Risk Factors for Retinal Redetachment After Silicone Oil Removal: A Systematic Review and Meta-Analysis

Yueqing He, MD; Shaoxue Zeng, MD; Yunni Zhang, MD; Junjun Zhang, MD

BACKGROUND AND OBJECTIVE: This systematic review and meta-analysis was made to measure risk factors for retinal redetachment (re-RD) after silicone oil removal (SOR) in a quantitative method.

PATIENTS AND METHODS: A comprehensive literature review relating to risk factors for re-RD after SOR was conducted before March 2017. Odds ratio (OR) with 95% confidence interval (CI) was calculated after data combination.

RESULTS: Sixteen studies were included, and risk factors with significant differences found between the re-RD and control groups are as follows: aphakic eye (OR = 1.50), high myopia (OR = 2.47), previous failed retinal surgery (OR = 1.71), and ocular trauma (OR = 3.52). Peripheral 360° laser retinopexy (OR = 0.40) and scleral encircling band (OR = 0.58) were found to be protective factors of re-RD after SOR.

CONCLUSION: Aphakic eye, high myopia, previous failed retinal surgery, ocular trauma, lack of 360° laser, and scleral encircling band were possible risk factors relating to the occurrence of re-RD after SOR.


INTRODUCTION

Vitrectomy with silicone oil (SO) tamponade is an effective way to treat complicated retinal detachment (RD) and has improved the prognosis of severe vitreoretinal diseases. Long-term silicone oil tamponade can lead to oil-related complications such as cataract, glaucoma, emulsification, and keratopathy; therefore, the oil is usually removed after a certain period of time. Silicone oil removal (SOR) improves the visual function and can reduce the oil-related complications. However, lack of oil-supporting effect and the proliferation of epiretinal membranes after SOR can result in retinal redetachment (re-RD). Several risk factors of re-RD after SOR have been studied, and some associations between them have been observed. The published results in these studies are not in accordance because of a variety of limitations and different methods. Therefore, we conducted a systematic review and meta-analysis to summarize the data extracted from including studies. This may be useful for doctors to decide the treatments and provide precautions for patients with higher risks.

PATIENTS AND METHODS

Search Strategy and Study Selection

We conducted a comprehensive literature search using PubMed, Embase, the Cochrane Library, the Wanfang database, and VIP databases to confirm appropriate studies with the language restricted to Eng-

From the Department of Ophthalmology, Sichuan University West China Hospital, Chengdu, Sichuan, China (YH, SZ, JZ); and the Department of Oncology, Sichuan University West China Hospital, Chengdu, Sichuan, China (YZ).

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Address correspondence to Junjun Zhang, MD, Department of Ophthalmology, Sichuan University West China Hospital, No. 37, Guoxue Road, Chengdu, China 610041; email: zhangjunjun@medmail.com.cn.

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lish and Chinese, with the final search performed on March 30, 2017. The following search terms were used: “retinal redetachment,” “redetachment of retina,” “recurrent retinal detachment,” “recurrent detachment of retina” in combination with “remove of silicone oil” or “silicone oil removal,” and “risk factor.”

The eligibility criteria were: (1) studies concerning risk factors related to re-RD after SOR; (2) the risk factors included must have existed before SOR; (3) comparative studies containing randomized, controlled trials (RCTs), retrospective or perspective case-control studies, or cohort studies; (4) the odds ratio (OR) or rate ratio values of each risk factor were reported with 95% confidence interval (CI), or raw data were available for calculating. Animal studies, case reports, abstracts, conference proceedings, repeated publications, nonpublished materials, reviews, and editorials were excluded from our study.

Data Extraction and Study Quality Assessment
Two investigators (YH, YZ) screened and extracted data independently and a third reviewer (JZ) made the
final decision when inconsistency occurred between the two reviewers. The following data were collected by YH and SZ from the included: first author, year of publication, country of study, study design, sample size, and number of patients. We evaluated the level of evidence of each study according to Oxford Centre for Evidence-Based Medicine levels of evidence system5 and applied the Newcastle-Ottawa Scale6 for the quality of nonrandomized, controlled studies. Studies scored with seven or more stars were regarded as high quality.

Statistics Analysis

Unadjusted ORs with 95% CIs were selected or calculated for being synthesized to identify the degree of relationship between these risk factors and re-RD after SOR. We used the Chi-squared test in the heterogeneity test on the basis of Cochran’s Q.
and I² statistic. No significant heterogeneity existed when the P value was greater than .10. If the I² statistic was less than 50% in the heterogeneity test, the fixed-effects model was then to be applied. Otherwise, a random-effects model was used. Publication bias was assessed by inverted funnel plot. We used the software RevMan (version 5.3; Cochrane Collaboration, Oxford, United Kingdom) for data analyses. We considered results in our meta-analysis to be significant if a two-sided P value was less than .05.

RESULTS

Studies Characteristics

We identified 16 studies with a total of 3,598 patients with 3,620 eyes in this systematic review and meta-analysis (Figure 1), the characteristics of which

![Figure 5](image-url)

Unadjusted odds ratio and 95% confidence intervals (CIs) of ocular trauma (ocular trauma / without trauma) for retinal redetachment (re-RD) after silicone oil removal.

![Figure 6](image-url)

Unadjusted odds ratio and 95% confidence intervals (CIs) of encircling band (encircling band / no encircling band) for retinal redetachment (re-RD) after silicone oil removal.

![Figure 7](image-url)

Unadjusted odds ratio and 95% confidence intervals (CIs) of peripheral 360° laser retinopexy (360° laser / no 360° laser) for retinal redetachment (re-RD) after silicone oil removal.
are listed in Table 1. The published time of these studies was from November 1997 to March 2017. Among the 16 studies, eight were retrospective case-control study,\(^8\) one was a prospective cohort study,\(^21\) one was a prospective, randomized, controlled experiment,\(^22\) and one was a retrospective cohort study.\(^23\) A total of 548 eyes got re-RD after SOR, and 3,072 eyes occupied the control group. Twelve factors referred in three or more studies were identified for further quantitative analyses. It was observed that aphakic eye, high myopia, previous failed retinal surgery, SO tamponade because of ocular trauma, shorter duration of SO, preoperative rubeosis, inadequate vitreous base shaving, and abnormal initial intraocular pressure (IOP) were significant risk factors relating to the occurrence of re-RD after SOR, whereas encircling band, peripheral 360° laser retinopexy, and emulsified oil were identified as possible protective factors for patients with the potential to have re-RD. SO tamponade resulting from giant retinal tear, proliferative diabetic retinopathy, proliferative vitreoretinopathy (PVR), gender, and retinectomy did not appear to be related to a higher frequency of re-RD.

**Aphakic Eye**

A total of seven studies reported the relationship between lens status before SOR and re-RD after SOR.\(^9,11,13,15,16,18,19\) The non-aphakic eye meant the patient’s eye still had its own lens or had received an intraocular lens (IOL). No significant heterogeneity was observed (I\(^2\) = 20%; \(P = .28\)), and a fixed-effects model was applied. These seven studies showed that an aphakic eye was a significant risk factor for re-RD after SOR (OR = 1.50; 95% CI, 1.08-2.09; \(P = .02\)) (Figure 2). No publication bias existed in the inverted funnel plot.

**High Myopia**

Five studies considered high myopia as a related factor of re-RD,\(^13,15,18,19,22\) whereas another study reported that statistical differences existed between long axial length (> 27.0 mm) and short axial length (\(\leq 27.0 \) mm).\(^11\) As 27.0 mm is approximately equivalent to a refraction of -6.00 diopters (D) and a commonly used epidemiologic definition of high myopia, this study was co-analyzed with the other five studies. No significant heterogeneity was concluded (I\(^2\) = 15%; \(P = .31\)), and a fixed-effects model was applied. The result of these six studies indicated the significant difference between case and control groups (OR = 2.47; 95% CI, 1.83-3.34; \(P < .00001\)) (Figure 3). No publication bias was discovered through inverted funnel plot with regard to these six studies.

**Previous Failed Retinal Surgery**

Four studies described previous failed retinal surgery before the operation of SO tamponade,\(^11,14,15,18\) and no significant heterogeneity was concluded (I\(^2\) = 0%; \(P = .45\)). After combination of data from these studies, previous failed retinal surgery was determined to be a significant risk factor for re-RD after SOR (OR = 1.71; 95% CI, 1.16-2.54; \(P = .007\)) (Figure 4). The inverted funnel plot did not show any publication bias.
A total of three studies reported on SO tamponade because of eye trauma. \textsuperscript{8,16,17} No significant heterogeneity was concluded ($I^2 = 42\%$; $P = .18$). Although only one of these studies showed trauma was a risk factor \textsuperscript{16} and two other studies showed no significant differences, \textsuperscript{8,17} we concluded that significant differences existed between the trauma and control groups ($OR = 3.52; 95\% CI, 1.84-6.74; P = .0001$) (Figure 5). No publication bias existed by applying inverted funnel plot to these studies.

Encircling Band
Seven studies researched the relationship of encircling band and re-RD after SOR. \textsuperscript{8,10,12,14,15,16,20} Significant differences existed between the case and control groups ($OR = 0.58; 95\% CI, 0.43-0.78; P = .0004$), with no heterogeneity ($I^2 = 4\%$; $P = .40$) (Figure 6). The findings from these studies indicated that encircling band could be a protective factor for patients with potential re-RD. We did not detect publication bias after conducting the inverted funnel plot.

Peripheral 360° Laser Retinopexy

<table>
<thead>
<tr>
<th>Included Study</th>
<th>Country</th>
<th>Case/Control</th>
<th>Mean Age</th>
<th>Sample (n)</th>
<th>Quality Score</th>
<th>Risk Factors</th>
<th>Study Design / LOE</th>
<th>Included Case / Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ünlü et al., 2004</td>
<td>Turkey</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>39</td>
<td>16 / 52</td>
<td>4,6,7,8,9,12</td>
<td>*******</td>
<td>Retrospective cohort study, 2\textsuperscript{b}</td>
<td>Turkey</td>
</tr>
<tr>
<td>Scholda et al., 2000</td>
<td>Austria</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>44 / 50</td>
<td>15 / 94</td>
<td>1,12</td>
<td>*******</td>
<td>Retrospective cohort study, 2\textsuperscript{b}</td>
<td>India</td>
</tr>
<tr>
<td>Jonas et al., 2001</td>
<td>Germany</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>51 / 50</td>
<td>57 / 168</td>
<td>4,8,9,12</td>
<td>*******</td>
<td>Retrospective cohort study, 2\textsuperscript{b}</td>
<td>China</td>
</tr>
<tr>
<td>Lam et al., 2008</td>
<td>China</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>81 / 42</td>
<td>43 / 120</td>
<td>6,14</td>
<td>98 / 42</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>China</td>
</tr>
<tr>
<td>Goezinne et al., 2007</td>
<td>Netherlands</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>54 / 44</td>
<td>118 / 233</td>
<td>8,10,11,14</td>
<td>******</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>China</td>
</tr>
<tr>
<td>Teke et al., 2014</td>
<td>Turkey</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>51 / 50</td>
<td>118 / 776</td>
<td>1,2,7,10,12,13</td>
<td>*******</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>Turkey</td>
</tr>
<tr>
<td>Laidlaw et al., 2002</td>
<td>England</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>53 / 42</td>
<td>57 / 230</td>
<td>3,4,5,7,10</td>
<td>******</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>England</td>
</tr>
<tr>
<td>Meng et al., 2013</td>
<td>Saudi Arabia</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>48 / 42</td>
<td>42 / 105</td>
<td>1,2,3,10,14</td>
<td>*******</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>China</td>
</tr>
<tr>
<td>Al-Wadani et al., 2014</td>
<td>Saudi Arabia</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>33 / 42</td>
<td>6 / 144</td>
<td>1,2,7,15</td>
<td>*******</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>Nagpal et al., 2012</td>
<td>India</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>38 / 41</td>
<td>117 / 323</td>
<td>4,5,16</td>
<td>*******</td>
<td>Retrospective case-control study, 3\textsuperscript{b}</td>
<td>India</td>
</tr>
<tr>
<td>Tufail et al., 1997</td>
<td>UK</td>
<td>Prospective cohort study, 2\textsuperscript{b}</td>
<td>40 / 42</td>
<td>15 / 16</td>
<td>5</td>
<td>*******</td>
<td>Prospective cohort study, 2\textsuperscript{b}</td>
<td>Italy</td>
</tr>
<tr>
<td>Avitabile et al., 2008</td>
<td>Italy</td>
<td>Prospective RCT, 1\textsuperscript{b}</td>
<td>45</td>
<td>39 / 126</td>
<td>2,5</td>
<td>*******</td>
<td>Prospective RCT, 1\textsuperscript{b}</td>
<td>India</td>
</tr>
<tr>
<td>Dhalla et al., 2016</td>
<td>Tanzania</td>
<td>Retrospective cohort study, 2\textsuperscript{b}</td>
<td>47.85</td>
<td>12 / 87</td>
<td>5</td>
<td>*******</td>
<td>Retrospective cohort study, 2\textsuperscript{b}</td>
<td>Tanzania</td>
</tr>
</tbody>
</table>

Baseline Characteristics and Quality Assessments of Included Studies

**Table 1**
rence of re-RD after SOR. Among these studies, four regarded peripheral 360° laser retinopexy as a protective factor of re-RD after SOR. No significant heterogeneity was concluded (I² = 0%; P = .68) and a fixed-effects model was applied subsequently, indicating significant differences between the re-RD and control groups (OR = 0.40; 95% CI, 0.29-0.56; P < .00001) (Figure 7). Publication bias did not exist in the inverted funnel plot.

Duration of SO

A total of 10 studies concentrated on the difference in duration of SO tamponade between the re-RD group and the control group; however, only six of those studies provided usable data for analysis. In total, a relative high heterogeneity was reached (I² = 80%; P = .0002), with a significant difference between the two groups, demonstrating that reattached eyes had longer tamponade of SO than re-RD eyes (OR = −1.49; 95% CI, −2.94 to −0.05; P = .04) (Figure 8). However, when we analyzed by subgroup, we found no significant difference was reached between the European and Chinese subgroups.

Other Factors

Some factors that were not significant risk factors, or that were researched in fewer than three studies, are included in Table 2, which includes their pooled effects. Among these factors, preoperative rubeosis, inadequate vitreous base shaving, and abnormal initial IOP could be regarded as significant risk factors, although emulsified oil might be a protective factor for re-RD after SOR. Nevertheless, additional quality studies were still needed to confirm the validity of the relationship between these factors and re-RD after SOR.

### DISCUSSION

This systematic review and meta-analysis consisted of 3,598 patients with 3,620 eyes from 16 studies. To our knowledge, the extraction and evaluation of 16 risk factors for meta-analysis is the first one concerning risk factors of re-RD after SOR. However, some of these factors still needed further systematically designed studies to confirm.

SO is commonly used in the management of complicated retinal detachment. Nevertheless, due to the time-related complications caused by SO such as cataract, glaucoma, emulsification, and keratopathy, the tamponade is often temporary and SO needs to be removed once the retina is flat. Re-RD after SOR seemed to be a major complication of the early postoperative period, which occurred in between 2% and 33% of cases.

Although, in this meta-analysis, we found PVR before operation was not a risk factor for re-RD after SOR, it was reported that formation of PVR after SOR could be a main cause of re-RD. PVR could be regarded as an over repair after injury with a characteristic of fibrous and non-vascular membrane. It was the formation and contraction of this membrane that appeared to cause most of the cases of re-RD. The reason for the rapidity of the detachment may be re-

### TABLE 2

<table>
<thead>
<tr>
<th>Potential Risk Factors</th>
<th>Number of Studies</th>
<th>Heterogeneity</th>
<th>OR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO tamponade because of giant retinal tear</td>
<td>6</td>
<td>56%</td>
<td>0.04</td>
<td>1.85 (0.84-4.04)</td>
</tr>
<tr>
<td>SO tamponade because of PDR</td>
<td>5</td>
<td>77%</td>
<td>0.001</td>
<td>0.79 (0.20-3.19)</td>
</tr>
<tr>
<td>SO tamponade because of PVR</td>
<td>6</td>
<td>22%</td>
<td>0.27</td>
<td>1.25 (0.90-1.75)</td>
</tr>
<tr>
<td>Gender</td>
<td>8</td>
<td>14%</td>
<td>0.32</td>
<td>0.90 (0.70-1.14)</td>
</tr>
<tr>
<td>Retinectomy</td>
<td>3</td>
<td>0%</td>
<td>0.80</td>
<td>1.43 (0.95-2.16)</td>
</tr>
<tr>
<td>Preoperative rubeosis</td>
<td>2</td>
<td>0%</td>
<td>0.38</td>
<td>2.42 (1.03-5.66)</td>
</tr>
<tr>
<td>Inadequate vitreous base shaving</td>
<td>1</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal initial IOP</td>
<td>1</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emulsified oil</td>
<td>1</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

re-RD = retinal redetachment; SOR = silicone oil removal; OR = odds ratio; CI = confidence interval; SO = silicone oil; PDR = proliferative diabetic retinopathy; PVR = proliferative vitreoretinopathy; IOP = intraocular pressure
sidual or new traction that is counteracted by the oil before its removal. Ocular trauma, previous failed retinal surgery, and inadequate vitreous base shaving would all activate the cellular and fibrosis proliferation and promote the formation of PVR, thus causing the persistent traction that increased the likelihood of re-RD occurring.

High myopia was often accompanied by extensive retinal choroid atrophy and degeneration, thus giving a higher incidence of atrophic retinal hole than that of non-high myopia eyes. Eyes undergoing SOR had their vitreous cavity filled with water. Without vitreous body, fluid would be easy to get into any tiny hole, which would develop to re-RD afterward. Moreover, retinal fissure and PVR promoted each other, making it difficult to judge the causality. In our meta-analysis, high myopia was shown to be a significant risk factor for re-RD after SOR, indicating that patients with high myopia should strengthen postoperative follow-ups after SOR in order to promote earlier discovery of the potential occurrence of re-RD.

Aphakia was showed to be a risk factor of re-RD after SOR in our meta-analysis. The mechanism of which aphakic eye would result in a higher frequency of re-RD was not quite clear. Speculation was made that the lens and lens capsule could prevent some inflammatory factors from entering the vitreous cavity from the anterior chamber. A normal blood-eye barrier would be broken once the lens and capsule were removed. On the other hand, aphakia was considered to be related to the formation of PVR after SOR, thus leading to the failure of retinal reattachment.

It was suggested that the application of peripheral 360° laser retinopexy before SOR might be associated with a reduced incidence of re-RD compared with that observed in patients who did not receive the treatment. This is because 360° laser retinopexy will treat unseen breaks or prevent formation of new breaks after SOR. In a prospective, randomized clinical trial, Avitabile et al. demonstrated that 360° laser retinopexy reduced the incidence of RD after SOR from 21.4% to 8.6%. The placement of an encircling band relieves circumferential traction, enhances the tamponade effect of SO, and might be an important factor in preventing new break formation after SOR. La Heij et al. showed that the absence of an encircling band was associated with re-RD after SOR. Velikay-Parel et al. reported only 5% re-RD after SOR in complicated RDs that were treated by placing an encircling band and the use of 360° endolaser retinopexy.

The timing for SOR is still controversial and varies, depending on the series, from between 8 weeks and 12 weeks to between 6 months and 11 months to 22 months. The duration of SO tamponade was not found by other authors to be related to a higher percentage of re-RD, whereas Hutton et al. found that SO tamponade was significantly shorter in re-RD patients. Although our meta-analysis indicated that re-RD patients had a significantly shorter period of SO tamponade, it was not quite cogent because of the high heterogeneity. Further study for more accurate and reliable conclusions is needed.

Our systematic review and meta-analysis concluded that aphakia, high myopia, previous failed retinal surgery, ocular trauma, shorter duration of SO, inadequate vitreous base shaving, preoperative rubeosis and abnormal preoperative IOP might be significant risk factors related to the occurrence of re-RD after SOR, whereas encircling band, 360° prophylactic laser before removal of SO, and emulsified oil might be potential protective factors. Therefore, doctors should take these factors into consideration and assign follow-up treatments as needed. Additionally, further prospective studies with larger samples and precise controls are needed for more reliable and convinced conclusions.

REFERENCES


