Original Article

Refractive outcomes of a single-step and a two-step approach for silicone oil removal and cataract surgery

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Purpose: To compare the intermediate-term refractive outcomes of a single-step and a two-step approach for silicone oil removal (SOR) and cataract surgery. **Methods:** Case records of patients who had SOR and phacoemulsification (PE) from 2011 to 2013 at a tertiary center in South India were retrospectively analyzed. A total of 135 eyes that underwent ultrasound biometry (UB) were studied. Eighty-seven eyes had SOR and PE at a single surgery (Group A), where as UB was done in a silicone oil (SO) filled eye. Forty-eight eyes had SOR followed by PE later (Group B), where UB was done in a fluid-filled eye. The refractive error (RE) and best-corrected visual acuity (BCVA) at postoperative day 45 (D45) and postoperative month 3 (M3) were compared. **Results:** Baseline axial length, intraocular lens (IOL) power, and RE in both groups were comparable. A myopic shift (4.18 ± 5.47 diopters [D]) was noted in 92% eyes at M3. Forty-nine percent eyes had a RE of ≤±1.5D at M3. RE at D45 and at M3 was significantly lesser in Group B (−1.73 ± 2.04 vs. −0.64 ± 1.75; *P*, 0.002). BCVA was significantly lesser in Group A at baseline, at D45, and at M3 (*P* < 0.01 for all). There was no difference in other baseline characteristics of eyes that had RE ≤±1.5D and those that had RE >±1.5D at M3. **Conclusion:** SO-filled eyes had a myopic shift in refraction after SOR and PE. When UB is used for IOL power calculation, better refractive outcomes are obtained when SOR and PE are performed in a two-step approach.

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Vitreoretinal (VR) surgery for retinal detachment (RD) often requires the use of tamponade agents. Silicone oil (SO) and intraocular gases are commonly used tamponade agents after RD surgery.[1] SO is a better alternative to intraocular gases when long-term tamponade is essential.[2] However, the presence of SO within the eye invariably leads to the development of cataract.[2,3] In addition, there is also the simultaneous occurrence of SO emulsification. Therefore, any vitrectomized eye filled with SO is a potential candidate for two further ocular procedures – SO removal (SOR) and cataract extraction with intraocular lens (IOL) implantation. Today, phacoemulsification (PE) is the preferred method for cataract surgery with IOL implantation.

Ultrasound biometry (UB) is commonly used for axial length (AL) estimation in IOL power calculation.[4] SO-filled eyes present certain challenges during ultrasonic examination owing to the altered speed of sound.[4,5] We compare the refractive outcomes of eyes that underwent combined SOR and PE, where UB was performed in a SO-filled eye with the refractive outcomes of eyes that underwent SOR followed by PE, where UB was performed in a fluid-filled eye.

Methods

A retrospective study was performed after Institutional Ethics Committee clearance. The tenants of the Declaration of Helsinki were followed. Case records of eyes that underwent SOR and PE with IOL implantation from January 2011 to December 2013 were reviewed. We excluded eyes that had complicated cataract surgery, recurrent RD, eyes with scleral fixated IOLs, eyes that underwent intraoperative posterior capsulotomy or Yag capsulotomy within postoperative month 3 (M3), and eyes with corneal opacities. We also excluded eyes that had biometry done with laser interferometry. Thereafter, 135 eyes of 135 patients were included in the study. Of these, 87 eyes underwent both SOR and PE at a single sitting and were grouped together in group A. Forty-eight eyes had SOR as a first surgery followed by PE at a later date. These eyes were grouped in Group B. Eleven patients did not undergo M3 follow-up and eyes were excluded from final analysis.

The study participants had comprehensive eye evaluation before SOR and PE, at postoperative day 45 (D45), and at M3. Best-corrected distance visual acuity (BCVA) was estimated using the Snellen's chart. The logMAR values were used for statistical analysis. In all eyes, UB (Ocuscan RXP, Alcon) was used to estimate the AL with the contact A scan technique. The velocity of sound was altered as per the need of the eye being analyzed. In group A, with SO-filled eyes, the velocity was taken to be 980 meters per second (m/s). In group B, as UB was done after SOR in fluid-filled eyes, sound velocity was taken as 1532 m/s. The corneal curvature was estimated

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by a manual method (Super KMS 6, Bausch and Lomb). The Holladay formula was employed for the calculation of IOL power in eyes with AL ≤26 mm, and SRK/T formula was used for eyes with AL >26 mm.[4] In all eyes, the IOL power closest to emmetropia was chosen.

Eyes in group A underwent clear corneal PE with IOL implantation followed by SOR using two 23-gauge sclerotomies (Constellation, Alcon). Sutures to the corneal incision and sclerotomies were placed only if persistent leak was noted. Eyes in group B underwent SOR and PE by the same method but during two different sessions.

The demographic and ocular characteristics of all eyes in the study were tabulated. Eyes in group A and in group B were tabulated separately. Differences between groups were evaluated using Chi-square for categorical data (Fisher exact test) and independent samples *t*-test (Mann–Whitney U-test) for continuous variables. Pre and postsurgical changes were analyzed with the paired *t*-test. Thereafter, eyes were divided into two groups based on RE at month 3 (RE ≤±1.5 D and RE >±1.5 D). Possible predictors for lesser final RE were analyzed. A statistically significant difference was made out when *P* was < 0.05. All the statistical analyses were performed with SPSS 20 (SPSS Inc., Chicago, IL, USA).

Results

The two groups were comparable with respect to age, gender, laterality, AL, IOL power, and RE at the start of the study (*P* > 0.05 for all) [Table 1]. For eyes in group B, PE was performed 124 ± 49 days after SOR. A myopic shift (4.18 ± 5.47 diopters [D]) was noted in 92% (114 of 124) eyes at M3. Forty-nine percent (61 of 124 eyes) eyes had a RE of ≤±1.5D on M3 [Table 2]. Of these, 29 eyes were in group A and 32 in group B (*P*, 0.005). When compared to baseline, BCVA improved significantly at M3 (1.05 ± 0.50 to 0.83 ± 0.53; *P* < 0.001).

The RE on D45 was significantly higher in group A than that in group B (−2.02 ± 1.68 vs. −0.63 ± 1.75; *P* < 0.001). The same difference was noted to persist at M3 (−1.73 ± 2.04 vs. −0.64 ± 1.59; *P* < 0.001) [Fig. 1]. Within the groups, RE decreased significantly from baseline to D45 (group A: *P* < 0.001; 95% confidence interval [CI], 3.46–5.76 and group B: *P* < 0.001; 95% CI, 2.51–6.14). When comparing RE on D45 and RE at M3, there was no significant difference in both groups (group A: *P*, 0.98 and group B: *P*, 0.11).

At the baseline, BCVA was significantly lesser in group A when compared to group B (1.22 ± 0.51 vs. 0.89 ± 0.50; *P* < 0.001). At D45, BCVA remained poor in group A (1.02 ± 0.56 vs. 0.73 ± 0.54; *P*, 0.004). This difference persisted at M3 (1.00 ± 0.57 vs. 0.65 ± 0.48; *P*, 0.006) [Fig. 2]. Within the groups, BCVA improved significantly from baseline to D45 in group A (*P* < 0.001, 95% CI, 3.46-5.76) and not in group B (*P*, 0.13). When BCVA on D45

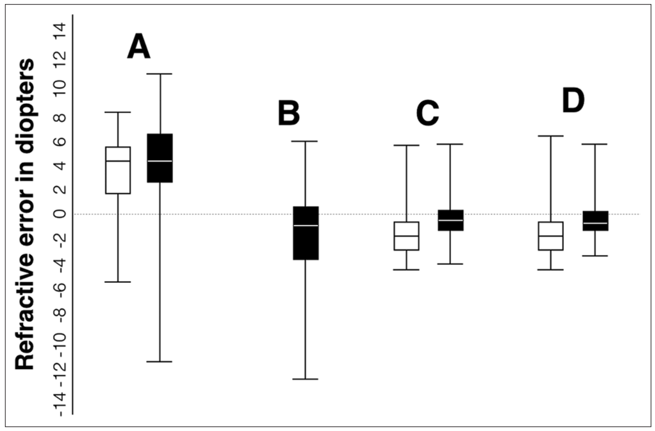

Figure 1: Whisker plot showing the refractive status of eyes in both groups Group A is shown in white boxes and group B is shown in black boxes. Plot A represents the refractive error (RE) before silicone oil removal (SOR) and phacoemulsification (PE). Plot B represents the RE after SOR (group B alone). Plot C shows the RE on postoperative day 45 (D45). Plot D shows the RE at postoperative month 3 (M3). The RE was comparable before SOR and PE. After SOR and PE, the RE was significantly lesser in group B

Table 1: Demographic and ocular characteristics of eyes that underwent silicone oil removal and cataract surgery at the same sitting (group A) and at two separate sittings (group B)

	Group A (*n*=87)	Group B (*n*=48)	*P*
Age, in years, mean (range; SD)	51.6 (11-73; 15.3)	53.2 (25-71; 14.8)	0.55
Males (%)	65 (75)	35 (73)	0.54
Right eye (%)	43 (49)	25 (52)	0.76
Axial length, in mm, mean (range; SD)	24.18 (21.43-30.68; 1.94)	24.24 (20.11-31.86; 2.37)	0.83
IOL power, in diopters, mean (range; SD)	19.45 (4-27.5; 4.86)	18.77 (7-29.5; 5.55)	0.46
Refractive error, in diopters, mean (range; SD)			
Before oil removal and cataract surgery	3.17 (−6 to 8; 3.40)	3.01 (−11.25 to 10.63; 4.68)	0.88
45 days after oil removal	-	−2.24 (−13 to 5; 4.11)	
45 days after oil removal and cataract surgery	−2.02 (−5 to 5; 1.68)	−0.63 (−4.5 to 4.5; 1.75)	<0.001***
3 months after oil removal and cataract surgery	−1.73 (−5 to 6.13; 2.04)	−0.64 (−3.37 to 4.5; 1.59)	0.002**
Visual acuity, in logMAR, mean (range; SD)			
Before oil removal and cataract surgery	1.22 (0.17-1.85; 0.51)	0.89 (0.17-1.85; 0.50)	<0.001***
45 days after oil removal	-	1.14 (0.17-1.85; 0.57)	
45 days after oil removal and cataract surgery	1.02 (0-1.85; 0.56)	0.73 (0-1.85; 0.54)	0.004**
3 months after oil removal and cataract surgery	1.00 (0-1.85; 0.57)	0.65 (8-43; 0.48)	0.006**

*P<0.05. **P<0.01. ***P<0.001, *n*-Number of Eyes, SD-Standard Deviation, mm -millimeters, IOL-Intraocular lens, logMAR-Logarithm of minimum angle of resolution

Table 2: Differences between the eyes based on refractive error at postoperative month 3

	Refractive error at month 3 ≤±1.5D (*n*=61)	Refractive error at month 3 >±1.5D (*n*=63)	*P*
Age, in years, mean (range; SD)	52.9 (25-73; 14.2)	51.9 (11-71; 16.1)	0.71
Males (%)	45 (73)	47 (75)	0.91
Right eye (%)	33 (54)	29 (46)	0.37
Group A: Group B, number of eyes	29:32	49:14	0.005**
Axial length, in mm, mean (range; SD)	24.31 (20.11-30.68; 2.18)	24.58 (21.50-31.86; 2.28)	0.67
IOL power, in diopters, mean (range; SD)	18.25 (4-29.5; 5.21)	18.29 (7-25; 5.07)	0.73
Refractive error, in diopters, mean (range; SD)			
Before oil removal and cataract surgery	3.55 (−8 to 10.63; 4.07)	2.24 (−6 to 8.5; 3.68)	0.11
45 days after oil removal and cataract surgery	−0.73 (−1.50 to 1.25; 0.65)	−1.85 (−5 to 6.13; 2.55)	<0.001***

**$P<0.01$, ***$P<0.001$, D-Diopters, *n*-Number of Eyes, SD-Standard Deviation, mm-millimeters, IOL-Intraocular lens

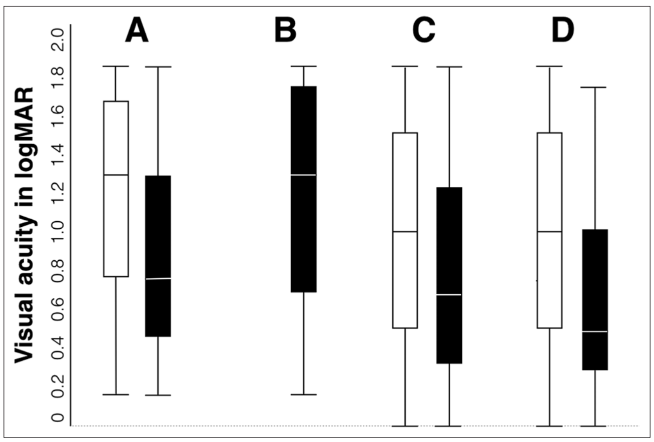

Figure 2: Whisker plot showing the visual acuity of eyes in both groups Group A is shown in white boxes and group B is shown in black boxes. Plot A represents the visual acuity (VA) before silicone oil removal (SOR) and phacoemulsification (PE). Plot B represents the VA after SOR (group B alone). Plot C shows the VA at postoperative day 45 (D45). Plot D shows the VA at postoperative month 3 (M3). The VA was significantly lesser in group A at all stages of the study. In both groups, there was significant correlation of VA before SOR and PE with VA on D45 and VA at M3 (Group A: R^2, 0.471; $P < 0.001$ and R^2, 0.413; $P < 0.001$, respectively. Group B: R^2, 0.348; $P < 0.001$ and R^2, 0.280; P 0.005, respectively)

and M3 were compared, there was no significant difference in both groups (group A: P, 0.19 and group B: P, 0.86). In both groups there was significant correlation of BCVA at baseline with VA on D45 and M3 (group A: r, 0.68; $P < 0.001$ and r, 0.64; $P < 0.001$, respectively; group B: r, 0.59; $P < 0.001$ and r, 0.52; P 0.005, respectively).

The eyes in the study were then divided into two groups based on the RE at M3 (RE ≤ ±1.5D and RE >±1.5D), and differences in demographic and ocular characteristics were compared [Table 2]. The age, gender, laterality, AL, and IOL power could not predict better refractive outcomes at M3 ($P > 0.05$ for all).

Discussion

The expectations of patients post cataract surgery are high and surgeons thus desire precise refractive outcomes. Despite the achievement of good BCVA, the use of high power spectacles or contact lenses after cataract surgery is seen as a suboptimal surgical outcome. In this scenario, surgeons often deal with SO-filled eyes that have a coexistent cataract.[2,3] The refractive shifts caused by the presence of SO within the eye are well studied.[6] The eye with SO lends itself to aberrant IOL power calculation as the velocity of sound waves during AL estimation are altered.[5,7] In calculating the IOL power for patients undergoing cataract surgery, the AL of the eye is of paramount importance. All theoretical regression formulae currently available make use of the AL to arrive at the required IOL power for a particular eye.[8,9] AL can be determined by ultrasonography, interferometry, or by X-ray computed tomography.[10] Laser interferometry is generally considered superior for IOL power calculation.[11,12] Despite the advantages offered by laser interferometry, with the use of an IOL master, Al-Habboubi *et al*. have reported that 42% of their patients who underwent SOR and cataract surgery had residual hyperopia.[13]

The use of UB is more common in the developing world where access to optical biometry is limited. When using UB for AL measurement in SO-filled eyes, adjustments are required for the different density of SO and the sound velocity.[5,7] Apart from changes in velocity, the absorption of sound waves passing through SO and the resultant loss of sensitivity often makes it impossible to get an accurate A-scan.[14] With regard to sound velocity through SO of different viscosities, Ghoraba and colleagues demonstrated that IOL power calculation using UB is comparable in eyes with 1000 cS SO and eyes with 5000 cS SO.[15] When dealing with the SO-filled eye, the AL may be estimated by other means as well. Grinbaum and coworkers used the AL values recorded before SO injection as a guide for IOL power calculation in a SO-filled eye. However, the changes induced by encircling elements may not be accounted for by this method.[16] There are also reports of intraoperative UB after SOR using a sterile ultrasound probe.[17] The AL of the contralateral eye may also be used for IOL power calculation.[18]

The option of a two-step operation for SOR and PE has also been recommended.[11] The aim of our study was to compare the single-step and two-step approach for SOR and PE, and ascertain if the RE at postoperative month 3 was better in a two-step approach. The eyes in our study were not randomized and the need for combined SOR and PE was based on the degree of cataractous changes at baseline. In our cohort, UB in a SO-filled eye resulted in poorer refractive outcomes than UB in a fluid-filled eye. The difficulty in AL measurement in a SO-filled eye interferes with precise refractive outcomes. Authors have recommended setting of different sound velocities (987–1139 m/s) for UB in a SO-filled eye.[7,14] In our institute, the sound velocity in a SO-filled eye is taken as 980 m/s. Furthermore, the extent of SO fill and degree of SO emulsification could also influence the speed of sound within the eye. In a SO-filled eye, sound travels with different velocities in the anterior segment that is aqueous-filled and in the posterior segment that is oil-filled. Newer machines allow for using differential sound speeds in different segments within the eye.

In our study, a hyperopic RE was observed in SO-filled eyes (3.09 ± 4.04 D). The same observation has also been reported in other studies (3–4.08 D).[3,9] At the third month after SOR and PE, we noticed a myopic refraction in our cohort of eyes (−1.18 ± 1.81 D). Even while aiming for emmetropia during PE, when the choice of IOL straddles emmetropia, surgeons tend to choose an IOL that would render the eye myopic rather than hyperopic. This could explain the final myopic refraction status in our cohort.

Krepler *et al*. have compared the visual outcomes for eyes undergoing SOR and cataract surgery at a single sitting and at two sittings.[19] They concluded that visual outcome is comparable with both strategies. This study did not assess the refractive outcomes. In our study, there was a significant visual improvement after SOR and PE. However, BCVA between the groups was not comparable at the baseline. Eyes in group A had poor BCVA at the baseline, and hence underwent a combined procedure, whereas eyes in group B did not have a visually significant cataract at the baseline, and hence underwent SOR alone as a first procedure. Of note, even after SOR and PE, BCVA was not comparable between the two groups in our study. Probably, the poor functional retinal status of eyes in group A could be responsible for this discrepancy.[20]

In addition to the refractive outcome, certain other factors also merit consideration when a single-step or two-step approach is to be decided upon. Where cataract is significant, it becomes imperative to combine the procedures so that detailed retinal evaluation after SOR is possible. Where SOR alone is performed, presence of the lens restricts the surgeon's reach of the retinal periphery, and hence may be more suited to relatively simpler cases where primary surgery was sufficient to address the retinal pathology and where additional retinal procedures may not be required at the time of SOR. On the other hand, combining the two surgeries would possibly result in more ocular inflammation. When combining the procedures, surgeons prefer completing the PE and IOL implantation before proceeding to SOR. This is so that oil in the posterior segment offers posterior capsular support during PE. A fluid-filled posterior segment is associated with more capsular excursion during PE, thereby increasing the risk of capsular compromise. Cost analysis and the patients' perspectives may also have to be taken into account when recommending a two-step approach.

When compared to previous studies that discuss SOR and cataract surgery,[3,9,11,12,15,17,19] a relatively large sample size is the advantage of our study. The drawback of our study was its retrospective nature, which did not allow for randomization. Similar to other studies, we could not include estimates of suture related or surgeon-induced astigmatism. Data regarding corneal suturing and suture removal in the postoperative period were not available. This is a possible confounding factor when refractive outcomes are being analyzed. These are considerations that could be addressed in future studies.

Conclusion

In conclusion, a hyperopic refraction was noticed in silicone oil-filled eyes. Thereafter, with SOR and cataract surgery, most eyes experienced a myopic shift and a significant visual improvement. With the use of ultrasound biometry, short-term refractive outcomes closer to emmetropia were obtained if SOR and PE are performed in a two-step approach.

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Conflicts of interest

There are no conflicts of interest.

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