

## ARTICLE ORIGINAL

**Silicone oil induced glaucoma: risk factors and management results**

Glaucome siliconique: facteurs de risque et résultats de la prise en charge.

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Faculty of Medicine, University of Tunis El Manar, Tunis, Tunisia**Keywords**Retinal detachment.  
Silicone oil. Glaucoma.  
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Therapeutics.**Abstract****Purpose.** Our aim was to describe the risk factors of silicone oil induced glaucoma (SOIG), to discuss the challenges encountered during management as well as its results.**Methods.** Retrospective study including 120 eyes operated by 23 gauges pars plana vitrectomy with silicone oil (SO) tamponade. All patients had a complete pre- and post-operative assessment. SOIG was defined as a postoperative intra ocular pressure (IOP) greater than 21mmHg for at least 6 weeks. Patients who developed intra ocular hypertension (IOHT) underwent SO removal and were put on medical, laser or surgical treatment if OHT persisted. We studied the risk factors SOIG onset as and IOP control rates with each therapeutical means.**Results.** SOIG was noted in 45 patients (37.5%). The risk factors found in the univariate study were diabetes ( $p=0.007$ ), rhegmatogenous retinal detachment ( $p=0.036$ ), SO presence in the anterior chamber (AC) ( $p<0.001$ ) and tamponade duration  $\geq 12$  months ( $p<0.001$ ). In the multivariate study retained only tamponade duration  $\geq 12$  months ( $OR=13.03$ ). SO was removed after  $14.53 \pm 8.87$  months on average. IOP control was achieved with SO removal in 6 cases (13.33%), medical treatment in 30 cases (77%), selective laser trabeculoplasty (SLT) treatment in 6 cases (13.33%), trabeculectomy in 2 cases (4.44%) and cyclo diode therapy in one case.**Conclusions.** SOIG is a complication of SO injection that can affect the visual prognosis. Its management is difficult and could requires medical, laser or surgical treatment. Tamponade duration appears to be an important risk factor for SOIG occurrence.**Mots-clés**Détachement de rétine.  
Huile de silicone.  
Glaucome. Facteurs de risque.  
Traitement.**Résumé****Objectif.** Le but de notre étude était de décrire les facteurs de risque du glaucome siliconique (GS), de discuter les difficultés de la prise en charge thérapeutique ainsi que ses résultats.**Méthodes.** Etude rétrospective portant sur 120 yeux opérés par vitrectomie 23 gauges à trois voies par la pars plana avec un tamponnement par HS. La survenue d'un GS a été défini comme un tonus post opératoire  $> 21\text{mmHg}$  pendant au moins 6 semaines en post opératoire. L'hypertonie oculaire a été traité par un traitement médical, physique ou chirurgical. Nous avons étudié les facteurs de risque de survenue de GS ainsi que les résultats du contrôle du tonus oculaire.**Résultats.** Un GS a été notée chez 45 patients (37.5%). Les facteurs de risque retrouvés étaient le diabète ( $p=0.007$ ), le décollement de rétine rhégmato-gène ( $p=0.036$ ), la présence de l'HS en chambre antérieure  $p<0.001$  et la durée de tamponnement  $\geq 12$  mois ( $p<0.001$ ). L'étude multivariée a retenu la durée de tamponnement  $\geq 12$  mois ( $OR=13.03$ ). Le silicone a été retiré après  $14.53 \pm 8.87$  mois. Le contrôle de l'hypertonie a été obtenu par l'ablation de silicone dans 13.33% des cas, par un traitement médical dans 77% des cas, par un traitement physique par SLT dans 13.33% des cas, par une trabéculéctomie dans 2 cas et par un traitement par cyclo-diode dans un cas.**Conclusions.** Le GS est une complication du tamponnement par HS engageant le pronostic visuel. Elle requiert un traitement lourd. La durée de tamponnement serait un facteur de risque important.**Introduction**

Silicone oil (SO) has been widely used in the management of different vitreoretinal diseases, especially retinal detachments (RD) with significant vitreoretinal proliferation (VRP), tractional RD, rhegmatogenous RD with giant tears, or traumatic RD [1]. It ensures a prolonged tamponade compared to gas, rapid functional recovery, and easy postoperative monitoring of the fundus. However, it exposes to complications such as cataracts and band keratopathy.

Ocular hypertension (OHT) represents the second most common complication of SO tamponade after cataract [2]. Pupillary block, inflammation, preexisting glaucoma, SO migration into the anterior chamber (AC), and silicone emulsification, have been

proposed to explain ocular hypertension onset after SO injection [3]. OHT can be transient or chronic, turning into silicone oil-induced glaucoma (SOIG) with optic nerve damages evolving even after SO removal. Many risk factors have been suggested such as diabetes, preexisting glaucoma or SO tamponade duration [4]. Identifying them is essential to depict patients who are more exposed to develop SOIG.

SOIG management is challenging because it often requires aggressive medical and surgical treatment. The results however remain unpredictable.

Our study aimed to describe the risk factors of silicone oil induced glaucoma (SOIG), to discuss the challenges encountered during management as well as its results.

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## Methods

We carried out a retrospective study, involving 120 eyes of 120 patients followed in our department between January 2010 and December 2019. All patients were followed up until the removal of SO. We included patients presenting rhegmatogenous RD with advanced VRP, diabetic tractional RD, inflammatory RD, vitreous hemorrhage and patients with at least six months of follow up after silicone removal.

We did not include patients presenting iris rubeosis, preoperative glaucoma or ocular hypertension, recurrent retinal detachment, early postoperative OHT and insufficient postoperative follow-up.

### Preoperative assessment

The patients' medical records were reviewed for age, gender, medical and surgical history. A complete preoperative examination was performed to determine the best-corrected visual acuity (BCVA), lens status, RD type and characteristics (location, extension, macula status, associated retinal tears, and the extension of the fibrovascular membranes), or associated complications such as rubeosis, NVG and VH. B-scan ultrasonography was performed each time the fundus was not accessible.

### Surgical procedures

All surgeries were performed by the same experienced surgeon. They were conducted under general anesthesia. The 23 G pars plana vitrectomy (PPV) was performed with the Stellaris Vitreoretinal Surgical System (Bausch & Lomb Incorporated, Bridgewater, NJ, USA) and a wide-angle viewing system. Additional procedures such as membrane segmentation and delamination, perfluorocarbon liquid injection (DK-line), endophotocoagulation, cryoretinopexy, scleral buckle, relaxing retinotomy, were associated, depending on the state of the retina. SO with 1,000-cSt viscosity was used in all cases.

### Postoperative assessment

Patients were examined on postoperative day one, 1 week, and 1 month after surgery, then every 3 months. At each visit, a complete examination was performed, including the BCVA measurement, slit-lamp biomicroscopy examination, intraocular pressure (IOP) measurement using applanation tonometry, and fundus examination with a three-mirror lens. Glaucoma was defined as postoperative IOP of 21 mmHg during six weeks or more. Topical antiglaucoma medications were automatically started as soon as postoperative OHT was detected. In cases of insufficient IOP control, additional glaucoma surgery or a selective laser trabeculoplasty was performed. The studied risk factors were summarized in **Table I**.

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IBM SPSS v25.0 (Chicago, IL, USA) was used for the statistical study. The categorical variables were tested for association with the incidence of elevated IOP using the  $\chi^2$  test for univariate analysis. The continuous variables were compared between the two groups using Student's *t* test. Multivariate analysis was then used to control for confounding factors and calculate the relative risks for the incidence of ocular hypertension.  $P < 0.05$  was considered statistically significant.

## Results

Our study included 120 eyes from 120 patients undergoing 23 G PPV with SO tamponade. The mean follow-up was  $24.20 \pm 16.08$  months (from six months to 8 years). Preoperative characteristics were reported in **Table II**.

**Table I.** The studied risk factors of SOIG onset.

Pre-operative risk factors
Diabetes
Myopia.
Pseudophakia
The surgical indication
Intraoperative risk factors
Additional procedures
Postoperative risk factors
Tamponade duration $\geq 12$ months
SO <sup>a</sup> emulsification in the anterior chamber

<sup>a</sup>SO: silicone oil

**Table II.** Preoperative characteristics.

Characteristics	Results
<b>Age</b>	57.39 $\pm$ 10.59 years (from 8 to 85 years)
<b>Sex Ratio (M/F)</b>	2.75
<b>General medical history</b>	
Diabetes	72 patients (60%)
Arterial hypertension	49 patients (41%)
<b>Ophthalmological history</b>	
Myopia	16 eyes (13.33%)
Proliferative Diabetic retinopathy	58 eyes (48.33%)
Pseudophakia	29 eyes (24.16%)

The mean value of the intraocular pressure was  $12.825 \pm 1.93$  mmHg (from 8 to 16 mmHg) and the iridocorneal angle was opened in all cases. Indication for surgery was: Diabetic tractional RD in 30 eyes (25%), VH in 32 eyes (26.50%), traumatic RD in one eye, inflammatory RD in 3 eyes (2.5%) and rhegmatogenous RD in 54 eyes (45%) including ten cases of pseudophakic RD (8.33%), ten cases of high myopia RD (8.33%), two cases of giant retinal tear detachment, three cases of macular hole-related RD.

RD extended to one quadrant in 20 eyes (22.7%), two quadrants in 43 eyes (48.9%), and three quadrants in 11 eyes (12.5%). A total retinal detachment was found in 14 eyes (15.9%). Retinal breaks were found in 49 eyes with RD (89%) and preoperative macular detachment was found in 57 eyes (64.77%). **Table III** summarized the additional procedures.

Intraoperative complications were iatrogenic retinal breaks in five eyes (4.17%), and VH in 17 eyes (14.17%) with proliferative diabetic retinopathy.

Postoperative complications were band keratopathy in six eyes (5%), cataract in 35 eyes (29.17%), inflammation in 11 eyes (9.16%), rubeosis iridis in three eyes of diabetic patients operated for tractional RD, and SO emulsification in the anterior chamber in 26 eyes (21.7%) (**Figure 1**).

SOIG was noted in 45 eyes (37.5%). The average delay of OHT onset was  $2.9 \pm 2.55$  months (from six weeks to ten months). The average IOP was  $26.13 \pm 5.48$  Hg mm with (from 21 to 43 mm Hg).

Risk factors that significantly correlated with SOIG were diabetes ( $p=0.009$ ), rhegmatogenous RD ( $p=0.047$ ), the presence of SO in the anterior chamber ( $p<0.001$ ), SO tamponade duration  $\geq 12$  months ( $p<0.001$ ). The multivariate analysis, retained only an SO tamponade duration  $\geq 12$  months as a risk factors for IOH ( $p<0.001$ ,

OR=13.03 [3,565 ; 47,635]).

Regarding SOIG management, the medical treatment permitted IOP control in 80% of patients before SO removal, the average IOP achieved was  $17.6\text{mm} \pm 4.67\text{Hg}$ .

SO removal delay after an average of  $14.53 \pm 8.87$  months (from 5 months to 48 months). Cataract surgery was associated in nine eyes (20%) with SOIG and in five eyes (15%) without SOIG. Trabeculectomy associated with SO removal, was performed in one patient with a resistant SOIG.

After silicone removal, 39 patients (86.67%) kept an OHT, the IOP was controlled by medical treatment in 30 patients (77% of cases). Six patients underwent a selective laser trabeculoplasty (SLT), one patient underwent a trans-scleral diode laser cyclophotocoagulation and two patients underwent trabeculectomy. The IOP decreased in all cases.

**Table III.** Intraoperative additional procedures.

Procedure	Patients' number	Percentage
Cataract surgery	19	15,83%
Segmentation	75	62,5%
Cryoretinopexy	4	3,33%
Epiretinal membrane removal	67	55,83%
Endo-photocoagulation	100	83,33%
Perfluorocarbonyl liquid injection	72	60%

## Discussion

SOIG is a difficult management glaucoma. Its mechanism is not clear and silicone oil removal does not allow in many cases IOP control. In our series, we defined the SOIG as an IOP of 21 mmHg or more persisting at least six weeks after SO injection. SOIG was noted in 45 patients (37,5%) after  $2,9 \pm 2,55$  months on average. In other studies, this prevalence ranged between 4.8% and 48% [4-10]. This variability is due to SOIG definition and exclusion criteria, such as pre-existing glaucoma or surgical indications.

Regarding risk factors, many studies found that diabetic patients are more likely to develop SOIG [5,6,11]. However, De Corral and Jabbour [4,12] found that diabetes was associated with a lower risk of SOIG, and that may be explained by detachment of the ciliary body and the aqueous hyposecretion consequent to the chronic traction exerted by the anterior vitreous base. Similar results were found after PPV without SO injection where pseudophakic diabetics developed less ocular hypertension than nondiabetic patients [13].

Higher IOP preoperatively was also associated with SOIG [4,6,8,14,15]. According to the Silicon Oil Study, preexisting glaucoma multiplied the risk by a factor of three. Therefore, a detailed clinical assessment searching for glaucoma signs in both eyes is recommended prior to the surgery [8].

For Jabbour [4] the detachment type might affect the onset of SOIG. Eyes with rhegmatogenous retinal detachment were at high risk of OHT compared with eyes with tractional retinal detachment. Literature data are however scarce, and this association needs to be demonstrated.

Pseudophakic eyes were found to be at risk to develop SOIG either by emulsified silicone passing more easily between the zonules of pseudophakic eyes or using YAG capsulotomy. A significant association between AC SO and SOIG was found in many studies [6,11,16,17], explained by the mechanical obstruction of the trabeculum by silicone droplets decreasing its filtration capacity [14].

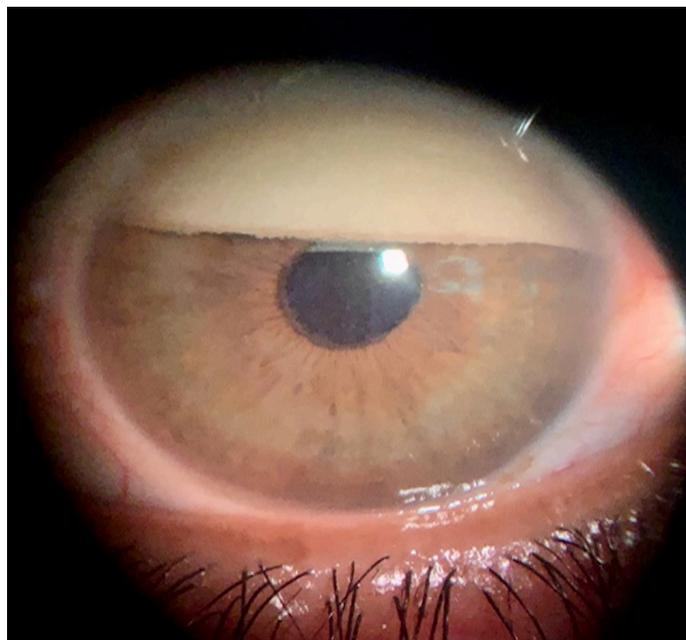
Avitabile et Al, by tracking and quantifying AC SO using UBM, found

a direct correlation between the emulsified SO (measured in mm) and the onset of OHT [18].

The emulsified SO rate was more important in pseudophakic and aphakic eyes than in phakic ones. Some studies found that the lighter the SO was, the higher the risk of earlier emulsification was, and that explain the higher prevalence of SOIG in patients receiving 1,000-cSt SO compared with 5,000-cSt SO [4]. Emulsification risk increased with the delay of SO removal in many studies [19-21]. In our multivariate analyses, we retained only the duration of tamponade longer than 12 months (OR=13,03) as a risk factor of SOIG onset. Knowing these risk factors helps to optimize our follow up to depict earlier OHT onset in exposed patient and to begin on time the treatment of this challenging glaucoma.

Removal of silicone oil is the surgical method used initially to reduce IOP when medical treatment no longer permits control. IOP control rate after SO removal reaches 57% [22-24]. The benefit of SO removal is time-dependent, removal moment must be chosen carefully to avoid the risk of retinal detachment recurrence and SO tamponade complications. Literature data do not indicate precisely SO removal delay, but it seems logical to intervene between three and six months. In our study, the silicone was removed on average after  $14,53 \pm 8,87$  months, which permitted IOP control in 6 cases (13,33%). After SO removal, the medical treatment permitted IOP control in 30 cases (77%) with a monotherapy in 50% of cases, similarly to al Jazzaf and Honovar results [5].

Other options such as laser or surgical treatments are used in case of IOP control failure with the methods mentioned above. The success rate of trabeculectomy varied between 36.7% and 55% [25,26], it appears to be lower than in the other refractory glaucoma types (congenital or neovascular glaucoma). The main limiting factors were inflammation, trabecular meshwork and the drainage bubble infiltration by silicone droplets, tamponade duration and conjunctival scarring [27]. Moltano and Ahmed implants achieved success rates of 60% and 76% [5,27]. However technical difficulties due to extensive conjunctival scarring from multiple previous operations, has limited the use of drainage surgery.



**Figure 1.** Anterior chamber emulsified silicone in a patient presenting SOIG before SO removal.

Cyclo-destruction methods especially cyclo diode laser therapy proved their interest in SOIG control. IOP control was obtained in 44% to 81.1% [6,28-30]. It allowed to reduce anti glaucomatous medication in many series [28-31]. Despite the limited publications, SLT appears to be a promising technique in SOIG treatment. Alkin [32] obtained an IOP<21mmHg in 91% of cases with a follow-up of

six months. Zhang's IOP control rate was 59.5% with IOP decrease of 4.7 mmHg, and a decrease of antiglaucomatous eye drops from 2.17 to 1.25 [33].

In our series, IOP control was obtained with SLT in 6 cases (13.33%), trabeculectomy in 2 cases (4.44%) and cyclo diode therapy in one case.

## Conclusion

SOIG is a complication of SO tamponade that can affect the visual prognosis. Its management is difficult and could require medical, laser or surgical treatment. The duration of the tamponade appears to be an important risk factor. IOP should be monitored regularly and for a long period in all patients especially in those presenting risk factors.

## Competing interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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