Corneal Endothelial Cell Loss After Multiple Vitreoretinal Procedures and the Use of Silicone Oil

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BACKGROUND AND OBJECTIVE: Corneal decompensation and complications are a frequent cause of visual loss after vitreoretinal surgery. This paper presents data regarding endothelial cell loss in aphakic and pseudophakic silicone oil filled eyes when oil was retained for many months. This study updates our previous investigation on the subject.

PATIENTS AND METHODS: The corneal endothelial cell count of 10 eyes of 10 consecutive patients who had undergone vitreoretinal surgery, including fluid-gas exchange and ultimately silicone oil placement, were obtained. The patients underwent an average of 2.7 ± 0.9 vitreoretinal procedures before the final procedure which induced the placement of silicone oil in the vitreous cavity. All had inferior iridectomies. The endothelial cell density measurements were obtained an average of 1 year after silicone oil placement. In all eyes, the oil was felt necessary for long term tamponade and therefore was not removed. The cell density of the operated eye was compared to the fellow eye, none of which had undergone silicone oil placement.

RESULTS: Both gas and retained silicone oil contribute to the loss of corneal endothelial cell density. The average endothelial cell loss in the 10 eyes with oil retained for an average of 10 ± 12 months was 68.8 ± 31.4%, as compared to the fellow eye. The average cell loss was higher in the three eyes with silicone oil in the anterior chamber (range 44 to >95%). Pseudophakic eyes fared better, on average, than aphakic eyes (51.66 ± 28% vs. 66.63 ± 26.3%) with respect to cell loss. Five aphakic eyes and 1 pseudophakic eye developed corneal edema.

CONCLUSIONS: Endothelial cell loss occurs after vitreoretinal surgery and is exacerbated by long term silicone oil retention. The corneal endothelial cell damage is probably cumulative from procedure to procedure. Endothelial cell loss may be pronounced in eyes without a physical barrier between the anterior segment and the vitreous cavity, and in eyes where oil migrates into anterior chamber.


INTRODUCTION

Corneal complications of vitreoretinal surgery are seldom the primary concern of the surgeon oper-
reduce cell density. For instance, during the early days of phacoemulsification surgery, many eyes developed corneal edema associated with endothelial cell loss, particularly if the surgeon was inexperienced.\textsuperscript{4,5} Historically, the measurement of corneal endothelial cell density was performed prior to cataract surgery until it was apparent that with better surgical techniques, corneal decompensation could usually be prevented. Viscoelastic agents proved invaluable in protecting the endothelium during surgery and soon were being used routinely.\textsuperscript{5}

Diddie and Shanzlin showed that pars plana vitrectomy in phakic eyes, and in those where lensectomy was performed but where the anterior lens capsule was retained until late in the case, suffered little cell loss.\textsuperscript{7} In a prospective study, Friberg and colleagues reported on the reduction of endothelial cell density after various vitreoretinal procedures.\textsuperscript{8}

They found that vitrectomy in phakic eyes was not associated with significant cell loss, but in an aphakic eye undergoing vitrectomy and scleral buckling, the mean cell loss was 12.6 ± 2.3% measured 3 months after surgery. In addition, a fluid gas exchange using 30% SF\textsubscript{6} and 70% air in an eye undergoing a vitrectomy and scleral buckle was associated with significantly more cell loss than if the fluid gas exchange was not performed. The effects of silicone oil, however, were not investigated; therefore, a further investigation into the effects of silicone oil on the cornea endothelium was conducted in this study.

**PATIENTS AND METHODS**

During a 48-month-period, 10 consecutive eyes of 10 patients who had previously undergone vitreoretinal surgery with placement of silicone oil were examined and asked to undergo an assessment of their corneal endothelium. In these eyes, the retinal pathology was so extensive that silicone oil removal was judged to be likely to lead to loss of the eye subsequent to re-detachment. After obtaining informed consent, endothelial cell count photos were taken of the operated and fellow eye with a Carl Zeiss, Inc. (Thornwood, N.Y.) non-contact photo slit lamp with cell count lens. Photographs were taken of the central 4 mm of the cornea of a zone 0.1 mm square using Kodak (Eastman Kodak Co., Rochester, N.Y.) high-contrast Technical Pan Professional film. The final magnification of 15× is seen in the photographs.

Cell count densities were calculated from the cell count photographs taken by an ophthalmic photographer experienced in the technique. All patients had had an inferior iridectomy and had undergone an average of 2.4 ± 0.9 vitreoretinal procedures, including the placement of the silicone oil. The fellow eye of the 10 patients had not undergone any surgical procedure except placement of an intraocular lens in patients 2, 4 and 6 (Table 1). Three patients had intraocular lenses while 7 were surgically aphakic when the silicone oil was placed into the eye with the retinal detachment. Four eyes had had previous fluid-gas exchanges prior to the silicone placement.
Table 2. Corneal Endothelial Cell Loss Compared to Fellow Eye

<table>
<thead>
<tr>
<th>Patient #</th>
<th>SO (months)</th>
<th>ECC SO eyes</th>
<th>ECC (fellow eye)</th>
<th>ECC Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48</td>
<td>Undetectable</td>
<td>2540</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>Undetectable</td>
<td>2000</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1460</td>
<td>2850</td>
<td>49%</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>1350</td>
<td>1600</td>
<td>16%</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>110-150</td>
<td>2880</td>
<td>95%</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>Undetectable</td>
<td>1250</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>1750</td>
<td>1930</td>
<td>9%</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>Undetectable</td>
<td>2520</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>Undetectable</td>
<td>3150</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1170</td>
<td>2090</td>
<td>44%</td>
</tr>
</tbody>
</table>

SO = silicone oil  
ECC = endothelial cell count

RESULTS

The patients included 6 women and 4 men. The ages at the time of measurement of the endothelial cell counts ranged from 27 to 83 years. On average, the endothelial cell count in eyes containing silicone oil were 70% lower (68.8 ± 31.4%) than the fellow eye for the 10 patients. Silicone had been placed from 2 to 48 months before the cell counts were obtained (average 10 ± 12 months).

Table 2 lists the endothelial cell counts of all 10 patients and their respective time between silicone oil placement and endothelial cell count measurements. The number of vitreoretinal procedures performed prior to the goal vitrectomy and placement of silicone oil is listed in Table 1. The mean number of antecedent procedures was 2.7 ± 0.9. All patients had at least one fluid-gas exchange with SF6, which failed before the final surgery with silicone oil placement.

Six eyes had corneal decompensation as manifested by gross corneal edema or band keratopathy. Five of these eyes were surgically aphakic; 2 were pseudophakic with oil present in the anterior chamber.

DISCUSSION

As surgery using silicone oil for complex retinal reattachment procedures was adopted, postoperative corneal decompensation, including band keratopathy (Figure 1), became more frequent. After 1985, numerous reports described the deleterious effects of silicone oil on the cornea. In a Canadian study, 50% of aphakic eyes undergoing silicone oil injection developed irreversible keratopathy within 2 weeks or surgery; however, the presence of the lens largely prevented this complication. Austrian investigators reported that 68% of aphakic patients develop band keratopathy after undergoing second surgery following failed vitrectomy and scleral buckling after penetrating trauma. In these studies, however, inferior iridectomies were not performed at the time of surgery. In a large German study of 361 eyes undergoing vitrectomy, investigators found that 60% of eyes developed corneal decompensation when silicone oil was present in the anterior chamber; band keratopathy occurred in 77% of the trauma cases, while bullous keratopathy developed in 47% of the eyes with idiopathic proliferative vitreoretinopathy.

The mechanism of corneal decompensation after silicone oil injection was investigated by Stemberg and
colleagues in an animal model. After silicone oil was injected into the anterior chamber of rabbit and cat eyes, a 40% loss of corneal endothelial cells occurred within 6 days. The detrimental effect of silicone oil on the cornea was felt to be largely a mechanical one, with some contribution from alterations in corneal nutrition secondary to the presence of oil. Direct toxicity of the oil was not believed to be a likely mechanism. Histopathologic features of corneas requiring transplantation due to silicone oil keratopathy have been described; these include endothelial cell loss, development of retrocorneal membranes, stromal hypercellularity, superficial calcification, and vascularization.

Because silicone oil in the anterior chamber causes rapid depletion of the population of the endothelial cells, preventing the anterior migration of oil from the vitreous cavity is important. In aphakic eyes, supine positioning can lead to endothelial damage. Corneal decompensation in the form of edema occurred in our series in 4 of 7 aphakic eyes, despite the fact that patients were cautioned against supine positioning. All of these patients had inferior iridectomies, but 4 had retained oil for 12 months or more. As silicone oil is buoyant, the inferior iridectomy allows aqueous from the posterior chamber to flow into the anterior chamber, even if the pupil is blocked by the silicone oil meniscus (Figure 2). The inferior iridectomy then indirectly limits access of silicone oil into the anterior chamber by establishing more normal aqueous fluid dynamics, reducing potential complications. In contrast to the high corneal decompensation rates in eyes with oil retained for long periods of time, Lemmen and colleagues reported a 6% incidence of aphakic eyes developing corneal decompensation when the anterior chamber was free of silicone, and an iridectomy had been performed below. Riedel found 5.5% of all eyes developed band keratopathy or edema after placement of silicone oil and performance of an iridectomy.

In the present study the corneal endothelial cell population was severely depleted in the studied eyes, compared to their fellow eye which had not undergone vitreous surgery. All oil-filled eyes had undergone multiple vitreoretinal surgical procedures. It was not possible to obtain preoperative cell count measurements on these patients for logistical reasons because many were referred for immediate surgery after having had vitreoretinal procedures without the placement of oil elsewhere. We cannot, therefore, quantitate the specific portion of cell loss ascribable to the silicone oil placement in this study. However, our data strongly suggests that cell loss occurring from serial vitreoretinal procedures is cumulative so when silicone oil is eventually used, the cornea may have already lost much of its endothelial cell reserve (Table 3).

Abrams speculated that there may be cumulative damage to corneal endothelial cells by repeated surgery. In his study population, 30% of the eyes having previous surgery had corneal abnormalities as compared to 16% of eyes that had no surgery prior to vitrectomy for proliferative vitreoretinopathy (PVR). We emphasize, however, that the high percentage of cell loss in our patients was reflective of the fact that 7 of the 10 eyes were aphakic, and the silicone oil was not deemed removable because of serious retinal pathology. Furthermore, we believe additional endothelial cell loss from the placement of intravitreous silicone oil is likely to worsen over time, particularly if the eye is aphakic. From Table 2, 6 eyes had endothelial cell loss of more than 50% compared to controls, 5 were aphakic, and 1 was pseudophakic. Four of these eyes with high endothelial cell loss percentages had retained silicone oil for 12 months or more. It is very likely that in an aphakic eye with intravitreous silicone oil, the longer the oil is retained the more likely it is for endothelial cell damage to occur.

To limit the damage to the corneal endothelium, intraocular gas should not be used indiscriminately, particularly if it touches the corneal endothelium. When silicone oil was used to treat PVR in a larger multicentered study, keratopathy was significantly more prevalent in eyes that had undergone previous...
Table 3. Estimates of Expected Cell Loss After Vitreoretinal Surgery

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Cell Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sceral buckle*</td>
<td>0%</td>
</tr>
<tr>
<td>Pars plana vitrectomy, phakic*</td>
<td>0%</td>
</tr>
<tr>
<td>Pars plana vitrectomy, aphakic*</td>
<td>12.6% ± 2.3%</td>
</tr>
<tr>
<td>Pars plana vitrectomy, lensectomy, scleral buckle* (average)</td>
<td>14.1 ± 1.9%</td>
</tr>
<tr>
<td>Without fluid gas exchange*</td>
<td>8.5 ± 1.8%</td>
</tr>
<tr>
<td>With fluid gas exchange (SF₆ 30%)*</td>
<td>16.9 ± 1.9%</td>
</tr>
<tr>
<td>Pars plana vitrectomy aphakic, with placement of silicone oil after previous vitreoretinal surgery with gas exchange</td>
<td>21-95%</td>
</tr>
<tr>
<td>Pars plana vitrectomy, pseudophakic, with placement of silicone oil after previous vitreoretinal surgery with gas exchange, oil in anterior chamber</td>
<td>44-95%</td>
</tr>
</tbody>
</table>

* From Frilberg TR, et al.®

vitrectomy with an intraocular gas tamponade. However, the overall incidence of corneal abnormalities at 24 months following surgery for PVR was 27% in both gas filled (C₃F₈) and silicone oil filled eyes.®

Prognostic factors for the development of corneal abnormalities, defined as corneal epithelial edema, stroma edema, corneal opacity or subsequent corneal transplantation, have been established. They include aphakia, iris neovascularization, reoperations, corneal touch with silicone oil, fluid gas exchange, and anterior segment inflammation.®

Corneal touch from silicone oil can be reduced by having an open inferior iridectomy. Forward migration of oil is highly correlated with closure of the peripheral iridectomy (80%), whereas only about 11% of eyes with a patent PI developed oil in the anterior segment.¹⁴ Unfortunately, many inferior iridectomies ultimately close from scarring across the posterior surface of the iris at the iridectomy. The iridectomy should be inferiorly located, peripheral, and large enough so as not to be easily closed. If the pupil needs to be enlarged in the course of vitreoretinal surgery, a sector iridectomy should be avoided, particularly in the superior locations.

If oil bubbles develop in the anterior segment, they should be removed. (Figure 3) In our series, corneal edema occurred in 2 of 3 pseudophakic eyes, each of which had oil in the anterior segment. This is not easily done without bringing the patient back into the operating room for unless the cause of forward migration is eliminated, oil will usually re-accumulate anteriorly.

Occasionally it is possible to displace the oil bubbles posteriorly by filling the anterior segment with air while the patient is supine. If the iridectomy is fibrosed closed, it should be first reopened. This procedure can be done in an outpatient clinic setting, but often is not

Figure 3. A bubble of silicone oil has been trapped within the anterior chamber in this phakic eye. Over a relatively short time, substantial loss of corneal endothelial cells is likely unless the oil is removed.

Figure 4. Emulsified oil has formed in an inverted meniscus and may ultimately lead to corneal decompensation or glaucoma if not removed.
successful because the cause of the anterior migration is usually not eliminated by these maneuvers. In our experience, most eyes with anterior oil migration have developed at least a partial retinal detachment with PVR posteriorly. The accumulated subretinal fluid then takes up a percentage of the volume of the vitreous cavity, displacing silicone oil anteriorly. To definitely eliminate oil in the anterior segment, eyes with recurrent retinal detachments should be repaired by removing any epiretinal proliferations and by removing the subretinal fluid. The patency of the inferior iridectomy should be re-established, and the eye refilled with oil or long-acting gas. Over-filling the vitreous cavity should be carefully avoided to prevent anterior oil migration. The vitreous cavity should be filled with oil just up to the plane of the iris, without bowing the iris forward.

If an intraocular lens is present, the posterior capsule is a relative barrier to anterior oil migration if it is intact. In traumatized eyes, or those which have undergone multiple surgical procedures, defects in the capsule or zonules will make anterior oil migration more likely. Ideally, the silicone oil should be removed from the eye but in some instances, particularly after multiple failed surgeries, removal of the oil may lead to recurrent retinal detachment. Hence, removal has to be weighed against this possibility for each patient.

Emulsification of silicone oil causes the formation of multiple small bubbles in the anterior segment (Figure 4). Silicone oil should be removed or replaced in most of these cases. In general, eyes which have had silicone oil removed have a lower incidence of corneal decompensation than eyes in which it has been retained. In some cases however, silicone oil removal can precipitate rapid decompensation of the cornea, although this is not the rule. Removal of silicone oil provides the surgeon with the opportunity to remove any pre-retinal membranes causing macular distortion. Moreover, certain corneal abnormalities, such as band keratopathy, can also be addressed at this point. Penetrating keratoplasty can be performed during the removal of the silicone oil on the decompensated eyes having good visual potential. Although little has been written regarding the possible mechanisms of corneal trauma from residual perfluorocarbon bubbles in the anterior segment, it seems prudent to remove these bubbles if they are large and numerous. This can be done at the slit-lamp by placing a needle in the anterior chamber and aspirating the bubbles in many instances.

In conclusion, corneal abnormalities are not unusual following repeated vitreoretinal surgery. It is known that corneal complications can be minimized by performing vitrectomy while preserving a barrier between the vitreous and anterior segment. If a lensectomy is necessary, consider retaining the anterior capsule for future placement of an intraocular lens in the sulcus, or consider placing an in-the-bag intraocular lens at the time of surgery. Avoid placing air or gas in the anterior segment unnecessarily. In aphakic gas-filled eyes, prone positioning will limit gas touch against the cornea. In silicone-filled aphakic eyes, supine position should generally be avoided.

REFERENCES


