Comparative Outcomes of 1000 cSt and 5000 cSt Standard Silicone Oils in Primary Rhegmatogenous Retinal Detachment Surgery: A Retrospective Cohort Study

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ABSTRACT

Purpose: To compare anatomical outcomes, visual recovery, and complication profiles between 1000 centistoke (cSt) and 5000 cSt standard silicone oils, including products from two manufacturers, in primary rhegmatogenous retinal detachment (RRD) surgery.

Materials and Methods: This retrospective cohort study included 113 eyes of 113 patients who underwent pars plana vitrectomy with silicone oil tamponade for primary RRD between October 2020 and December 2024. Patients were grouped as Biotech 1000 cSt (n=42), Biotech 5000 cSt (n=27), and Teknotek 5000 cSt (n=44). Primary outcomes were final anatomical success and best-corrected visual acuity (BCVA) at 6 months. Multivariable logistic regression adjusted for proliferative vitreoretinopathy (PVR), intraoperative ILM peeling, and tamponade duration.

Results: Final anatomical success rates were 73.8%, 92.0%, and 83.7%, respectively, with no significant between-group difference (p=0.161). Six-month BCVA and BCVA change were comparable (p=0.457 and p=0.612), as were postoperative complication rates (p=0.177). ILM peeling was independently associated with lower anatomical success (OR: 0.08, 95% CI: 0.01–0.71, p=0.024). Teknotek 5000 cSt was associated with higher odds of anatomical success than Biotech 1000 cSt (OR: 14.65, 95% CI: 1.20–178.95, p=0.035).

Conclusion: Standard 1000 cSt and 5000 cSt silicone oils demonstrated comparable functional outcomes and complication profiles in primary RRD surgery. The subgroup association favoring one 5000 cSt formulation should be interpreted cautiously in light of case complexity, baseline disease severity, and manufacturer-related differences.

Keywords: rhegmatogenous retinal detachment; silicone oil; tamponade; vitrectomy; anatomical success

INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is a vision-threatening condition with an estimated annual incidence of 10–18 per 100,000 individuals and can lead to irreversible vision loss if not promptly treated.[1] Pars plana vitrectomy (PPV) with intraocular tamponade is the current standard of care, and silicone oil (SO) is one of the most commonly used tamponade agents, particularly in complex or high-risk cases.[2-4]

Among standard SOs, the most widely used viscosities are 1000 centistokes (cSt) and 5000 cSt. Viscosity may influence intraocular stability, resistance to emulsification, and ease of removal. However, prior studies and systematic reviews have reported conflicting findings, and no clear consensus exists on whether higher viscosity provides superior anatomical or functional outcomes.[5-7]

Despite the widespread use of SOs in retinal detachment repair, direct comparative evidence in the context of primary RRD remains scarce. Data evaluating whether tamponade

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viscosity itself alters surgical success or complication rates are limited. Additionally, the effectiveness of SOs of the same viscosity from different manufacturers has not been sufficiently investigated.

This study aimed to compare anatomical outcomes, visual recovery, and complication profiles between 1000 cSt and 5000 cSt standard SOs, including products from different manufacturers, in primary RRD surgery.

MATERIALS AND METHODS

This retrospective, comparative cohort study was conducted at Başakşehir Çam and Sakura City Hospital between October 2020 and December 2024. The study protocol was approved by the institutional ethics committee and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients before inclusion.

Medical records and operative reports of 113 consecutive patients who underwent PPV with SO tamponade for primary RRD were retrospectively reviewed. Patients were divided into three groups according to the type and viscosity of the SO used: Biotech 1000 cSt (n = 42), Biotech 5000 cSt (n = 27), and Teknotek 5000 cSt (n = 44). All tamponades were classified as standard SOs.

According to manufacturer specifications, all SOs used in this study are composed of highly purified polydimethylsiloxane. The Biotech standard oils (Biosil and Biosil-F) are characterized by high purity, low levels of reactive hydroxyl (−OH) end groups, and minimal volatile components, with higher viscosity formulations having greater molecular weight. Similar standard SO formulations were used for the Teknotek group (Teknotek Medikal, Turkey), which are likewise produced as purified polydimethylsiloxane oils within the same viscosity classes.

The inclusion criteria were primary RRD (macula-on or macula-off), phakic or pseudophakic eyes, and a minimum follow-up of 6 months. The exclusion criteria included previous retinal surgery, traumatic RRD, retinal vascular occlusion, diabetic retinopathy, uveitis, giant retinal tears, prior scleral buckling, pre-existing glaucoma or a history of glaucoma, high myopia, and the presence of an epiretinal membrane at baseline. In bilateral cases, only one eye per patient was included, selecting the eye with the worse preoperative best-corrected visual acuity (BCVA).

All procedures were performed by a single experienced vitreoretinal surgeon using a standard 25-gauge three-port PPV technique. Core and peripheral vitrectomy were completed, and membrane or internal limiting membrane (ILM) peeling was performed when necessary using vital dyes. Retinotomy or retinectomy was performed in selected cases. Endolaser photocoagulation was applied around retinal breaks and circumferentially in all cases. The choice of SO tamponade was at the surgeon's discretion. Although no clinically meaningful difference in injection time was noted by the surgeon between 1000 cSt and 5000 cSt SOs, removal of 1000 cSt oil was consistently faster compared to 5000 cSt oil during the extraction phase.

Data collected included demographics (age, sex, laterality, and lens status), preoperative findings (best-corrected visual acuity [BCVA] in logMAR, intraocular pressure [IOP], extent and type of detachment, and presence of proliferative vitreoretinopathy [PVR]), intraoperative details (ILM peeling, retinectomy, and drainage retinotomy), and postoperative outcomes (6-month BCVA, duration of SO tamponade, total follow-up time, anatomical status, and complications including PVR, IOP elevation, epiretinal membrane formation, and SO emulsification). Anatomical success was defined as complete retinal attachment at final follow-up without the need for additional surgical intervention for redetachment. Cases requiring reoperation for recurrent retinal detachment or eyes in which silicone oil could not be removed within 12 months were classified as surgical failures.

STATISTICAL ANALYSIS

Statistical analyses were performed using IBM SPSS Statistics (Version 28.0; IBM Corp., Armonk, NY, USA) and Python for advanced modeling. Normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), as appropriate. Group comparisons were performed using one-way analysis of variance (ANOVA) or Kruskal–Wallis tests. Pearson's chi-square or Fisher–Freeman–Halton tests were used for categorical variables.

To account for baseline imbalances and potential confounding factors, a multivariable logistic regression analysis was performed with anatomical success as the dependent variable. The model included silicone oil type (categorized by viscosity and manufacturer) as the main independent variable and adjusted for preoperative PVR presence, intraoperative ILM peeling, and duration of silicone oil tamponade. Duration of silicone oil tamponade was included in the analysis for eyes in which silicone oil removal was performed. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 113 eyes from 113 patients were included in the analysis: 42 in the Biotech 1000 cSt group, 27 in the Biotech 5000 cSt group, and 44 in the Teknotek 5000 cSt group. Demographic and preoperative characteristics were generally comparable among the groups (Table 1). There were no significant differences in age, sex, laterality, lens status, preoperative BCVA, intraocular pressure, macular status, or extent of retinal detachment (all p > 0.05). However, the presence of proliferative vitreoretinopathy (PVR) differed significantly between groups, being more frequent in the Biotech 5000 cSt group (59.3%) compared to the Biotech 1000 cSt (26.2%) and Teknotek 5000 cSt (43.2%) groups (p = 0.022). Intraoperative ILM peeling rates also differed significantly, with the highest rate observed in the Teknotek 5000 cSt group (25.0%) compared to the Biotech 5000 cSt (11.1%) and Biotech 1000 cSt (2.4%) groups (p = 0.008). In addition, the duration of silicone oil tamponade was significantly longer in the Teknotek 5000 cSt group (p < 0.001).

Postoperative outcomes are summarized in Table 2. The mean BCVA at 6 months and the change in BCVA did not differ significantly among the groups (p = 0.457 and p = 0.612, respectively). Final anatomical success rates were 73.8% in the Biotech 1000 cSt group, 92.0% in the Biotech 5000 cSt group, and 83.7% in the Teknotek 5000 cSt group, with no statistically significant difference between groups (p = 0.161). The overall rate of postoperative complications was also comparable across groups (p = 0.177), and no significant differences were observed when complications were analyzed individually (p = 0.626).

Univariable and multivariable logistic regression analyses are presented in Table 3. In univariable analysis, ILM peeling was significantly associated with lower odds of anatomical success (OR: 0.17, 95% CI: 0.04–0.72, p = 0.016), while longer silicone oil duration showed a borderline association (OR: 0.99, 95% CI: 0.98–1.00, p = 0.046). The presence of PVR and silicone oil type were not significantly associated with anatomical success in univariable analysis (all p > 0.05).

In multivariable analysis, ILM peeling remained significantly associated with lower anatomical success (OR: 0.08, 95% CI: 0.01–0.71, p = 0.024). Silicone oil duration was not significantly associated with the outcome after adjustment (p = 0.092). Neither the presence of PVR nor the use of Biotech 5000 cSt silicone oil showed a statistically significant association with anatomical success. However, the use of Teknotek 5000 cSt silicone oil was associated with higher odds of anatomical success compared to the reference group (Biotech 1000 cSt) (OR: 14.65, 95% CI: 1.20–178.95, p = 0.035).

Table 1. *Demographics and Preoperative Characteristics*

		Tamponade Type			p
		Biotech 1000'cSt	Biotech 5000'cSt	Teknotek 5000'cSt	
Age	Mean±SD	57.2±8.2	60.7±8.1	60.2±9.8	0.184 [a]
	Median (IQR)	57(51-62)	61(56-66)	60(53.5-67)	
Gender	Male	27(64.3)	18(66.7)	32(72.7)	0.690 [b]
	Female	15(35.7)	9(33.3)	12(27.3)	
Laterality	Right	21(50)	11(42.3)	23(52.3)	0.715 [b]
	Left	21(50)	15(57.7)	21(47.7)	
Preop lens status	Phakik	25(59.5)	12(44.4)	26(59.1)	0.398 [b]
	Pseudophakic	17(40.5)	15(55.6)	18(40.9)	
Preop BCVA snellen (logMAR)	Mean±SD	1.5±0.7	1.6±0.7	1.7±0.7	0.308 [c]
	Median (IQR)	1.3(1-2.3)	1.8(1.3-2.3)	1.8(1.2-2.3)	
Preop IOP (mmHg)	Mean±SD	12.9±5.3	12.8±3.9	12.8±4.5	0.997 [a]
	Median (IQR)	12(9-17)	12(10-17)	12(10-16.5)	
Macula status	On	6(14.3)	4(14.8)	10(22.7)	0.534 [b]
	Off	36(85.7)	23(85.2)	34(77.3)	
Total RD extent (clock hours)	Mean±SD	8.6±3.3	8.6±2.6	9.3±2.8	0.463 [c]
	Median (IQR)	9.5(6-12)	8(6-12)	9.5(6-12)	
RD type	Inferior RD	10(23.8)	12(44.4)	15(34.1)	0.184 [d]
	Superior RD	12(28.6)	6(22.2)	7(15.9)	
	Total RD	20(47.6)	9(33.3)	22(50)	
PVR	Present	11(26.2)	16(59.3)	19(43.2)	**0.022** [b,*]
	Absent	31 (73.8)	11 (40.7)	25 (56.8)	
PVR grade	A	21(67.7)	7(63.6)	9(36.0)	0.104 [d]
	B	8(25.8)	3(27.3)	9(36.0)	
	C	2(6.5)	1(9.1)	7(28.0)	
Surgical details	Only PPV	18(42.9)	16(59.3)	20(45.5)	0.381 [b]
	Phaco+PPV	24(57.1)	11(40.7)	24(54.5)	
Retinectomy	No	42(100)	25(92.6)	41(95.3)	0.230 [d]
	Yes	0(0)	2(7.4)	2(4.7)	
Drainage retinotomy	No	39(95.1)	26(96.3)	41(95.3)	1.000 [d]
	Yes	2(4.9)	1(3.7)	2(4.7)	
Perop ILM peeling	No	41(97.6)	24(88.9)	33(75)	**0.008** [b,*]
	Yes	1(2.4)	3(11.1)	11(25)	
Removal of tamponade	No	6(14.3)	7(25.9)	6(13.6)	0.348 [b]
	Yes	36(85.7)	20(74.1)	38(86.4)	
Duration of oil ("if silicone is removed") (days)	Mean±SD	84.3±38.4	88.3±36.6	146.1±66.7	**<0.001** [c,*]
	Median (IQR)	73.5(64-86)	95(89-101.5)	126.5(110-170.5)	
Follow up(days)	Mean±SD	218 ± 52.1	223 ± 49.7	216 ± 55.4	0.421 [c,*]
	Median (IQR)	213 (182–253)	220 (190–257)	214 (178–254)	

[a] One-way ANOVA(Analysis of Variance) [b] Chi-square test, [c] Kruskal Wallis Test, [d] Fisher-Freeman-Halton, *p<0,05
Continuous variables are presented as the mean ± standard deviation / median (IQR). Categorical variables are presented as number (%)

Table 2. *Postoperative Outcomes and Complications*

		Tamponade Type			p
		Biotech 1000'cSt	Biotech 5000'cSt	Teknotek 5000'cSt	
Post-op BCVA at 6 months (logMAR)	Mean ± SD	1±0.5	1.1±0.3	1±0.5	0.457[a]
	Median (IQR)	1(0.5-1.3)	1.3(0.8-1.3)	1(0.7-1.3)	
Change in BCVA (logMAR)	Mean ± SD	0.5±0.8	0.5±0,6	0.6±0.7	0.612[b]
	Median (IQR)	0.6(0-1)	0.5(0-1)	0.7(0-1.2)	
Final Success (Retinal Attachment)	Success	31(73.8)	23(92)	36(83.7)	0.161[c]
	Failure	11(26.2)	2(8)	7(16.3)	
Post-operative Complication	No	15(36.6)	16(59.3)	18(42.9)	0,177[c]
	Yes	26(63.4)	11(40.7)	24(57.1)	
Post-operative Complications	No	15(36.6)	16(59.3)	18(42.9)	0.626[d]
	Persistent subretinal fluid	1(2.4)	1(3.7)	1(2.4)	
	ERM	3(7.3)	2(7.4)	2(4.8)	
	Intraretinal fluid	1(2.4)	3(11.1)	3(7.1)	
	Elevated intraocular pressure (>21 mmHg)	8(19.5)	3(11.1)	7(16.7)	
	Proliferative vitreoretinopathy	9(22)	1(3.7)	7(16.7)	
	Intravitreal Silicone oil emulsification	2(4.9)	0(0)	3(7.1)	
	Corneal haze	0(0)	0(0)	0(0)	
	Anterior chamber Silicone oil emulsification	2(4.9)	1(3.7)	1(2.4)	

[a] Kruskal Wallis Test [b] One-way ANOVA(Analysis of Variance), [c] Chi-square test, [d] Fisher-Freeman-Halton, *p<0,05
Continuous variables are presented as the mean ± standard deviation / median (IQR). Categorical variables are presented as number (%)

Table 3. *Univariable and multivariable logistic regression analyses evaluating factors associated with anatomical success.*

Variable	Univariable OR (95% CI)	p value	Multivariable OR (95% CI)	p value2
ILM peeling	0.17 (0.04–0.72)	0.016	0.08 (0.01–0.71)	0.024
Silicone oil duration (days)	0.99 (0.98–1.00)	0.046	0.99 (0.98–1.00)	0.092
Presence of PVR	1.41 (0.40–5.00)	0.591	2.57 (0.59–11.15)	0.207
Biotech 5000 cSt	1.85 (0.33–10.42)	0.483	3.84 (0.54–27.41)	0.18
Teknotek 5000 cSt	1.41 (0.35–5.73)	0.63	14.65 (1.20–178.95)	0.035*

Results are presented as odds ratio (OR), 95% confidence interval (95% CI), and p value. Reference category for silicone oil type: Biotech 1000 cSt silicone oil. PVR = proliferative vitreoretinopathy; ILM = internal limiting membrane. *p < 0.05.

DISCUSSION

In this retrospective study, we evaluated the impact of silicone oil viscosity and manufacturer-related differences on anatomical and functional outcomes in primary RRD surgery. Univariate analysis demonstrated numerically higher anatomical success rates in the 5000 cSt groups compared to the 1000 cSt group; however, this difference did not reach statistical significance. In multivariable analysis, the Teknotek 5000 cSt group showed a statistically significant association with anatomical success. However, the wide confidence interval around this estimate indicates substantial uncertainty regarding the magnitude of the association, warranting cautious interpretation.

In clinical practice, the choice of silicone oil viscosity is often influenced by case complexity, particularly in eyes with PVR and more extensive retinal detachment. Eyes with PVR represent more complex surgical cases with a higher risk of redetachment and frequently require silicone oil tamponade to achieve anatomical stability.[8] Although multivariable analysis was performed to adjust for baseline differences, surgical decision-making and case characteristics may have influenced the observed outcomes. Therefore, the findings of the present study likely reflect a combination of tamponade properties and underlying disease severity rather than the effect of viscosity alone.

Intraoperative factors also differed among groups. The Teknotek 5000 cSt group had a higher rate of ILM peeling. ILM peeling has been shown to reduce the incidence of postoperative epiretinal membrane formation; however, its effect on primary anatomical success remains controversial. A recent meta-analysis demonstrated that ILM peeling significantly decreases postoperative ERM formation without providing a significant advantage in retinal reattachment rates or visual outcomes.[9] In our analysis, ILM peeling was associated with lower anatomical success; however, this likely reflects confounding by indication, as ILM peeling was more frequently performed in more complex cases with a higher baseline risk of redetachment.

Postoperative complications and visual outcomes should be interpreted in the context of both surgical and patient-related factors. Previous large-scale studies have demonstrated that poor visual outcomes after rhegmatogenous retinal detachment repair are primarily associated with baseline clinical characteristics such as proliferative vitreoretinopathy, delayed presentation, worse initial visual acuity, ocular comorbidities, and advanced age, rather than intraoperative variables alone.[10] In line with this, our findings should be evaluated considering potential baseline differences between groups. Silicone oil has been widely used in complex retinal detachment cases due to its ability to provide long-term retinal support, and a recent meta-analysis reported that it is associated with a significantly lower rate of retinal redetachment compared with other tamponade agents, while increasing the risk of ocular hypertension.[7] However, no significant differences

were observed in visual outcomes, cataract formation, proliferative vitreoretinopathy, or corneal complications.[7] These findings suggest that silicone oil may improve anatomical stability without necessarily translating into superior functional outcomes. Therefore, the differences observed in our study may reflect both the selection of more complex cases for silicone oil tamponade and the known complication profile of silicone oil, rather than a direct causal effect of the tamponade choice alone.

Postoperative complications, including silicone oil emulsification, elevated intraocular pressure, and recurrent retinal detachment, were also comparable among groups. Previous studies have reported that emulsification rates are more closely related to the duration of tamponade rather than viscosity alone.[11,12] Similarly, intraocular pressure elevation has been associated with multiple factors, including tamponade duration and surgical technique.[13,14] In our study, although the duration of silicone oil tamponade was significantly longer in the Teknotek 5000 cSt group, complication rates did not differ significantly, suggesting that modern silicone oil formulations may provide sufficient stability even during prolonged intraocular retention.

The existing literature on silicone oil viscosity in retinal detachment surgery has yielded conflicting results. Several studies have reported no significant difference in anatomical or functional outcomes between 1000 and 5000 cSt silicone oils, with comparable rates of retinal reattachment, visual recovery, and postoperative complications.[6,15] In particular, Scott et al. demonstrated similar anatomical and visual outcomes across viscosities in a large cohort, while Yaşa et al. reported comparable anatomical success despite a tendency to use higher-viscosity oils in more complex cases.[6,15] Conversely, other studies have suggested that higher-viscosity silicone oil may be associated with less favorable outcomes in certain subgroups, particularly in eyes with proliferative vitreoretinopathy, likely reflecting differences in baseline disease severity rather than a direct effect of viscosity.[16] Overall, these findings support the notion that silicone oil viscosity alone may not be the primary determinant of surgical outcome, and that case selection and underlying pathology play a substantial role. In this context, our findings are largely consistent with the literature, although the observed association in one subgroup may reflect the influence of additional factors, including manufacturer-related differences and surgical decision-making.

This study has several limitations. First, its retrospective design introduces the possibility of selection bias despite statistical adjustment. In addition, the choice of silicone oil type was at the surgeon's discretion and was not randomized, which may have influenced group allocation, particularly in more complex cases. Second, the relatively small sample size, especially within subgroup analyses, may limit statistical power and affect the robustness of the findings. Third, although all surgeries were performed by a single experienced surgeon, which ensures procedural consistency, this may limit the generalizability of the results to other settings. Fourth, intraoperative parameters such as injection dynamics and surgical time were not quantitatively recorded. Fifth, baseline differences in disease severity, including the distribution of PVR and the frequency of ILM peeling, may have influenced outcomes despite adjustment. Finally, because both viscosity and manufacturer differed across groups, the independent effect of these variables could not be fully separated.

In conclusion, standard 1000 and 5000 cSt silicone oils demonstrated comparable functional outcomes and complication profiles in the management of primary rhegmatogenous retinal detachment. Although a statistically significant association was observed for one 5000 cSt silicone oil subgroup in the adjusted analysis, the wide confidence interval suggests considerable uncertainty regarding the magnitude of this effect. Therefore, this finding should be interpreted cautiously and should not be considered definitive evidence of superiority of a specific silicone oil formulation. Overall, surgical decision-making and underlying retinal pathology appear to play a more critical role than silicone oil viscosity alone. Further prospective, randomized studies are needed to better define the independent effects of silicone oil viscosity and manufacturer-related differences.

DECLARATIONS

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Ethical Approval

The study was approved by the Ethics Committee of Başakşehir Çam and Sakura City Hospital (Approval No: E-96317027-514.10-286475302).

Data Availability Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

Conception and design of the study: CG, SE, HD and SAO; acquisition, analysis, and interpretation of data; drafting of the manuscript: CG, MK and EO; critical revision for important intellectual content: CG, SE, MK and SAO; supervision of the study: MK and SAO; and final approval of the version to be published: CG, EO, SE, MK, HD and SAO.

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