our patients was 0.4 ± 0.09 (logMAR) at 2 weeks after vitrectomy, which was decreased to O.6 ± 0.2 at three months postoperatively (P=0.001). According to Antoun et al. (2016), BCVA improved markedly from a preoperative mean of 1.64 ± 0.81 logMAR to a postoperative mean of 0.45 ± 0.40 logMAR [15].

The CMT, two weeks after vitrectomy, ranged between 222 – 303 with a mean of 261.5 ± 22.1. This CMT was significantly decreased to 245.1 ± 40.2 at three months post vitrectomy (P=0.001). Our results were similar to Rabina et al. (2020), who declared that using silicone oil as a tamponade causes a temporary decrease in the CMT. However, the mechanism is unknown [12].

Christensen U, Sander B & Villumsen J (2007) who reported that Foveal retinal thickness at a mean of 2 years postoperatively was significantly increased in patients with preoperatively detached macula [17]. Additionally, retinal thickness in the fovea and postoperative visual acuity were positively correlated. They concluded that Successful surgery for macula-off retinal detachment is associated with significant thickening of the neurosensory retina when examined with optical coherence tomography 6 months postoperatively.

Amer et al. (2019) found that, at one month after vitrectomy, the CMT ranged from 177 to 850 microns with Mean± SD of 306.67±168.49 microns [18]. At three months after vitrectomy, CMT ranged from 154 to 708 microns with Mean± SD of 274.76±106.78 microns. While no statistically significant difference was detected from 1 month after vitrectomy to 3 months after vitrectomy (P=0.175).

Based on our OCT findings, 26 patients (52%) had normal scans, while others demonstrated various abnormalities: atrophic maculopathy in 6 patients (12%), attenuated IS/OS in 2 (4%), epiretinal membrane in 3 (6%), CME in 2 (4%), focal photoreceptor loss in 6 (12%), macular hole in 2 (4%), and intraretinal cysts in 5 (10%). These results are consistent with Christensen and La Cour (2012), who also reported postoperative OCT changes [19].

Also, Amer et al., (2019), found that, the OCT examination showed that, 35.2 % with normal OCT findings, 22.5% with attenuated IS/OS and RPE, 9.8% with atrophic maculopathy & diffuse thinning of retinal layers, 9.8% with cystoid macular edema, 4.2% with localized macular edema, 7.04% with diffuse (sponge like thickening) retinal edema, 7.04% with serous macular detachment, 7.04% with macular hole, 5.6% with corrugated retinal pigment epithelium, 4.2% with perfluorocarbon under retina, 9.8% with Intraretinal cysts, 2.8% with persistent subretinal fluid, and 2.85 with multiple pigmented epithelium detachment [18].

Najapal et al. (2012) found that the OCT findings showed ERMs in 16.3% of cases, macular edema was noted in 21.15% of cases, 7.6% of cases had subfoveal fluid, macular thinning at the fovea was noticed in 5.7% of eyes, and 9.61% of eyes had recurrent RD after silicon oil removal [20].

In our study, 50% of the patients had clinically normal macula. The clinical examination was confirmed by OCT, which revealed that 52% of the cases had a normal macula.

Rashad et al. (2016) reported that the macula was clinically normal in 22 eyes (43%) [7]. However, the OCT revealed that only 4 eyes showed normal macula. The OCT also showed macular edema in 5 eyes (22.72%), serous macular detachment in 3 eyes (13.63%), atrophic maculopathy in 3 eyes (13.63%), and fine ERM in 2 eyes.

Amer et al. (2019) stated that the macula was clinically normal in 22 eyes (30.99%) [18]. In contrast, the OCT examination of the clinically normal macula was normal in 7 eyes (9.86%), macular edema in 31.8%, macular detachment in 9.1%, atrophic maculopathy in 27.2%, fine ERM in 22.7%, and interrupted IS/OS and RPE choriocapillaries complex irregularity in 72%.

Lee et al. (2019) stated that cystoid macular edema (CME) following silicone tamponade may be attributed to the increased vascular permeability because of the inflammatory mediators at the silicone–retina interface [21]. Studies in the literature, however, show variable incidences of CME in eyes treated with silicone. Bae et al. (2012) finding CME in 19.6% of eyes that resolved after silicone removal [22], whereas Kiss et al. (2007) observed 17.1% during tamponade and 47% after removal [23]. Eibenberger et al. (2020) identified microcystic inner nuclear layer changes in 21% of eyes after silicone removal, while Bae et al. (2012) demonstrated that CME may resolve following removal, suggesting variable retinal responses to silicone tamponade[24, 22].

In our study, CME developed in 4% of eyes after silicone injection but resolved after removal, with prolonged tamponade (>6 months) appearing to increase inflammatory risk. Prior studies, like Shimoda et al., 2010 and Benson et al., 2006, suggest additional retinal damage from mechanical pressure, high intraocular pressure, or retinal dehydration [25,26].

It has also been reported in the literature that potassium released from Müller cells causes neuronal degeneration due to its inability to pass into the silicone, and for this reason, retinal thinning can be observed in the presence of silicone endotamponade [27].

These series are supported by our findings that CMT measured after silicone removal increased significantly in the longer duration groups but not in eyes with a silicone duration of less than 3 months. Another phenomenon seen after surgery in vitrectomized eyes that receive silicone is the accumulation of SFF. It is reported to occur at rates of 0-40% after vitrectomy surgery [25, 26].

Veckeneer et al. 2012 reported that eyes with prolonged detachment were at risk of developing more intense subfoveal fluid (SFF) [28]. However, in our study, no SFF was detected in SD-OCT measurements taken immediately after surgery, but developed later in 9.2% of the eyes. Therefore, we think that this SFF may be a reactive exudation to silicone or that silicone may have an effect on the pump function of the RPE, which spontaneously resolved in all cases after silicone removal.

In our study, Retinal reattachment was achieved in all cases, which is in agreement with Horozoglu et al. (2022), who reported that retinal reattachment was achieved in 18 eyes (90%) with a first operation [16]. Recurrent detachment with PVR occurred after silicon oil removal in 2 eyes, and retinal reattachment was achieved in these two eyes after the second operation.

Jonas et al. (2001) evaluated the frequency and risk factors of retinal redetachment following intraocular silicone oil removal [29]. In their cohort of 225 patients who underwent silicone removal at a mean interval of 10 months after pars plana vitrectomy, retinal attachment was maintained in 168 eyes (74.7%), whereas redetachment occurred in 57 eyes (25.3%). Among these, three eyes (two with proliferative vitreoretinopathy and one with proliferative diabetic retinopathy) required enucleation due to persistent detachment complicated by painful absolute secondary angle-closure glaucoma.

Pars plana vitrectomy with SO injection appears to be a safe and efficient surgical approach for treating primary rhegmatogenous retinal detachment. OCT is a very useful tool for detecting macular changes related to silicone oil tamponade. However, larger multicenter clinical trials are needed to consolidate and fully validate our results.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement:
Supporting data are not publicly available due to the sensitive nature of the study and because participants did not provide written consent for data sharing.

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