

## Visual Outcomes and Refractive Status after Combined Silicone Oil Removal/Cataract Surgery with Intraocular Lens Implantation

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### Abstract

**Purpose:** To evaluate refractive status and identify predictors of surgical success following a combined silicone oil removal/cataract surgery with intraocular lens (IOL) implantation procedure.

**Methods:** In this single-armed, retrospective study, we reviewed patients who underwent vitreoretinal surgery followed by a combined silicone oil removal/cataract surgery procedure between 2009 and 2013. Preoperative data included patient demographics, refractive status, IOL power, and axial length (measured with the IOL Master). Postoperative data were obtained from the 8-week follow-up visit and from the last follow-up visit attended that included refractive error (RE) evaluation (e.g., myopic, hyperopic, and astigmatic). Associations between variables and refractive status were examined. Blindness was defined as a best-corrected visual acuity (BCVA) worse than 3/60.

**Results:** Ninety-eight eyes were ultimately included in analyses. Following surgery, 37.0% of eyes achieved BCVA better than 6/18. The incidence of blindness (BCVA worse than 3/60) was reduced from 47.0% before surgery to 17.3% after surgery. Additionally, 33.7% of eyes did not require refractive correction. Forty-two percent of eyes were under-corrected (>0.5 D hyperopia) following surgery. Age, gender, silicone oil viscosity, axial length, IOL type, initial vitreoretinal pathology, surgeon, and IOL calculation formula were not significantly associated with surgical outcomes (all  $P > 0.05$ ).

**Conclusion:** A combined silicone oil removal/cataract surgery with IOL implantation procedure restored functional vision in approximately one-third of cases. However, nearly half of patients were under-corrected. Unfortunately, we did not identify any factors that predicted surgical success.

**Keywords:** Cataract Extraction; Intraocular Lens Implantation; Refractive Errors; Silicone Oil

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### INTRODUCTION

Silicone oil tamponade is often used in eyes with a complicated vitreoretinal pathology<sup>[1]</sup> and is usually

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removed 3 to 6 months after surgery.<sup>[2]</sup> However, the presence of silicone oil accelerates cataract progression, which justifies performing proactive cataract surgery and intraocular lens (IOL) implantation at the time of silicone oil removal.<sup>[3]</sup> Unfortunately, silicone oil makes it challenging to accurately calculate IOL power, increasing the chances for residual refractive error. Previous studies have evaluated refractive status following combined cataract surgery/posterior chamber silicone oil removal.<sup>[4-6]</sup> However, these studies had small sample sizes and, to the best of our knowledge, none included Arab patients.

The current study evaluates ocular refractive status (e.g., myopic, hyperopic, and astigmatic) before and after a combined silicone oil removal/cataract extraction with IOL implantation procedure. Factors associated with final refractive error and surgical outcomes are also examined.

## METHODS

The institutional research board approved this single-armed, retrospective study. All patients who were willing to participate in the study provided written informed consent and all study conduct adhered to the tenets of the Declaration of Helsinki. Patients with vitreoretinal pathologies who had undergone silicone oil tamponade between 2012 and 2016 were included in this study. Patients with no refraction data following surgery and those with a history of vitrectomy with suturing were excluded.

The sample size was calculated assuming that refractive status was more severe than  $\pm 2.00$  D in 72% of eyes following a combined silicone oil removal/cataract surgery with IOL implantation procedure.<sup>[7]</sup> A sample size of 100 eyes was required to power the study comparison (preoperative estimate to postoperative spherical equivalent RE mismatch) to 80% (with a 95% confidence interval [CI]).

Two ophthalmologists served as the field investigators. Preoperative data regarding patient demographics (age, gender, eye involved), time between silicone oil tamponade and cataract surgery, visual acuity, and pre-cataract surgery ocular status were collected. Best-corrected distance visual acuity (BCVA) was measured using an Early Treatment Diabetic Retinopathy Study (ETDRS) chart placed at 6 meters. If the patient could not correctly identify the top letter on the chart, the test was repeated at distances of 3 and 1.5 m. The BCVA was recorded in meter.

Patients underwent anterior segment examination using slit lamp biomicroscopy (Topcon Corp., Tokyo, Japan). The IOL power for implantation was measured using laser interferometry (IOL Master; Zeiss, Jena, Germany) and a Pentacam (Oculus GmbH, Wetzlar, Germany). Partial coherence interferometry was performed while patients were in the upright position.

The following data were collected: surgical date, implant position, IOL power, silicone oil viscosity (1,000 or 5,000 cSt), and complications.

Based on axial length, IOL power was calculated using the SRK/T, Hoffer, or Holladay formula.<sup>[8]</sup> Technicians from the ultrasonography department performed all measurements using a consistent standard to minimize inter-observer variation.

All patients underwent standard phacoemulsification surgery thru a 2.2 mm corneal incision at the temporal position. Surgery included a continuous curvilinear capsulorhexis, hydrodissection, phacoemulsification with cortex removal using automated irrigation/aspiration, and foldable IOL implantation into the capsular bag.<sup>[9]</sup> The target refraction in all cases was approximately -0.5 D. The pars plana entry was performed using a 23-gauge Constellation vitrectomy system (Alcon laboratories, Fort Worth, TX, USA) and valved trocars in the inferotemporal and superior quadrants 3.5 mm from the limbus. An infusion line was inserted into the inferotemporal port and fluid pressure was set to 30 mmHg. All silicone oil was removed using a supratemporal approach with the vacuum set at 480-650 mmHg. Following silicone oil removal, the trocars were removed and ocular patency was tested. If leakage was detected, the sclerotomy was closed with a 7-0 vicryl suture.

All eyes underwent standard 3-port 23-gauge sutureless pars plana vitrectomy. Additional retinal procedures (e.g., membrane peeling, endolaser photocoagulation, and residual vitreous removal) were performed at the surgeon's discretion.

The following postoperative data were collected: BCVA, refraction, and date BCVA was tested. All postoperative manifest refraction measurements were converted to the spherical equivalent for analysis. The most recent value was used if BCVA was the same with different manifest refractions. The observed refraction was compared with predicted refraction to determine IOL calculation accuracy. Visual acuity for distance was graded as "normal" if BCVA was better than 6/18, "moderate visual impairment" if BCVA was between 6/18 and 6/60, "severe visual impairment" if BCVA was between <6/60 and 3/60, and "blindness" if BCVA was worse than 3/60.

The main outcome measure was postoperative refractive error. We calculated the spherical equivalent for eyes with <2.0 D astigmatism. An IOL calculation success was defined as postoperative emmetropia or <2.0 D of myopia (intentional overcorrection for spectacle-free near vision). An IOL calculation failure (did not achieve spectacle-free vision after cataract surgery) was defined as a postoperative RE more severe than -2.0 D (over-corrected, Failure 1) or more severe than +0.5 D (hyperopic, Failure 2). A postoperative astigmatism >2.0 D was also considered an IOL

calculation failure (Failure 3). Associations between success and pre- and intraoperative factors were also evaluated.

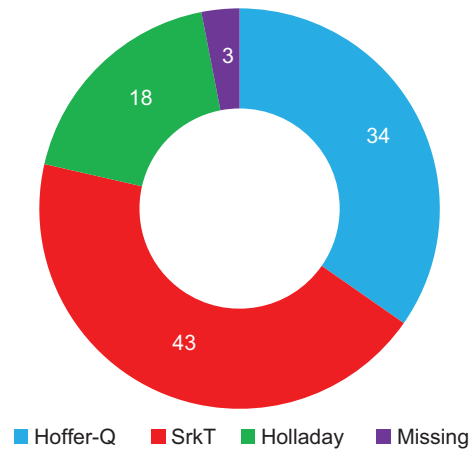
Data were collected using a pretested data collection form and transferred to an Excel® (Microsoft Corp., Redmond, WA, USA) spreadsheet. A commercially available statistical software package (SPSS version 23; IBM Corp., New York, NY, USA) was used to perform univariate analyses using both parametric and non-parametric methods. For qualitative variables, frequencies and proportions (as percentages) were calculated. For normally distributed quantitative variables, the mean and standard deviation were calculated. For quantitative variables that were not normally distributed, the median and 25% quartile were calculated. Two-tailed calculations were used for all *P* values. The odds ratio (OR), 95% CI, and two-sided *P* values were used to evaluate associations between final refractive error and potentially predictive factors. Statistical significance was defined as *P* < 0.05.

## RESULTS

This study ultimately included 98 eyes (49 right eyes) of 98 patients (54 men) that underwent a combined silicone oil removal/phacoemulsification with IOL implantation procedure. Mean patients age was  $48.0 \pm 13.5$  years. The median time period between silicone oil tamponade and removal during cataract surgery was 9 months (25% quartile cut-off = 6.6 months, minimum = -2.3 months, maximum = 36 months). Silicone oil tamponade was performed in 36 eyes with a rhegmatogenous retinal detachment (RD, including 4 eyes with high myopia and 2 eyes with a total RD), 45 eyes with a tractional RD, and 17 eyes with vitreous hemorrhage. Nine eyes had a history of 360° scleral buckling and 4 eyes had a history of segmental scleral buckling. Prior to combined surgery, BCVA was less than 3/60 in 46 eyes. Additionally, average preoperative corneal curvature was  $43.7 \pm 2.3$  D (steep meridian =  $43.0 \pm 2.1$  D, flat meridian =  $44.3 \pm 2.2$  D) and mean axial length was  $24.4 \pm 2.75$  mm.

Axial length was measured with the IOL Master in 91 eyes (92.9%) and with A-scan ultrasound sonography in 7 eyes (7.1%). The distribution of formulas used to calculate IOL power is summarized in Figure 1. The SRK/T formula was used in nearly half of cases [Figure 1]. Mean calculated IOL power was  $18.6 \pm 7.1$  D (minimum = -6.0 D, maximum = +30.0 D). The IOL was implanted in the capsular bag in 96 eyes and sulcus fixation was required in 1 eye. In the remaining eye, the surgeon attempted to place the IOL in the posterior chamber, but ultimately decided against it because of the presence of neovascularization.

Three cataract surgeons performed all surgeries. Surgeon 1 operated on 41 eyes, Surgeon 2 operated on 17 eyes, and Surgeon 3 operated on 36 eyes.



**Figure 1.** Proportion of eyes in which each formula was used to calculate intraocular lens power.

Information regarding the operating surgeon was missing for 4 eyes. An Acrysof IOL (Alcon, Inc., Fort Worth, TX, USA) was implanted in 81 eyes (82.7%), an [IOL model name] IOL (AMO, Inc., Santa Anna, CA, USA) was implanted in 1 eye, an AMO IOL (Alcon, Inc., USA) was implanted in 5 eyes, an Acrysof IQ IOL was implanted in 9 eyes, and a Rayner IOL (Rayner Surgical Group Ltd., Hove, United Kingdom) was implanted in 1 eye. Fifty-one eyes (52%) underwent tamponade with a more viscous silicone oil ( $\geq 5000$  cSt) and 47 eyes (48%) underwent tamponade with a less viscous silicone oil (<1500 cSt).

Figure 2 summarizes visual function status before surgery and at the last follow-up visit (6–8 weeks after cataract surgery). Before surgery, 47.0% of eyes had blindness (BCVA worse than 3/60). At the last postoperative follow-up visit, 37.0% of eyes had functionally normal vision (BCVA better than 6/18) and 17.3% of eyes had blindness.

Refractive error status at the last follow-up visit is summarized in Table 1. Spectacle-free distance vision was achieved following cataract surgery in 33.7% of eyes (95% CI: 24.3% to 43.1%). At the last follow-up visit, 42% of eyes were under-corrected (more than +0.5 D of hyperopia). Associations between success/failure and various pre- and intraoperative variables are presented in Tables 2 and 3 compares outcomes of the current study to those of previously published studies.

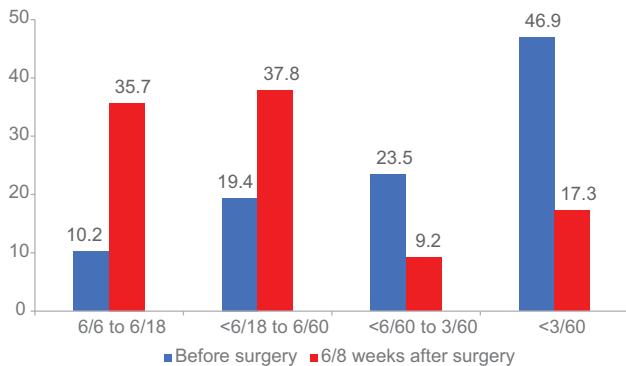
## DISCUSSION

The current study may be the largest study of eyes undergoing a combined silicone oil removal/phacoemulsification with IOL implantation procedure. Distance visual acuity better than 6/18 was achieved in more than one-third of the current cases. A similar proportion of eyes achieved spectacle

**Table 1. Success rates for providing spectacle independence following a combined silicone oil removal/phacoemulsification with intraocular lens implantation procedure**

Spectacle-free distance vision	Refractive status	n (eyes)	%	95% CI
Success	-2.00 to +0.25 D	33	33.7	24.3-43.1
Failure 1 (myopia)	Worse than -2.00 D	7	7.1	2.0-12.2
Failure 2 (under-correction)	+0.50 to +8.50 D	41	41.8	32.0-51.6
Failure 3 (astigmatism)	Cylinder >2.00 D	17	17.3	9.8-24.8

n, number; D, diopter; CI, confidence interval



**Figure 2.** Percentage of eyes with a visual disability before and after a combined silicone oil removal/cataract surgery with intraocular lens implant procedure. The x-axis shows visual disability categories and the y-axis shows the percentage of eyes operated on. The blue column indicates preoperative vision status and the red column indicates postoperative vision status. The blindness reduced from 47% to 17% and severe visual impairment reduced from 24% to 9% due to intervention.

independence for distance vision. Estimations of IOL power resulted in more hyperopic cases than IOL power estimation in eyes without silicone oil. Unfortunately, we were not able to identify any preoperative factors that predicted postoperative success.

Conclusions regarding axial length and IOL power estimations in eyes with silicone oil could not be drawn from previous studies because of small sample sizes.<sup>[4,5,7]</sup> However, the study by Kas'yanov et al<sup>[10]</sup> had a larger sample size and suggested that adequate axial length measurements could be made in eyes with silicone oil if a specific A-scan setting was used. Patwardhan et al<sup>[6]</sup> and Habibabadi et al<sup>[4]</sup> reported a reduced postoperative incidence of functionally normal vision because of IOL power miscalculations, especially in highly myopic eyes. Selecting the appropriate IOL calculation formula and adjusting for high myopia may mitigate these miscalculations.<sup>[5,10]</sup>

Our study has several limitations. First, sample size calculations were based on outcomes published by Ghoraba et al<sup>[7]</sup> The success rate of the current study was in agreement with the 28% rate obtained by Ghoraba et al<sup>[7]</sup> despite differences between studies in definitions of success. Ophthalmologists generally aim for emmetropia or leave the eye slightly myopic

to achieve spectacle-free near vision.<sup>[11]</sup> Thus, we defined cataract surgery success as a postoperative RE between -2.00 and + 0.25 D. Hence, comparing our results to previous studies should be done with caution. Second, the median interval between silicone oil tamponade and cataract surgery in our study was 9 months. Early cataract development is very common in eyes that have had silicone oil in the vitreous cavity for more than 3 months.<sup>[12]</sup> Unfortunately, we were not able to determine the time between silicone oil tamponade and cataract development. Knowing the cataract status at each follow-up visit is crucial and patients should be educated on the possibility of needing cataract surgery in the future. Third, accurately measuring axial length with ultrasound is challenging in eyes with silicone oil, but can be done when A-scan velocity is set to 1000 m/s.<sup>[13]</sup> The IOL Master measures axial length using laser interferometry (using partially coherent light) and can also be used in the "silicone oil" mode.<sup>[10]</sup> Fourth, our study sample included highly compromised eyes with posterior segment pathology and a history of retinal surgery. Therefore, in our opinion, achieving functionally normal vision in more than one-third of cases is a good outcome. Half of the number of eyes in our study had a tractional RD and 2 eyes had a total RD. Therefore, decreased vision was expected in eyes with an RD, even after successful cataract surgery. However, our study cohort should be further assessed for diabetic retinopathy, the main underlying cause of tractional RDs and vitreous hemorrhages. Fifth, in our study, refractive status was not different between eyes that received low and high viscosity silicone oil. Zafar et al<sup>[14]</sup> reported that visual and anatomical outcomes were comparable between eyes that underwent tamponade with 1000 and 5000 cSt silicone oil. However, 1000 cSt silicone oil emulsifies early. Lastly, we were not able to identify preoperative predictors of surgical success, likely because small subgroup sample sizes limited our ability to detect statistically significant associations. Prospective studies that include a larger number of subjects are needed to identify predictors of spectacle independence and BCVA following cataract surgery in eyes with silicone oil.

**Table 2. Factors associated with success rates for providing spectacle independence following a combined silicone oil removal/phacoemulsification with intraocular lens implantation procedure**

	Success -2.00 to +0.25 D n=33		Failure 1 Myopia worse than -2.00 D n=7		Figure 2 Under- correction +0.50 to -8.50 D n=41		Failure 3 Astigmatism cylinder >2.00 D n=17		P
	n	%	n	%	n	%	n	%	
Gender									
Male	17	51.5	5	71.4	23	56.1	9	52.9	0.9
Female	16	48.5	2	28.6	18	43.9	8	41.1	
Viscosity									
≥5000 cSt	14	42.4	4	57.1	21	51.2	8	47.1	0.3
<1500 cSt	19	57.6	3	42.9	20	48.8	9	52.9	
Axial length (mm)									
Mean±SD	24.3±3.0		25.7±2.5		24.1±2.3		25±3.3		0.4
Age (years)									
Mean±SD	49.7±9.1		42.9±15.4		48.6±15.2		45.1±15.7		0.5
IOL type									
Acrysof	29	87.9	5	71.4	33	80.5	14	82.4	0.5
Other	4	12.1	2	28.6	7	19.5	3	17.6	
Initial vitreoretinal									
RRD	13	39.4	4	57.1	11	27.5	7	41.2	0.9
Disease									
PDR	17	51.5	1	14.3	15	37.5	7	41.2	0.7
High myopia	0	0.0	0	0.0	1	2.5	2	11.8	
VH	3	9.1	2	28.6	11	27.5	1	5.9	
Total RD	0	0.0	0	0.0	2	5.0	0	0.0	
Surgeon									
1	14	42.4	3	42.9	15	36.6	9	52.9	0.7
2	6	18.2	0	0.0	9	22.0	2	11.8	
3	11	33.3	3	42.8	15	36.6	6	35.3	
Not noted	2	6.1	1	14.3	2	4.9	0	0.0	
Formula									
Hoffer Q	9	27.3	1	14.3	19	46.3	5	29.4	0.2
Holladay	5	15.2	2	28.6	8	19.5	3	17.6	
SRK/T	18	54.5	3	42.9	13	31.7	9	52.9	
Not noted	1	3.0	1	14.3	1	2.4	0	0.0	

Statistical significance defined as  $P < 0.05$ . SD, standard deviation; IOL, intraocular lens; RRD, rhegmatogenous retinal detachment; PDR, proliferative diabetic retinopathy; VH, vitreous hemorrhage; RD, retinal detachment, D, diopter; n, number

**Table 3. Historical outcomes of a combined silicone oil removal/phacoemulsification with intraocular lens implantation procedure**

Study	Country	n	Main outcome	Ref #
Habibabadi et al., 2005	Iran	13	RE=-0.30±0.91 D (at 12 weeks)	4
el Baha et al., 2003	Egypt	12	SRK/T and Holladay formulas best for eyes with a high AL	5
Patwardhan et al., 2009	India	12	RE=±0.50 D in 4 eyes RE=±1.00 D in 12 eyes	6
Ghoraba et al., 2002	Egypt	29	RE=3.04±2.68 D (all highly myopic eyes)	7
Parravano et al., 2007	Italy	10	Silicone oil does not affect AL measurement	12
Kas'yanov et al., 2015	Russia	60	AL measurement sufficient when A-scan velocity=1000 m/s	13
Current study	Saudi Arabia	98	Spectacle-free distance vision in 33.7% of eyes	----

RE, refractive error; Ref, reference; AL, axial length; D, diopter; n, number

## CONCLUSION

In summary, estimating IOL power in eyes with silicone oil is challenging. One-third of our patients had normal functional vision and one-third of cases had spectacle-free distance vision following a successful combined silicone oil removal/cataract surgery with IOL implantation procedure.

## Financial Support and Sponsorship

Nil.

## Conflicts of Interest

There are no conflicts of interest.

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