The Impact of Delayed Silicone Oil Removal on Visual Acuity after Pars Plana Vitrectomy: A Cross-sectional Study

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Abstract:
Aims:
This study aimed to compare the effects of delayed silicone oil (SO) removal on visual acuity (VA) in eyes that underwent pars plana vitrectomy (PPV) and oil injection for retinal detachment (RD) or vitreous hemorrhage (VH) with patients who retained SO tamponade for longer periods of time.

Methods:
This was a retrospective analysis of 212 consecutive eyes that underwent PPV and had SO tamponade for more than one year. Phakic eyes also underwent phacoemulsification and intraocular lens implantation at the same surgery, rendering all cases pseudophakic. The cases were followed up post-operatively, and VA data were documented before SO, with SO, and after SO, if removed.

Results:
RD was the indication for surgery in 165 eyes (77.8%), while 47 (22.2%) underwent PPV and SO injection for VH. The difference in VA gain was statistically significant between RD cases who had SO removal and those who had not (P= 0.047). Meanwhile, the difference was not statistically significant in the VH group.

Conclusion:
In this cohort of patients who underwent PPV and SO injection, delayed oil removal in cases operated for RD repair resulted in an improvement in VA despite prolonged oil tamponade for one year or more, compared to similar patients who still had the SO in situ. For VH cases, this effect was less pronounced.

Keywords: Silicone oil, Pars plana vitrectomy, Retinal detachment, Vitreous hemorrhage, Visual acuity, Vitreous substitutes.

1. INTRODUCTION

Since the introduction of pars plana vitrectomy (PPV) in 1971, advances in surgical techniques have gone hand in hand with the need for biocompatible vitreous substitutes and tamponading agents [1 - 3]. Depending on the clinical indication, silicone oil (SO) has emerged as a reliable tamponading agent that promotes adhesion between the retina and the underlying pigment epithelium (RPE) [4].

Compared to intraocular gases, the physical characteristics of SO stand in favor of its use: the volume of SO does not change over time, and is immune to the effects of atmospheric pressure, thereby facilitating prolonged anatomical support of the retina [5, 6]. Common indications for SO injection in PPV include retinal detachment (RD), vitreous hemorrhage (VH), viral retinitis, proliferative diabetic retinopathy, hypotony, and ocular trauma [7].

SO is usually removed after 3-6 months to minimize the risk of emulsification, raised intraocular pressure, and proliferative vitreoretinopathy [8]. Other published studies report vision loss, cataract formation, and RD as complications following the use and removal of SO [9 - 11].
Phacoemulsification with an intraocular lens implant (IOL) may be performed along with PPV, as a combined surgery, in patients with cataracts and RD [12].

Prolonged and even indefinite SO tamponade can be resorted to in certain cases, and few studies have looked into the long-term effects of different oil viscosities used in such cases [13, 14]. This study identified a cohort of patients with prolonged SO tamponade after PPV for two different indications, and aimed to study the impact of delayed SO removal (after one year or more) on visual acuity (VA) in comparison to a similar cohort with retained SO for more than one year.

2. MATERIALS AND METHODS

2.1. Study Design and Data Collection

This study was conducted after the approval of the Institutional Review Board at Jordan University Hospital (Approval no. 871/2022/67). A retrospective observational analysis involving patients who underwent PPV with SO injection for macula-off RD or VH with the SO remaining in situ for one year or more between February 2011 and January 2022 was performed. Exclusion criteria were cases who lost follow-up after surgery, had incomplete or missing medical records or a concomitant ocular disease that may affect vision (glaucoma, optic atrophy, corneal pathology, etc.), and had undergone surgical intervention indicated for reasons other than RD or VH. This cohort of patients with prolonged SO tamponade was a result of the high surgical load at our center. Furthermore, many patients referred for vitrectomy surgery had limited insurance coverage at presentation. Many cases struggled to obtain financial coverage to perform SO removal surgery afterward. These circumstances contributed to creating this unique cohort of patients with prolonged SO tamponade.

Data collected included the date of the operation, diagnosis/indication for surgery, pre-operative lens status, best-corrected VA, if SO removal was done, and the duration of SO tamponade. We obtained VA pre-operatively within one week before surgery, one year after surgery with silicon in situ, and one month after silicon removal if performed. Counting fingers, hand motion, light perception, and no light perception were quantified, according to the ETDRS and FrACT, as 0.014, 0.005, 0.0016, and 0.0013, respectively [15]. These parameters were retrieved from the patients’ surgical records, progress notes, and archive records at the institution and abstracted into a standardized data collection sheet.

2.2. Surgical Setting and Technique

All surgeries were performed by a single vitreoretinal surgeon (NAY) with the same surgical setting for each case. The initial surgical intervention consisted of a 20-gauge three-port vitrectomy system (DORC International BV, Zuidland, Netherlands), complete vitrectomy with shaving of vitreous up to the ora serrata, 360 degrees laser retinopexy and around retinal breaks, and infusion of 1000 centistokes silicon oil for near-complete fill. Additionally, all phakic patients underwent standard phacoemulsification and posterior chamber IOL implantation during the same surgical session. For SO removal, a three-port pars plana surgery was performed on all cases, with the eye filled with atmospheric air or balanced salt solution.

2.3. Statistical Analysis

We used IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA) in our analysis. We used the mean (± standard deviation) to describe continuous variables and the count (frequency) to describe other nominal variables. We categorized the data according to the indication of surgery into the RD group and VH group, and performed the analysis separately. We performed an independent sample t-test to analyze the mean difference between the eyes that had the SO removed versus the group with retained SO, and we presented the data in mean difference and standard deviation (±). We used the Chi-square test to analyze the frequency difference between the eyes that had the SO removed and those that had not, and each categorical variable was included in our analysis. All underlying assumptions were met. We adopted a p-value of 0.05 as a significant threshold.

3. RESULTS

From a total of 852 charts for vitrectomy surgery reviewed between February 2010 and January 2022, 212 eyes from 195 patients had SO tamponade for one or more years, and thus were enrolled in this study. One hundred eyes had a combined PPV with phacoemulsification and IOL implantation surgery. The mean age of this series was 54.5 (±16.78) years. Out of the included sample, 102 (53.1%) patients had their SO removed after one year or more with a mean SO tamponade duration of 17 months. Regarding the indication for surgery, 165 (77.8%) patients underwent vitrectomy for rhegmatogenous or combined rhegmatogenous/traumatic RD, while 47 (22.2%) underwent the surgery for VH. Table 1 summarizes the characteristics of the sample included.

<table>
<thead>
<tr>
<th>Age of Patient (years)</th>
<th>Mean 54</th>
<th>Standard Deviation 17</th>
<th>Count 95</th>
<th>Column N % 45.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye</td>
<td>Left -</td>
<td>-</td>
<td>95</td>
<td>45.0%</td>
</tr>
<tr>
<td></td>
<td>Right -</td>
<td>-</td>
<td>116</td>
<td>55.0%</td>
</tr>
<tr>
<td>Lens status pre-op</td>
<td>Aphakic -</td>
<td>-</td>
<td>9</td>
<td>4.3%</td>
</tr>
<tr>
<td></td>
<td>Pseudophakic -</td>
<td>-</td>
<td>101</td>
<td>48.1%</td>
</tr>
<tr>
<td></td>
<td>Phakic -</td>
<td>-</td>
<td>100</td>
<td>47.6%</td>
</tr>
<tr>
<td>Indication of vitrectomy</td>
<td>Retinal detachment -</td>
<td>-</td>
<td>165</td>
<td>77.8%</td>
</tr>
<tr>
<td></td>
<td>Vitreous hemorrhage -</td>
<td>-</td>
<td>47</td>
<td>22.2%</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of eyes enrolled in the study.
Visual Acuity after Delayed Silicone Oil Removal

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### Table 2. The association between silicone oil removal and visual acuity in retinal detachment cases.

<table>
<thead>
<tr>
<th>-</th>
<th>Mean VA after PPV with silicone oil (one year post-operative)</th>
<th>Standard Deviation</th>
<th>Count</th>
<th>Column N %</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Mean VA with silicone oil (at last documented visit)</td>
<td>0.1294</td>
<td>0.2324</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Mean VA one month after silicone oil removal</td>
<td>0.1012</td>
<td>0.1730</td>
<td>-</td>
</tr>
<tr>
<td>Silicone oil removed?</td>
<td>No</td>
<td>0.1517</td>
<td>0.2172</td>
<td>-</td>
</tr>
<tr>
<td>Yes</td>
<td>-</td>
<td>90</td>
<td>46.9%</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Mean duration of silicone oil</td>
<td>17</td>
<td>16</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: VA: Visual Acuity (in decimals); PPV: Pars plana vitrectomy.

### Table 3. The association between silicone oil removal and visual acuity in vitreous hemorrhage cases.

<table>
<thead>
<tr>
<th>-</th>
<th>Mean VA after PPV with silicone oil (one year post-operative)</th>
<th>Standard Deviation</th>
<th>Count</th>
<th>Column N %</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Mean VA with silicone oil (at last documented visit)</td>
<td>0.1442</td>
<td>0.2576</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Mean VA one month after silicone oil removal</td>
<td>0.1404</td>
<td>0.2441</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Mean duration of silicone oil</td>
<td>17</td>
<td>16</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: SO: Silicone oil; VA: Visual acuity (in decimals); PPV: Pars plana vitrectomy.

Out of the 165 eyes operated for RD, 85 (51.5%) had SO removal surgery after a mean of 15.82 (±2.56) months, while 30 (63.8%) did not have SO removal. Both groups had a comparable proportion of lens status preoperatively (p=0.528), as shown in Table 3. We observed a non-statistically significant difference in visual acuity gain between patients who had SO and patients who did not, with a mean difference of 0.153 (95% CI -0.02 to 0.32), p= 0.086. Yet, visual acuity change from the pre-operative to the last post-operative vision was higher for those who had SO removal.

Out of the 47 VH eyes, 17 (36.2%) had SO removal surgery after a mean of 15.82 (±2.56) months, while 30 (63.8%) did not have SO removal. Both groups had a comparable proportion of lens status preoperatively (p=0.610), as shown in Table 2. Upon comparing VA change from pre-operative to last post-operative vision, we observed a statistically significant difference in visual acuity gain between patients who had oil removal and patients who did not have SO removal, with a mean difference of 0.077 (95% CI 0.001 to 0.15), p= 0.047.
4. DISCUSSION

RD and VH are the main indications for PPV surgery. As a tamponading agent, SO is used to attach the retina on the RPE in RD cases and also prevent vitreous cavity re-bleeding after vitrectomy for VH [16]. Retained SO after PPV surgery may cause complications, such as emulsification and raised intraocular pressure, while removal of SO can also be associated with loss of vision [17, 18]. Previous studies have reported an improvement in VA after SO removal [19, 20]. The improvement of visual acuity after SO removal can be explained by the elimination of the variability in refraction induced by the anterior curve of the silicon oil bubble and light diffraction induced by droplets of emulsified oil [21]. Issa et al. noticed an initial rapid improvement in VA during the first 6 months after SO removal, followed by a slower, progressive improvement [10]. Overall, improved VA after SO removal is due to a combination of factors, including the slow recovery of the naturally reattached retina, altered optics during SO tamponade with improved refraction after oil removal, and possible retinal toxicity with improved function after SO extraction. However, the best corrected VA remained unchanged in 56.3% of eyes in the report presented by Shah et al. [22]. Williams reported no visual improvement among patients after SO removal compared to their best-recorded acuities under oil tamponade [9]. Worse visual outcomes were reported in other studies, with Roca et al. reporting a significant visual loss following SO in 13% of eyes [23]. Similarly, in 34.8% of the cases reported by Oliveira-Ferreira, there was VA loss by at least two Snellen lines [18].

In our study, RD was the major indication of the original PPV with the injection of SO. We observed an overall improvement in VA after the removal of SO in cases where the oil was used as a tamponade for one or more years. Flaxel studied a similar cohort, although with a shorter tamponade time, and reported that 63% had either maintained or improved their VA after SO removal [19]. In contrast, Moissetiev et al. reported no visual improvement after silicon removal where RD was the main indication for SO injection [24, 25]. Interestingly, we found a non-statistically significant difference in visual acuity gain between patients who had SO removal versus patients who did not have SO removal among VH patients.

This study is inherently limited by its retrospective nature. Incomplete data have precluded addressing details related to intraocular pressure fluctuations and refractive error changes after SO removal. All eyes in this cohort were operated upon by a single surgeon and in the same surgical setting, and the effect of cataract formation on visual acuity changes was stratified as all cases were either pseudophakic to start with or had undergone cataract extraction at the same time of vitrectomy surgery. Lastly, our cohort included a relatively large number of cases from a single tertiary center and they were followed up for more than one year.

CONCLUSION

Despite prolonged SO tamponade for more than one year, delayed oil removal in cases that underwent PPV for RD repair resulted in an improvement in VA in this cohort of consecutive patients when compared to similar patients who still had the SO in situ. For VH cases, this effect was less pronounced.

LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO</td>
<td>Silicone oil</td>
</tr>
<tr>
<td>PPV</td>
<td>Pars plana vitrectomy</td>
</tr>
<tr>
<td>VA</td>
<td>Visual acuity</td>
</tr>
<tr>
<td>RD</td>
<td>Retinal detachment</td>
</tr>
<tr>
<td>VH</td>
<td>Vitreous hemorrhage</td>
</tr>
<tr>
<td>RPE</td>
<td>Retinal pigment epithelium</td>
</tr>
<tr>
<td>IOL</td>
<td>Intraocular lens</td>
</tr>
</tbody>
</table>

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study has been approved by the Institutional Review Board at Jordan University Hospital (Approval no. 871/2022/67).

HUMAN AND ANIMAL RIGHTS

No animals were used for studies that are the basis of this research. No procedures were performed on humans as this was a retrospective analysis of patients' records.

CONSENT FOR PUBLICATION

A written informed consent form was obtained from patients to review their files for this retrospective study.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available from the corresponding author upon reasonable request and is stored at the Ophthalmology Division archives at Jordan University Hospital.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES


Schulze-Bonsel K, Felgent N, Burau H, Hansen L, Bach M. Visual acuities “hand motion” and “counting fingers” can be quantified with the freiburg visual acuity test. Invest Ophthalmol Vis Sci 2006; 47(3): 1226-40. [http://dx.doi.org/10.1167/iovs.05-0981] [PMID: 16505064]


