Intraocular silicone oil removal: timing, outcome, and silicone oil complications encountered

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Abstract

Introduction: Silicone oil is the preferred tamponade agent used in pars-plana vitrectomy for retinal detachment when a long duration of endotamponade is intended. Due to its possible long-term complications, removal of silicone oil (ROO) is recommended.

Purpose: This study is done to evaluate the mean duration and complications of silicone oil tamponade, and the anatomical and visual outcomes after silicone oil removal.

Study design: Retrospective study.

Materials and methods: Retrospective review was done on 55 eyes of 55 patients, in which ROO was carried out at Hospital Sultanah Bahiyah in 2016 with a minimum six months follow-up postoperatively.

Results: The duration of silicone oil tamponade in these eyes ranged from 1.0 to 55.5 months, with mean duration of 10.8 months (SD 7.74). Common complications of silicone oil tamponade observed were cataract in 30 eyes (54.5%), followed by secondary high intraocular pressure in 6 eyes (10.9%), and band keratopathy in 3 eyes (5.5%). Six eyes (10.9%) developed retinal re-detachment after oil removal.

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The majority in the anatomically attached group post ROO (40 eyes, 81.6%) showed improvement of vision after ROO, with mean best corrected vision of LogMAR 1.38 (6/150) with silicone oil in situ to LogMAR 0.88 (6/48) at the latest follow-up.

**Conclusions:** Although the recommended duration of silicone oil tamponade ranges from three to six months, the optimal timing for silicone oil removal still remains unknown. ROO is recommended due to oil-related complications, but the anatomical outcome should be evaluated as well. However, in our setting, with limited resources and time, and increasing number of patients indicated for silicone oil, it is impossible to comply with the recommended time for ROO and the timing is usually set on an individual basis.

**Keywords:** cataract, glaucoma, internal tamponade, keratopathy, pars-plana vitrectomy, retinal detachment, silicone oil

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**Penyingkiran minyak silikon intraokular: Penentuan masa, hasil, dan penemuan komplikasi minyak silikon**

**Abstrak**

**Pengenalan:** Minyak silikon adalah agen tamponad pilihan yang digunakan dalam vitrectomy pars-plana untuk masalah retina lekang apabila kesan tamponade dari dalam diperlukan untuk jangkamasa yang panjang. Disebabkan kemungkinan komplikasi jangka panjang, penyingkiran minyak silikon (ROO) adalah disyorkan. **Tujuan:** Kajian ini dilakukan untuk menilai jangka masa dan komplikasi minyak silikon tamponad, dan hasil anatomi dan tahap penglihatan selepas penyingkiran minyak silikon. **Reka bentuk kajian:** Kajian retrospektif. **Bahan dan kaedah:** Kajian retrospektif dilakukan kepada 55 mata daripada 55 orang pesakit, yang mana ROO telah dijalankan di Hospital Sultanah Bahiyah pada tahun 2016 dengan tempoh enam bulan susulan selepas pembedahan. **Keputusan:** Tempoh tamponad minyak silikon di dalam mata ini antara 1.0 hingga 55.5 bulan, dengan jangka masa purata 10.8 bulan (SD 7.74). Komplikasi biasa minyak silikon tamponad yang diperhatikan adalah katarak dalam 30 mata (54.5%), diikuti oleh tekanan tinggi intraokular sekunder dalam 6 mata (10.9%), dan keratopati band dalam 3 mata (5.5%). Enam mata (10.9%) mengalami lekang retina semula selepas penyingkiran minyak. Majoriti mata dalam kumpulan melekat secara anatomi selepas ROO (40 mata, 81.6%) menunjukkan peningkatan ketajaman penglihatan, dengan penglihatan yang terbaik LogMAR 1.38 (6/150) sewaktu minyak silikon
Introduction

There are several tamponade agents available to be used in pars-plana vitrectomy (PPV), but silicone oil is the preferred endotamponade agent if longer duration of tamponade is needed for retinal re-attachment. However, silicone oil can lead to long-term complications such as cataract formation, secondary high intraocular pressure (IOP), and corneal endothelial decompensation.1-6 Hence, removal of silicone oil (ROO) is recommended once anatomical re-attachment has been achieved.7 The exact timing for silicone oil removal is still controversial and debatable, as it depends on multiple factors such as stability of the retinal status and complications from the silicone oil itself. Therefore, recommendations range from three to six months in successfully attached eyes.6,9 Most authors reported an improvement in final visual acuity post-ROO, but it is believed that duration of silicone oil tamponade may have an effect on visual acuity. However, current evidence to support this is lacking. Compared to other tamponade agents, silicone oil is more likely to enhance anatomical re-attachment rates, but its functional outcome is still debatable.

This study was conducted to determine the mean duration and complications of silicone oil tamponade, as well as the anatomical and visual outcomes after silicone oil removal.

Materials and methods

The medical and surgical records of all patients who underwent silicone oil removal from January 1 to December 31, 2016 at Hospital Sultanah Bahiyah (Alor Setar, Kedah, Malaysia) were reviewed. A minimum postoperative follow-up duration of
six months was taken to determine the anatomical and visual outcomes after ROO. Ten eyes from an initial 65 ROO cases performed were excluded from the study for lack of follow-up before the six months appointment.

Out of 55 patients with 55 silicone oil-filled eyes who fulfilled our inclusion and exclusion criteria, 36 were males (64.5%) and 19 were females (35.5%). Subjects’ age ranged from 11 to 75 years, with mean age of 52.9 years. The demographic features of the analysed eyes are shown in Table 1.

The two common indications for using silicone oil as tamponade agent during PPV were:

1. advanced diabetic eye disease (ADED) with combination of tractional (TRD) and rhegmatogenous retinal detachment (RRD) affecting the macula (n = 31, 56.5%); and
2. proliferative vitreoretinopathy (PVR) from RRD (n= 21, 38%).

### Table 1. Demographic features, initial indication for PPV, and duration of silicone oil tamponade

| Variables                                      | Patients |
|------------------------------------------------|----------|
| **Demographic feature:**                       |          |
| Total number of patients                       | 55       |
| Males, no. (%)                                 | 36 (64.5) |
| Females, no. (%)                               | 19 (35.5) |
| Age (years) mean (SD) (range)                  | 52.9 (13.33) (11-75) |
| **Indication for PPV with silicone oil tamponade:** |          |
| ADED (combined TRD, RRD affecting macula), no. (%) | 31 (56.5) |
| RRD with PVR, no. (%)                          | 21 (38)  |
| Vitreomacular traction, no.                    | 1        |
| Traumatic endophthalmitis with RD, no.         | 1        |
| Full thickness macula hole, no.                | 1        |
| **Duration of silicone oil tamponade:**        |          |
| < 3months, no. (%)                             | 1 (1.8)  |
| 3-6 months, no. (%)                            | 7 (12.7) |
| 6-12 months, no. (%)                           | 35 (63.7) |
| > 12 months, no. (%)                           | 12 (21.8) |

PPV: pars-plana vitrectomy; ADED: advanced diabetic eye disease; TRD: tractional retinal detachment; RRD: rhegmatogenous retinal detachment; PVR: proliferative vitreoretinopathy
The rest of the indications were listed in Table 1. Silicone oil with 5000 Centistokes (CS) viscosity was used in all of these eyes.

Decision for ROO was made once retinal re-attachment had been achieved anatomically, frequently more than three months after vitrectomy. However, the decision was also made based on the initial indication of silicone oil usage as tamponade agent and any severe complications arising from the oil tamponade requiring early ROO.

Surgeries were done by a qualified vitreoretinal surgeon and two vitreoretinal fellows using either the trans-pupillary or pars-plana sclerotomy approach. Thirty eyes (54.5%) had ROO combined with cataract extraction in the same setting (i.e., phacoemulsification followed by controlled posterior capsulotomy and oil removal via trans-pupillary approach before intraocular lens implantation) due to lack of resources. The remaining 25 eyes (45.5%) had ROO via pars-plana sclerotomy approach.

Statistical analysis was performed on the extracted data using the two-sample t-test and simple linear regression test. A p-value of less than 0.05 was set for statistical significance.

Results

Duration of silicone oil tamponade in these 55 eyes ranged from 1 to 55.5 months, with a mean duration of 10.85 months (SD 7.74). We divided the duration of oil tamponade into four categories: less than 3 months, 3 to 6 months, 6 to 12 months, and more than 12 months. The majority had an oil tamponade for 6 to 12 months (n = 35, 63.7%), as shown in Table 1.

Of the 55 eyes that were anatomically attached during preoperative assessment for ROO, 6 eyes (10.9%) developed retinal re-detachment after oil removal (Table 2). The mean duration of silicone oil tamponade in eyes that remained attached post-operatively was 11.0 months (SD 8.0), but was shorter (9.4 months [SD 5.2]) in the re-detached group. The difference of mean duration between these two groups was investigated using the two-sample t-test, which appeared not significant (Table 3). The simple linear regression test was used to find out any correlations between duration of silicone oil tamponade and re-detachment rates after ROO, but the result was not significant (Table 3). Most re-detachment occurred in eyes with PVR (66.7%, n = 4). The earliest re-detachment occurred at day 1 after ROO in a case of poor prognosis with 19.5 months of silicone oil tamponade duration for post-traumatic endophthalmitis and RD complicated with band keratopathy. The latest re-detachment occurred four months after ROO due to severe PVR changes in an eye with a giant retinal tear.

The complications of silicone oil tamponade observed in this study are listed in Table 2. The most common complication was cataract formation (54.5%, n = 30),
Table 2. Complications of silicone oil tamponade, anatomical and visual outcome after ROO

| Variables                                      | Patients                  |
|------------------------------------------------|---------------------------|
| **Anatomical outcome after ROO:**              |                           |
| Attached, no (%)                               | 49 (89.1)                 |
| Re-detached, no. (%)                           | 6 (10.9)                  |
| ADED with combined RD, no.                     | 31                        |
| Attached, no. (%)                              | 30 (96.8)                 |
| Re-detached, no. (%)                           | 1 (3.2)                   |
| PVR, no.                                       | 21                        |
| Attached, no. (%)                              | 17 (81.0)                 |
| Re-detached, no. (%)                           | 4 (19.0)                  |
| Others, no.                                    | 3                         |
| Attached, no. (%)                              | 2 (66.7)                  |
| Re-detached, no. (%)                           | 1 (33.3)                  |
| **Complications of silicone oil:**             |                           |
| Cataract, no. (mean duration (months), SD)     | 30 (9.9, 5.0)             |
| High IOP (mean duration (months), SD)          | 6 (11.2, 10.9)            |
| Band keratopathy (mean duration (months), SD) | 3 (12.8, 5.97)            |
| Emulsified oil (mean duration (months))        | 1 (12.5)                  |
| **Visual acuity outcomes after ROO:**          |                           |
| ADED with combined RD, no.                     | 30                        |
| Improved vision, no. (%)                       | 24 (80.0)                 |
| Unchanged vision, no. (%)                      | 3 (10.0)                  |
| Worsening vision, no (%)                       | 3 (10.0)                  |
| PVR, no.                                       | 17                        |
| Improved vision, no. (%)                       | 14 (82.4)                 |
| Unchanged vision, no. (%)                      | 2 (11.8)                  |
| Worsening vision, no (%)                       | 1 (5.8)                   |
| Others, no.                                    | 2                         |
| Improved vision, no. (%)                       | 2 (100.0)                 |
| Unchanged vision, no. (%)                      | n/a                       |
| Worsening vision, no (%)                       | n/a                       |

n/a: non-applicable; PPV: pars-plana vitrectomy; ADED: advanced diabetic eye disease; TRD: tractional retinal detachment; RRD: rhegmatogenous retinal detachment; PVR: proliferative vitreoretinopathy
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Six (10.9%) of these eyes developed secondary high IOP with mean tamponade duration of 11.2 months (SD 10.9). Three eyes (5.5%) developed band keratopathy; mean duration of oil tamponade in these eyes was longer, 12.8 months (SD 5.97). All of them underwent chelation of band keratopathy in the same setting of ROO, but the condition persisted postoperatively, and no further chelation was planned.

Visual acuity outcomes after ROO excluding eyes with re-detachment are summarised in Table 2. This was determined by comparing the best corrected visual acuity at the last follow-up visit after ROO with preoperative visual acuity. Improvement of vision of at least 1 line using the Snellen chart was considered as visual improvement, while worsening of vision was defined as a drop of at least 1 line using the Snellen chart. The majority (40 eyes, 81.6%) showed improvement in vision regardless of the underlying ocular problem. Overall, the mean visual acuity of these eyes with silicone oil in situ was LogMAR 1.38 (6/150), while the mean at last follow-up visit was LogMAR 0.88 (6/48). There was no statistically significant correlation between visual acuity before ROO and visual improvement after ROO with duration of silicone oil tamponade, as shown using the simple linear regression test (Table 4).

Table 3. Association between re-detachment rate after ROO with duration of silicone oil tamponade

| Duration of tamponade: | Attached retina | Re-detached retina | P-value |
|------------------------|----------------|--------------------|---------|
| Patients, no.          | 49             | 6                  |         |
| Range (months)         | 1–55.5         | 5.5–19.5           | 0.636   |
| Mean (months, SD)      | 11.0 (8.0)     | 9.4 (5.2)          | 0.793   |

Table 4. Association between visual acuity before ROO and visual outcome after ROO with duration of silicone oil tamponade

| Vision before ROO | Visual outcome after ROO |
|-------------------|--------------------------|
| Range (LogMAR)    | 0.3–2.6                  | 0.2–2.9               |
| Mean (LogMAR, SD) | 1.38 (0.64)              | 0.88 (0.53)           |
| P-value           | 0.722                    | 0.507                 |
Discussion

In this study, the mean duration of silicone oil tamponade was 10.85 months (SD 7.74). The majority had an oil tamponade duration of 6 to 12 months (n = 35, 63.6%). The shortest duration was one month, as early ROO was done due to uncontrolled high IOP with persistent vitreous haemorrhage. The longest duration was 55.5 months, in which the patient had the operation done at a different centre and defaulted follow-up for a few years before he was referred to us. Timing of ROO has no significant effect on the re-detachment rate in our study. Re-detachment occurred in 10.9% (n = 6) of the eyes and mostly (n = 4) in eyes with PVR changes. There was no specific timing reported for oil removal, but some authors recommended that it should ideally be done if the retina is anatomically stable in the surgeon’s opinion.9-13 Having said that, there are other factors that affect the decision for timing of ROO, such as causes and severity of retinal detachment before surgery and complications arising from the silicone oil itself (i.e., uncontrolled IOP, emulsified oil).

Various mechanisms of action have been postulated on how silicone oil can cause complications in the eye. More than half of our patients (54.5%) developed or had worsening cataract with silicone oil, hence had combined cataract extraction and intraocular lens implantation done in the same setting during ROO. Cataract formation, mainly posterior subcapsular opacity, was observed to occur after intra-vitreal silicone oil injection and continued to develop even after ROO.14 The exact mechanism of cataract formation remains unknown, but it is believed to be related to the following factors:

1. bright and prolonged exposure to intra-operative illumination, leading to changes in the transparency of the lens;
2. increase in oxygen tension within the lens, which increases the risk of cataract formation;
3. changes in lens metabolism; and
4. inflammatory reaction.15

New research found that, at the molecular level, silicone oil can cause changes in secondary structures of αB-crystallin protein and amyloid-like aggregation, which have been linked with the mechanism of cataract formation.15

As is widely known, silicone oil tamponade may cause secondary high IOP. Different mechanisms of raised IOP either due to secondary open or closed angles have been discussed, such as:

1. mechanical obstruction of aqueous humour outflow by silicone oil in the anterior chamber;
2. pupillary block with silicone oil in the anterior chamber,
3. trabecular meshwork obstruction by silicone oil micro-droplets; and
4. inflammation.16

A recent study found that the level of inflammatory mediators in aqueous humour were increased in silicone oil-filled eyes with secondary high IOP, suggesting the
involvement of inflammation in its pathogenesis. About 10.9% of our patients had secondary high IOP. Of these, four eyes were controlled with medical treatment alone, one eye was planned for drainage device implantation, and one eye required early oil removal. The silicone oil was removed a month after initial vitrectomy for ADED, as there was uncontrolled IOP secondary to silicone oil with persistent vitreous haemorrhage. After ROO, the patient developed suprachoroidal haemorrhage and subsequently the eye became phtisical.

The other dreaded complication of silicone oil is corneal decompensation and band keratopathy, but the incidence was generally low. Three of our patients developed band keratopathy. They had chelation done at the time of ROO, and the condition was reversible in two eyes. None of them needed keratoplasty. This complication may occur when silicone oil comes in contact with the corneal endothelium, causing a reduction in endothelial cell density and pleomorphism of remaining endothelial cells, hence resulting in corneal oedema and bullous keratopathy, stromal hypercellularity, superficial stromal calcification, and retrocorneal membrane formation.

There are several types of silicone oil being used as a tamponade agent in vitrectomy for complex retinal detachment, the most widely used types being 1000, 2000, and 5000 CS. The decision of which oil to use may depend on surgeon preference. These oils are almost similar in terms of surface tension and specific gravity, but have significantly different molecular weights. Evidence has shown that there was no significant difference in incidence of complications between these silicone oils, but a study reported that high-viscosity silicone oil (5000 CS) is more resistant to emulsification. There are several more silicone oil complications other than the ones mentioned above, but not observed in our study, such as macular pucker formation, cystoid macular oedema, and rubeosis.

Most of our patients (40 eyes, 81.6%) had improved vision after ROO. Removing the silicone oil bubble reduces optical interference, hence resulting in better visual acuity. About half of these patients had cataract extraction done in the same setting as ROO, which may contribute to better visual acuity post ROO. Only a small number of patients experienced unchanged (five eyes) or worsening vision (four eyes). These eyes were those with ADED with vitreous haemorrhage, persistent macular oedema, epiretinal membrane formation, and unhealthy macula with disruption of ellipsoid-myoid junction on optical coherence tomography observed during the postoperative period. Possible mechanisms for worsening vision after silicone oil usage were: optic nerve damage as a result of direct tissue infiltration of SO, generalized macular dysfunction with lesions of ganglion cells and horizontal-bipolar cells, and significant reduction in the inner retinal thickness indicating neuronal cell loss in the macular area. From this study, the duration of silicone oil tamponade does not affect patients’ visual acuity before ROO and visual outcome after ROO. However, very few studies have commented on this correlation, but similar findings were reported in Ellen et al.
The mean duration of silicone oil tamponade in our study may not truly reflect the intended practice we want to achieve. With limited time and resources as well as increasing number of patients indicated for silicone oil in our setting, it is impossible for us to comply with the recommended time for ROO.

In conclusion, there should be no exact timing for ROO but, if possible, it should be performed within the recommended duration of three to six months. Having said that, surgeons must also evaluate the anatomical stability and oil-related complications before deciding for ROO. Therefore, the timing for ROO should be made on a case-to-case basis. Thorough examination checking for silicone oil complications is mandatory. This is also applied after ROO to identify early signs of re-detachment. Further study should be carried out to identify the risks of re-detachment among patients after ROO. Patients should also be made aware that even though overall visual improvement after ROO is promising, there is a small risk of vision remaining the same or even worsening after the procedure. This outcome depends greatly on the initial anatomical and functional condition of the retina before vitrectomy. With several types of silicone oil available in the market, the search for an ideal intraocular tamponade with long-acting effect but fewer potential complications will continue.

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