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Research Article

Post-operative Complications of Silicone Oil Removal

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Abstract

Purpose: To outline the features, results and associated complications following the removal of silicone oil from the eyes.

Methods: This is a retrospective study of eyes treated for silicone oil removal between 2017 and 2021. Visual acuity (VA), intraocular pressure (IOP) and rates of retinal re-detachment, hypotony, ocular hypertension, corneal complications, cystoid macular oedema (CMO) and cataract progression were evaluated. Several variables were analysed, including preoperative and postoperative visual acuity (VA) (at 1 month, 3 months and 6 months), preoperative and postoperative intraocular pressure (IOP) (at 1 month, 3 months and 6 months), and the prevalence of complications after silicone oil removal. The complications investigated were mainly retinal re-detachment, ocular hypotony, ocular hypertension, corneal complications, cystoid macular oedema (CMO), macular hole and cataract progression.

Results: Totally, 59 eyes of 59 patients (83% male, average age 42.9 years) were identified. Silicone oil tamponade had been used for retinal detachment (RD) surgery as a tamponade agent in all eyes, including two that had also had surgery for an open globe injury. Salt solution (BSS) or air were chosen as vitreous substitutes in the majority of eyes (85%) after removal of the oil. The average duration of SO tamponade was 16.1 months. The average logMAR VA before oil removal was 1.55. which improved to an average of 1 post-operatively. The average IOP pre-operatively was 18.9mmHg, which reduced by 4.6mmHg after surgery. Complications following SO removal were: retinal re-detachment (12%), CMO (8%), ocular hypertension (7%), hypotony (5%), cataract progression (5%), macular hole (5%), corneal complications (3%), and epiretinal membrane (3%).

Conclusion: Following SO removal, as shown in this study, VA has significantly improved overall and IOP has been reduced. In this study, the two most prominent complications encountered were Re-detachment and ocular hypertension.

Keywords: Silicone Oil; Silicone Oil Removal; Complications; Re-detachment; Visual Prognosis; Hypotony; Ocular Hypertension

Introduction

Silicone oil has been used in vitreoretinal surgery for many years, mainly for long-term tamponade in the management of eyes with complicated retinal detachment (RD) aggravated by proliferative vitreoretinopathy (PVR), proliferative diabetic retinopathy (PDR), and in traumatized eyes as well as in a wide variety of other indications [1]. The visual and anatomical prognosis with SO tamponade when used for complex RRD appears to be better than with SF6 [18]. Silicone oil retention in the eye is associated with numerous possible side effects including: glaucoma, cataract, corneal complications and retinal damage. [1,2]. In order to reduce the risk of complications, it is generally recommended to remove the silicone oil 3 to 6 months after insertion [2]. It is a well-established fact that after silicone oil

removal (SOR) there is a risk for recurrent RD. Yet another important aspect of using SO to consider is the additional surgical procedure required to remove the oil once the retina has healed.

The aim of this study is to assess the visual outcome and the incidence of complications post-SO removal in the eyes who have had silicone oil tamponade for RD surgery and to evaluate our results in comparison with the literature in recent years.

Methods

This is a retrospective study of a series of eyes that had SO removal between January 2017 and June 2021 in our department. Patients who had incomplete records were excluded from the study. Those cases who have a minimum six months of follow-up were exclusively included.

We recorded preoperatively and postoperatively visual acuity (VA), slit lamp examination and fundus findings, intraocular pressure (IOP) measured by Goldman applanation tonometry or non-contact tonometer and optical coherence tomography (OCT) findings. An analysis of the original DR repair surgery were documented including the type of SO employed, the procedures undertaken and the surgical particularities of the SO removal. We used the Snellen chart for measuring VA and transformed it into the logarithm of the minimum angle of resolution (logMAR) for statistical purposes. We also followed the incidence of retinal detachment, cystoid macular edema (CME), hypotony, ocular hypertension, corneal complications, macular hole, epiretinal membrane (ERM), and cataract evolution at 1-month, 3-month, and 6-month intervals after surgery.

Two vitreoretinal surgeons at the University Hospital of Fez, Morocco, conducted the surgical interventions. We used the term hypotony to define an IOP <6 mmHg taken on at least 2 examinations. Elevated IOP was defined as high mean post-operative IOP>24mmHg. All scleral buckling procedures were performed prior to re-detachment vitrectomies, and only one eye had scleral buckling at the same time as the initial vitrectomy.

We conducted an empirical analysis which led to several statistical results.

Results

A total of 59 eyes of 59 patients had removal of the SO during the period from January 2017 to June 2021.All of these eyes have a reattached retina and we considered oil tamponade was no longer needed. The patients have an average age of 42.97 ± 14.40 years (age range between 6 and 64). Men represent 83% of cases and sex ratio M/F was 4.9. The indications of oil insertion were diabetic tractional retinal detachments in 7% of eyes, complex rhegmatogenous retinal detachments in 81% of yes, and post-traumatic retinal detachment including open globe injury in 12% of eyes.

The mean time to oil removal was 16.1 ± 9.32 months (Figure 1). Twenty-three gauge sclerotomies were used for SO extraction. Pre-operatively (prior to SO removal), 25 eyes (42%) were phakic, 33 (56%) were pseudophakic (all posterior chamber intraocular lens, one eye (2%) was aphakic (was aphakic before vitrectomy) cataract was detected in 24 eyes (41%). These 24 phakic eyes were all treated with a combined surgery (phacoemulsification associated with SO removal).

Figure 1: Time to oil removal by aetiology of retinal detachment (RD).

Prior to oil removal, we found 68% of eyes (n = 40) with oil emulsification in the anterior chamber (18 phakic eyes and 22 pseudophakic eyes). Two of these 40 eyes had corneal oedema (time of SO tamponade was 28.5 and 24 months).

The visual acuity and intraocular pressure preoperatively and postoperatively in all patients that underwent SO removal and according to the initial indication of the silicone oil insertion is displayed in table 1. The preoperative VA (logMAR) before oil

removal was 1.55 ± 1.27 which has improved to 1.27 ± 0.65 at 1month post-op, and to 1.10 ± 0.60 at 3 months post-op, to finally reach 1.05 ± 0.63 at 6 months post-op. The mean IOP before OS removal was 18.9 ± 6.37 mm Hg, which has reduced to 14.35 ± 4.85 at the last follow-up (6mOths post-op). Seven per cent of eyes have developed ocular hypertension (despite maximal medical therapy) following SO removal, and 17 (29%) eyes has ocular hypertension that was controlled under medical therapy. VA of 73% of eyes have improved with two lines minimum and IOP of 23% of eyes have decreased with 5mmHg minimum at the last follow-up (6 months), as shown in table 2.

Indications of SO insertion	N (%)	Pre-op VA (logMAR ± SD)	Post-op VA (logMAR ± SD)	Pre-op PIO p (mmHg ± SD)	Post-op PIO (mmHg ± SD)
Post-Traumatic RD	4 (7%)	1,20 ± 0,34	0,30 ± 0,11	21,25 ± 8,5	13,25 ±2,22
RRD	48 (81%)	1,50 ± 0,59	1,52 ± 0,63	16,85 ± 5,24	14,21 ± 4,38
TRD	7 (12%)	2,11 ± 0,67	1,62 ± 0,53	22,86 ± 10,59	12,83 ± 5,12
All groups	59 (100%)	1,55 ± 1,27 (1,6/10)	1,05 ± 0,63 (3,1/10)	18,90 ± 6,37	14,35 ± 4,85

Table 1: Indications of SO insertion, VA and IOP pre- and post-SO removal.

SO: Silicone Oil, VA: Visual Acuity, IOP: Intraocular Pressure, RRD: Rhegmatogenous Retinal Detachment, TRD: Tractional Retinal Detachment.

Months	Percentage of eyes with VA improvement of at least two lines of (%)	Percentage of eyes with at least 5 mm Hg decrease in IOP (%)
1	54	36
3	71	29
6	73	25

Table 2: Percentage of eyes with VA improvement by two lines and percentage of eyes with a 5 mm Hg decrease in IOP after oil removal.

Balanced salt solution (BSS) and air were employed to replace SO after its ablation in 80% and 5% of eyes. Nine (15%) eyes was administered a gas tamponade (SF6 18-20% or C3F8 12-15%). At the time of initial DR repair, 360° peripheral retinal laser was applied to 48% of eyes and scleral buckle was performed in 13% of eyes. 36 (61%) eyes had low viscosity SO (2000 centistokes) and 23 (39%) eyes had high viscosity SO (5000 centistokes).

Post-operative complications are outlined in figure 2. Following oil removal, Supplementary interventions were needed, which consisted of three trabeculectomies, four PPVs, and two anterior chamber oil removals.

Corneal complications were seen in 2 (3%) eyes one eye developed corneal edema associated with ocular hypertension, and one eye developed corneal stromal oedema with a normal IOP. The first case was related with SO emulsification in the anterior chamber preoperatively, and the second one associated with residual SO post oil ablation. The length of silicone oil retention in these eyes were 23 and 34 months respectively, significantly longer than in eyes that did not develop keratopathy ($p<.05$) (table 3).

Figure 2: Post-operative complications after SO removal.

Cystoid macular oedema (CMO) was seen in 5 eyes (8%) after SO removal that was not present before SO removal, except for one of them who was diabetic.

Epiretinal membrane (ERM) without macular edema was noted in one eye (1.5%) two months after silicone oil removal.

Full thickness macular hole was seen in 3 (5%) eyes. Two of them have macular hole preoperatively and was treated by inverted ILM Flap Technique with SF6 tamponade, and one have no macular hole before SO removal.

Following SO removal, five eyes (8%) were re-operated including two re-detachments and three macular holes.

Three (5%) eyes presented with hypotony post-oil removal. These eyes had a mean IOP 19.6 mm Hg preoperatively, with no eyes with hypotony observed pre-oil removal. These three eyes had retinotomy and/or retinectomy during the initial repair. Also, two of them underwent post-traumatic RD (OGI) and one had complex RD. The onset of hypotony in theses eyes was early, usually within the next day of surgery. The mean pre-SO removal VA for these eyes was 1.6. One eye progressed to phthisis (was associated with retinal detachment). Our results demonstrate that eyes with RDs associated with globe trauma (very significant β =39,23%, p <,005) , complex rhegmatogenous RD (significant β =-28.54%, p <,005) , and retinotomy (highly significant β =45.81 %, p <,0005) have a greater risk of hypotony after SO removal (table 3).

Ocular hypertension was detected in 4 (7%) eyes following SO ablation. Three had trabeculectomy after maximal therapy was reached at an average of months. One of these eyes had silicone oil removal from AC associated with trabeculectomy. In our series, Pseudophakic eyes with emulsified oil before SO removal are prone to have ocular hypertension after SO removal (β=34.65, p <.01 (table 3).

Factors	complications	Correlation	p value	Significance
Time of oil tamponade before removal	**All complications**	**29.32%**	**0.002**	**Significant**
2000 Cs SO	All complications	-5.91%	0.65	Not significant
5000Cs SO	All complications	5.91%	0.65	Not significant
Time of oil tamponade before removal	Re-RD	-4.99%	0.7	Not significant
Encircling Scleral buckling	**Re-RD**	**-35.81% (OR : 0.06/ SD : 1.3/ CI : [0.0, 0.78])**	**correlation p value: 0.005 Odds Ratio p value: 0.03**	**Very significant**
PRP 360°	Re-RD	8.22%	0.53	Not significant
Gaz tamponade (SF6/ C3F8)	Re-RD	1.23%	0.92	Not significant
complex RRD with advanced PVR	Re-RD	19.35%	0.14	Not significant
RDs associated with globe trauma	Re-RD	-14.82%	0.26	Not significant
Retinotomy/ Retinectomy	Re-RD	-6.16%	0.64	Not significant
High Myopia	Re-RD	0	1	Not significant
Previous Failed Retinal Surgery	Re-RD	2.83%	0.83	Not significant
Peeling of ERM	Re-RD	3.33%	0.8	Not significant
RDs associated with with Advanced PVR	**Hypotony**	**-28.54%(OR : 0.1/ SD : 1.28/ CI : [0.01, 1.17])**	**correlation p value: 0.002 Odds Ratio p value:0.06**	**Significant**

RDs associated with globe trauma	**Hypotony**	**39.23% (OR : 20.4/ SD : 1.31/ CI : [1.56, 266.59])**	**correlation p value: 0.002 Odds Ratio p value: 0.02**	**Very significant**
Retinotomy/Retinectomy	**Hypotony**	**45.81%**	**0.0003**	**Highly significant**
High myopia	Hypotony	-7.32%	0.58	Not significant
Emulsified oil in AC (pseudophakic before SO removal)	**Ocular hypertension**	**34.65%**	**0.008**	**Very significant**
Emulsified oil in AC (phakic before SO removal)	Ocular hypertension	-18.66%	0.1	Not significant
Time of oil tamponade before removal	Ocular hypertension	-4.14%	0.75	Not significant
Time of oil tamponade before removal	**Keratopathy**	**25.47%**	**0.048**	**Significant**

Table 3: Descriptive statistics: Correlation of prognostic factors to post-operative Silicon Oil (SO) complications

RD: Retinal Detachment /AC: anterior chamber / OR: Odds Ratio/ SD: Standard Deviation /CI: Confidence Interval

Seven (12%) eyes developed re-detachment. Five of these eyes needed an additional procedure including the use of gas or silicone oil. Therapeutic abstention was recommended in the remaining 2 eyes (poor prognosis including one phthisis). The incidence of re-detachment after SO removal was in a mean of 30 days. The indications of the initial oil insertion in these re-detached eyes were complex rhegmatogenous retinal detachments in 5 eyes, and post-traumatic retinal detachment (OGI) in 2 eyes. A further PPV was undergone and C3F8 was used as a tamponnade agent in two eyes, SF6 in one eye and SO in two eyes. ERM removal was combined with SO removal in ten eyes (17%). These eyes had an average VA of 1.94 before the surgical procedure and 1.34 after the removal of the SO. We studied protective factors of redetachment: 360° peripheral laser, Encircling Scleral buckling, Retinotomy/Retinectomy, peeling of ERM, Gaz tamponade (SF6/C3F8) during SO removal, and as risk factors of redetachment: complex RRD with advanced PVR, high myopia, RDs associated with globe trauma, Previous Failed Retinal Surgery, time of oil tamponade before removal (table 3). Our results show a Scleral buckling surgery as a protective factor to have a statistically significant relationship with anatomical success after SO removal (β= -35.81%, p < .005) (Table 3).

Three (5%) eyes had Posterior Capsular Opacification (PCO) after SO removal. All were phakic preoperatively, underwent combined phaco-cataract removal and silicone oil, and presented PCO postoperatively. Yag laser was permormed in these eyes. Rupture of the posterior capsule was seen in 5 eyes: in 4 (7%) eyes underwent initial RD repair combined with phaco-ablation and in one eye (2%) that underwent the SO removal comined with phaco-ablation. Posterior capsulotomy was performed in the initial RD repair in 5(8%) eyes and in the SO removal in 15 (25%) eyes.

Following SO extraction, Emulsification of oil in the anterior chamber was seen in 30% of eyes (n=7) with an opening in the posterior capsule posterior (capsule rupture or posterior capsulotomy), and 33% (n=12) of eyes with an intact posterior capsule.

Discussion

SO is more advantageous than SF6 tamponade in treatment of complex RDs [18]. Its anatomic and functional results are earlier and more successful, avoids the strict positioning and allows travel at high altitudes [19]. SO also decreases the incidence and severity of neovascular glaucoma through section-

alisation of pro-angiogenic factors. SO is an effective tamponnade agent for vitreous hemorrhage hemorrhages complicating diabetic retinopathies [1,19]. Nevertheless, the need to re-operate the patient to extract the oil remain a significant disadvantage of SO insertion. Some clinicians recommend removing the SO as soon as possible after retinal healing to prevent oil-related complications [20]; others have shown that prolonged tamponade of the SO does not meaningfully increase these risks [7]. The vast majority of authors recommend SO removal 3 to 6 months after the initial SO insertion [9,21].

The time to oil removal in in our study was 16.1 months, which was more prolonged than in other studies. [1-3]. This is because our waiting list has grown due to the large area served by our department; this list has been amplified by the COVID pandemic. The duration of SO was found in our study to be related to complications post-SO removal ($p<.05$) (Figure 3). As in other series, the initial indication for HS tamponade is the complex RRD. Thirty-nine percent of cases employed SO with higher viscosity, 5000cs, whereas 61% used SO of 2000cs viscosity. Whereas in the series of Issa et al [1] and Falkner et al [3], 5000cs SO was used in almost all eyes. Our results show a non-significant relationship between type of SO used and complications of SO removal, which is in line with the study of Teke et al. [24]. Rapid initial improvement in VA was achieved within the first 3 months after SO removal, followed by more gradual improvement. IOP decreased significantly during the first month after SO removal then plateaued.

Figure 3: Scatter plots showing correlations between the duration of SO tamponade and the incidence of complications. This figure shows a positive correlation between time of oil tamponade and complications post-SO removal ($\beta=29.32$) with a significance of $p < .05$

The reported rate of recurrent RD after SO removal varies between 0 and 33% [1,6-12], with most studies reporting a prevalence of 8-12%. Redetachment after SOR was reported as the main complication of the early postoperative period [6,11].

The recurrence of retinal detachment was seen in 12% of eyes in our study. Re-detachment was observed at 30 days post-oil removal. Panretinal laser photocoagulation was used in the first RD surgery in 4 out of 7 re-detached eyes, and gas a tamponade agent in two eyes (out of 7). Only one re-detached eye has scleral buckle performed in the first surgery. These features could have influenced the outcome of the subsequent surgery (oil removal). Open globe injury or complex RDD with PVR is associated with all cases of re-detachment, which is consistent with the series of Issa et al. [1] and Moisseiev et al. [2] stated that open globe injury and/or advanced PVR are associated with a high risk of recurrent RD. Three out of 7 redetached eyes had these indications in the series of Issa et al. (2 traumas and one PVR) and all detached eyes (19 eyes) had theses indications in Moisseiev et al.'s series (4 traumas and 15 PVRs). However, we did not found statistically significant relationship between indication of initial repair and anatomical success. This is probably due to the small samples of our series.

The 360° peripheral laser is usually employed during the insertion and removal of SO. Avitabile et al. [10] and other studies have reported that prophylactic 360° peripheral laser at the time of vitrectomy can be effective in minimising the incidence of re-detachment [1,4,3,8,10], yielding 3-12% rates versus up to 33% in those who did not receive 360° laser treatment. The reason is that 360° laser retinopexy could be used to treat invisible breaks or to avoid the apparition of new breaks after a SOR [1]. In the present series, 81% eyes had received 360° peripheral laser treatment at the original surgery (including 4 of the 7 eyes who presented re-detachment after SO removal), but no eyes underwent supplemental laser at the time of SO removal. However, in our series, 360° peripheral laser was found not to be related to anatomical success following SO removal. One reason could be that we don't apply additional 360° laser treatment during SO removal, or because of the small sample of our series.

Gas tamponade was also performed in 15% of eyes after SOR in our series and was reported in the series of Lam et al. [7] to be performed in 31.1% of eyes but was not predictive of anatomical success, which is also the case in our series. This is caused generally

gas as used after SO removal in high risk eyes with poor prognosis (eyes with previous failed retinal surgery, high myopic eyes).

The estimated range of hypotony after SO removal (some was transient and resolved over a few weeks) is 2-39%, with most studies reporting it in 3-7% of eyes [1,2,4,9,11,12]. Many studies have also indicated that eyes with preoperative hypotony are substantially more prone to develop persistent hypotony after removal of the OS. Five per cent of eyes presented with hypotony post-oil removal in our study, which is in line with other studies [1,2]. No eyes presented hypotony pre-oil removal. Hypotony was observed in two eyes that underwent post-traumatic retinal surgery (OGI) and in one eye that had complex retinal detachment surgery. These three eyes had retinotomy and/or retinectomy during the initial repair. The onset of hypotony in theses eyes was early, usually within the next day of surgery, similar to the series of Issa., *et al.* [1]. It can be stated that RDs associated with globe trauma (β =39,23%, p <,005) , complex rhegmatogenous RD with advanced PVR (β =-28.54%, p <,005) , and retinotomy (β =45.81 %, p <,0005) could have a greater risk of hypotony after SO removal. This result is consistent with the series of Issa et al. [1] reported that OGI , RD with advanced PVR, and retinotomy have a high risk of developing hypotony following SOR. Kim et al [13] reported a higher rate of transient hypotony with longer axial length (AL), because thin sclera in eyes with longer axial length might be more sensitive to mechanical stress and might be insufficiently strong to hold the ciliary body in place during surgical manipulation and during IOP fluctuation with silicone oil removal. However, in our series, high myopia was not found to be related to hypotony occurrence after SO removal.

The cataract formation or progression rate is generally reported to reach 90% [1,14]. Recently, due to the frequent progression of cataract after HS tamponade, the combination of phaco-ablation with HS is often performed. This is the case in our present series, which explains the lower incidence of cataract after SO removal. Before SO removal, 33 eyes were pseudophakic (56%), 25 were phakic (43%), 1 eye was aphakic (2%). A phacoemulsification was performed in 24 out of the 25 phakic eyes because thecataract interfered with visibility during HS removal. Three of them presented PCO postoperatively. Yag laser was performed in these eyes.

The incidence of ocular hypertension in the postoperative period of oil removal has been recorded in the range of 9-16% in the literature [2,4]. Ocular hypertension was detected in our study in 7% of eyes following SO ablation**.** Three eyes (5%) had trabeculectomy after SO removal, which is in line with other the series of Issa et al and Al-Wadani et al. [1,2,3,4,5]. Pseudophakic eyes with emulsified oil before SO removal were more susceptible to have ocular hypertension after SO removal (p <.01) in our series. In aphakic patients, but also in phakic and pseudophakic patients with disrupted lens zonule or capsular defects, a SIO bubble can migrate into the anterior chamber right at the end of SO insertion, and could be prevented by inferior iridectomy. After SO removal, residual micro-droplets of SO in the trabecular meshwork are responsible for trabeculitis and chronic IOP elevation [2,4].

The rate of corneal complications after SO removal ranges from 3 to 11% [2,4,12]. SO could act as a physical barrier and when removed it can cause corneal edema by allowing water to access the stroma due to endothelium damage. This damaged endothelium no longer fulfills its barrier function, and this is due to the presence of silicone oil in the anterior chamber which causes the loss of endothelial cells [1,23].

Keratopathy occurred in 2 (3%) eyes included in the study, and was not present prior to SOR. One corneal edema was associated with ocular hypertension and improved considerably after trabeculectomy. The other had corneal stromal haze and was not associated with ocular hypertension (had residual SO in the anterior chamber after SO removal). The length of silicone oil retention in these eyes were 23 and 34 months respectively, significantly longer than in eyes that did not develop keratopathy (p<.05). This is consistent other studies in the literature [11, 16, 22, 2], which consider the rate of keratopathy to be related to prolonged retention of silicone oil. Particularly, Moisseiev et al. reported the occurrence of keratopathy after SO removal in 10 eyes (11.2%) and found that this complication was correlated with the time of oil retention (p=0.05) [2].

More than half of all patients have OCT done before and after removal of silicon oil.

Concerning the complications detected by OCT, Cystoid macular oedema (CMO) was seen in 5 (8%) eyes, Epiretinal membrane (ERM) without macular edema in one eye (1.5%), and full thickness macular hole was seen in 3 (5%) eyes, and two months after silicone oil removal

Following vitrectomy for RRD, a structural change in the macula may be seen on OCT [15], especially with the SO tamponade, as thinning of the parafoveal retina and RNFL has been reported in studies [23]. This is due to SO exerting some pressure on the retina. After SO removal, these changes disappeared, except for RNFL thinning that remained in place [23].

Conclusion

Compared to other tamponade agents, SO is more likely to improve anatomical reapplication rates, but its functional outcome is still controversial. SO insertion is generally reserved for severe pathologies. Removal of SO should be done as early as possible. However, its removal depends on the indication for tamponade and on the severity of the underlying pathology.

This study shows a general trend towards improved visual acuity and decrease in IOP after silicone oil removal. Recurrence of retinal detachment and ocular hypertonia are the two most common complications in our series.

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