·Clinical Research·

Efficacy and safety of active silicone oil removal through a 23-gauge transconjunctival cannula using an external vacuum pump

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Abstract

• **AIM: To evaluate the efficacy and safety of active removal of silicone oil with low and high viscosity through a 23-gauge transconjunctival cannula using an external vacuum pump.**

• **METHODS: This study was conducted as a prospective, interventional case series. A total of 22 eyes of 21 patients [1000 centistokes (cSt): 17 eyes, 5700 cSt: 5 eyes] were included in this study. All patients underwent active silicone oil removal *via* the entire lumen of a 23-gauge microcannula with suction pressure of a 650-700 mm Hg vacuum using an external vacuum pump. A tubing adaptor from the Total Plus Pak® (Alcon, Fort Worth, USA) was used to join the microcannula and silicone vacuum tube connected to an external vacuum pump. Main outcome measures were mean removal time, changes of intraocular pressure (IOP) and visual acuity, and intraoperative and postoperative complications.**

• **RESULTS: Mean removal time (min) was 1.49±0.43 for 1000 cSt and 7.12±1.27 for 5700 cSt. The IOP was 18.57±7.48 mm Hg at baseline, 11.68±4.55 mm Hg at day 1 postoperatively (P<0.001), and 15.95±4.92, 16.82±3.81, 17.41±3.50, and 17.09±3.01 mm Hg after one week, one month, three months, and six months, respectively. All patients showed improved or stabilized visual acuity. There was no occurrence of intraoperative or postoperative complications during the follow up period.**

• **CONCLUSION: This technique for active removal of silicone oil through a 23-gauge cannula using an external vacuum pump is fast, effective, and safe as well as economical for silicone oil with both low and high viscosity in all eyes with pseudophakia, aphakia, or phakia.**

• **KEYWORDS:** active removal; external vacuum pump; silicone oil

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INTRODUCTION

Since its first use in vitreoretinal surgery in 1962, silicone oil has been widely used as an intraocular tamponade in complex retinal detachments [1]. However, the incidence and severity of its complications, such as glaucoma, cataract, and keratopathy increase with duration of its intraocular stay[2-6]. Therefore, in order to minimize the long-term complications, removal of silicone oil is recommended if the objectives of the tamponade have been achieved and the retinal status is stable [7]. Various techniques and preferences for removal of silicone oil have been reported[8-12].

Since the introduction of the transconjunctival sutureless vitrectomy system, notably the 25-guage vitrectomy system by Fujii *et al*[13] in 2002 and the 23-gauge vitrectomy system by Eckardt [14] in 2005, new approaches for removal of silicone oil using sutureless vitreoretinal surgery have been reported. A passive approach using 25-gauge cannulas introduced by Kapran and Acar [15] was appropriate only for silicone oil with low viscosity [1000 centistokes (cSt)] while less efficient for silicone oil with higher viscosity (5000 cSt). In addition, 25-gauge cannulas specially designed by Kaplan and Acar [16] have been introduced for removal of silicone oil by active suction *via* pars plana; however, these are not commercially available [12,13]. Song *et al* [10] suggested a surgical technique for active removal of silicone oil through the entire lumen of a 23-gauge cannula using suction of a 600 mm Hg vacuum of a vitrectomy machine. However, prospective evaluation of the efficacy and safety of active removal of silicone oil with various viscosities has been insufficient.

In this study, we suggest a new practical technique for active removal of both 1000 and 5700 cSt silicone oil through the entire lumen of a 23-gauge instrument cannula using an external suction pump, which is generally equipped in the operation room and provides stronger vacuum pressure than a vitrectomy machine. The efficacy and safety of this technique are also evaluated prospectively.

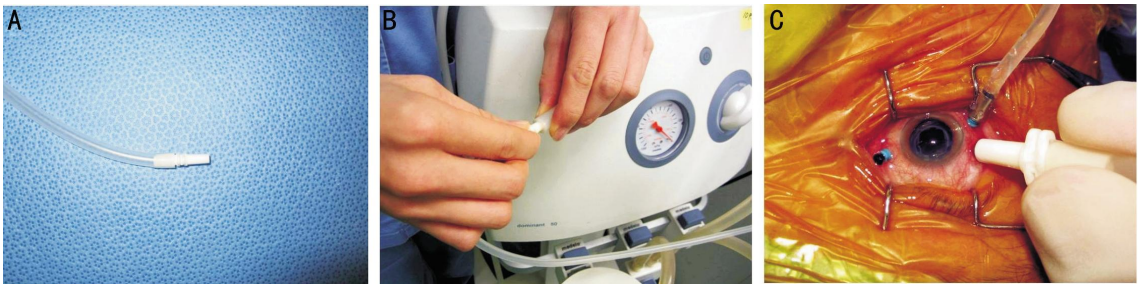

Figure 1 The assembly used for removal of silicone oil using an Alcon trocar-cannula system A: A tubing adaptor with the Total Plus Pak® (Alcon, Fort Worth, USA) was used for connection with the silicone tube line; B: The silicone tube line was connected to the external suction pump; C: The tubing adaptor connected to the silicone tube line was inserted, covering the collar of the 23-gauge microcannula from the outside.

SUBJECTS AND METHODS

This study was conducted as a single center, prospective, interventional case series. A total of 22 eyes of 21 consecutive patients were enrolled in the study and underwent active silicone oil removal via pars plana through a 23-gauge cannula using an external vacuum pump at our hospital, Department of Ophthalmology, College of Medicine, Yeungnam University, from July 2011 to June 2012. The Institutional Review Board of the College approved the design of the study. Informed consent was obtained in accordance with the Declaration of Helsinki before the start of the procedures.

Inclusion criteria were age >18y who had undergone previous vitreoretinal surgery with silicone oil (1000 cSt or 5700 cSt) injection for complicated retinal detachments, duration of intraocular silicone oil greater than or equal to three months, and stable retinas without redetachments or severe hypotony [intraocular pressure (IOP)≤6 mm Hg].

All procedures were performed by the same surgeon (Sagong M) under retrobulbar anesthesia with a half mixture of 4% lidocaine and 0.75% bupivacaine. All procedures were performed using the Accurus 23-gauge surgical vitrectomy system (Alcon Laboratories, Inc., Fort Worth, TX, USA). Beginning the surgery, 23-gauge microcannulas were placed using the one step technique, using a trocar-cannula system. The first microcannula was placed in the inferotemporal region and an infusion tube line was connected to the microcannula. The infusion tube line was connected to the vented gas fluid infusion (VGFI) pump. Two additional microcannulas were placed in the superotemporal and superonasal regions. The microcannula in the superotemopral region was chosen for silicone oil removal. A tubing adaptor was then obtained from the Total Plus Pak ® (Alcon Laboratories, Inc., Fort Worth, TX, USA) in order to join the microcannula and the silicone tube line directly. One end of the tubing adaptor was connected to the silicone tube line (Figure 1A), and the silicone tube line was connected to an external vacuum pump (Figure 1B). The external vacuum pump (Medela Dominant 50 mobile, Switzerland) for active aspiration of silicone oil was an ordinary machine, with suction pressure of 650-700 mm Hg vacuum, commonly used in the operation room. Additional complex manipulation was not required for preparation of the cannula-vacuum connection. The tubing adaptor connected with a silicone tube line was then inserted into the microcannula in the superotemporal region (Figure 1C).

The internal diameter (3.00 mm) of the tubing adaptor is slightly larger than the external diameter (2.20 mm) of the collar of the 23-gauge microcannula to wrap it from the outside. Therefore, slight pushing force was required in order to maintain a watertight seal while joining the tubing adaptor and the microcannula.

The silicone oil was then removed actively with suction pressure of a 650-700 mm Hg vacuum through the entire lumen of the watersealed microcannula using an external vacuum pump. The infusion pressure using the VGFI pump was set to 45-50 mm Hg during removal of the silicone oil. At the end of surgery, when the remaining oil bubble was observed, the eyeball was tilted in order to place the oil bubble into the microcannula connected to the tubing adaptor, which was helpful in complete removal of the silicone oil and prevention of sudden eyeball collapse. After removal of silicone oil, additional procedures, including endolaser and membrane peeling were performed as needed. At the end of the surgery, all sclerotomy sites were sutured in order to prevent postoperative hypotony. Ocular examination with Snellen visual acuity, applanation tonometry, slit-lamp biomicroscopy, and indirect fundus ophthalmoscopy was performed on all patients at baseline, and at one-day, one-week, one-month, three-month, and six-month postoperative visits. Main outcome measures were mean removal time, changes of best corrected visual acuity (BCVA) and IOP, and intraoperative and postoperative complications. Silicone oil removal time was defined as the interval between connection of the tubing adopter-cannula and the end of silicone oil removal. For statistical analysis, BCVA was converted to logarithm of the minimum angle of resolution (logMAR).

Table 1 Demographic characteristics of patients

Baseline characteristics	1000 cSt	5700 cSt
Participant (eye, *n*)	17	5
Gender (M:F)	11: 6	4: 1
Age (a)	49.05±22.86	49.80±10.04
Lens state (phakic: pseudophakic: aphakic)	1: 14: 2	0: 5: 0
Interval between silicone oil endotamponade and silicone oil removal (mo)	10.53±7.50	26.89±7.30

cSt: Centistokes.

Table 2 Mean silicone removal time, mean operation time, and complications of active silicone oil removal through a 23-gauge microcannula using an external vacuum pump

Parameters (*n*)	Silicone removal time (min)	Operation time (min)	Complications
1000 cSt (17)	1.49±0.43	20.14±9.04	None
5700 cSt (5)	7.12±1.27	25.30±6.06	None

cSt: Centistokes.

Table 3 Mean intraocular pressure measurements overall and types of silicone oil

Type of silicone oil (No. of patients)	Preop.	Postop. 1d	Postop. 1wk	Postop. 1mo	Postop. 3mo	Postop. 6mo
1000 cSt (17)	19.12±8.18	11.53±5.11	15.88±5.16	17.00±3.95	17.76±3.79	16.59±3.24
5700 cSt (5)	16.80±2.68	12.20±1.92	16.20±4.55	16.20±3.63	16.20±2.17	18.80±0.84
Overall (22)	18.57±7.48	11.68±4.55	15.95±4.92	16.82±3.81	17.41±3.50	17.09±3.01

SD: Standard deviation; cSt: Centistokes. Values are presented as mean IOP (mm Hg)±SD (range) or *n*.

SPSS 13.0 for Windows XP (SPSS Sciences, Chicago, IL, USA) was used in performance of statistical analysis. Differences between preoperative and postoperative data in terms of BCVA and IOP were compared using the Wilcoxon signed rank test. The P value <0.05 was considered statistically significant.

RESULTS

A total of 22 eyes (17 eyes with 1000 cSt and 5 eyes with 5700 cSt) of 21 patients underwent active silicone oil removal *via* pars plana through a 23-gauge microcannula using an external vacuum pump. The mean age was 49.21 ±20.65y. Previous vitrectomy was performed due to retinal detachment (RD) secondary to trauma in three cases, atopy in three cases, recurred or failed RD surgery in three cases, RD with severe proliferative vitreoretinopathy (PVR) in six cases, and diabetic traction in seven cases. Before silicone oil removal, two eyes were aphakic, 19 eyes were pseudophakic, and one eye was phakic. The mean interval between vitrectomy with silicone oil endotamponade and silicone oil removal was 14.25±10.11mo (Table 1).

Mean removal time for 1000 cSt and 5700 cSt was 1.49 ±0.43min and 7.12 ±1.27min, respectively (Table 2). The preoperative and postoperative IOPs are shown in Table 3. Mean preoperative IOP was 18.57 ±7.48 mm Hg at baseline, and mean postoperative IOPs at one-day, one-week, one-month, three-month, and six-month visits were 11.68± 4.55, 15.95 ±4.92, 16.82 ± 3.81, 17.41 ±3.50, and 17.09 ±3.01, respectively. A statistically significant decrease in mean postoperative IOP was observed on day 1 in both groups of 1000 cSt and 5700 cSt (P=0.001, P= 0.043, respectively). However, it returned to normal on week 1 and remained stable thereafter without additional surgical intervention. Only one eye of 1000 cSt silicone oil showed postoperative hypotony on postoperative day 1, however, IOP was restored spontaneously on day 2 without extra-surgical intervention (Figure 2, Table 3). The preoperative and postoperative visual acuities are shown in Table 4. The mean visual acuity of logMAR showed a significant increase, from 1.31 ±0.52 at baseline to 0.81 ±0.60 (P<0.001) at postoperative month 6. Visual acuity showed improvement in 18 eyes (81.8%), and remained stable in 4 eyes (18.2%). During the follow up period, eyes with 5700 cSt silicone oil showed a tendency to catch up slowly compared to eyes with 1000 cSt silicone oil (Figure 3, Table 4).

Additional procedures were performed as needed. Endolaser photocoagulation was performed in 11 (50%) eyes, membrane peeling was performed in one (5%) eye, and synechiolysis was performed in 7 (32%) eyes. In addition, surgical capsulotomy was performed in 9 of 19 pseudophakic eyes with posterior capsular opacity and secondary intraocular lens implantation with scleral fixation was performed in one of two aphakic eyes.

No intraoperative or postoperative complications, such as choroidal detachment, vitreous hemorrhage, macular edema, clinically significant corneal endothelial decompensation, or endophthalmitis, were reported during the follow up period. The retina remained attached in all eyes without recurrence of retinal detachment at the last follow up.

Table 4 Mean visual acuity (logMAR) overall and types of silicone oil

Type of silicone oil (No. of patients)	Preop.	Postop. 1d	Postop. 1wk	Postop. 1mo	Postop. 3mo	Postop. 6mo
1000 cSt (17)	1.32±0.56	1.22±047	1.01±0.54	0.86±0.55	0.79±0.58	0.75±0.60
5700 cSt (5)	1.32±0.41	1.32±0.41	1.36±0.46	1.30±0.51	1.10±0.51	1.01±0.58
Overall (22)	1.32±0.52	1.24±0.45	1.09±0.53	0.96±0.56	0.86±0.57	0.81±0.60

CSt: Centistokes. Values are presented as mean visual acuity (logMAR)±SD (range) or *n*.

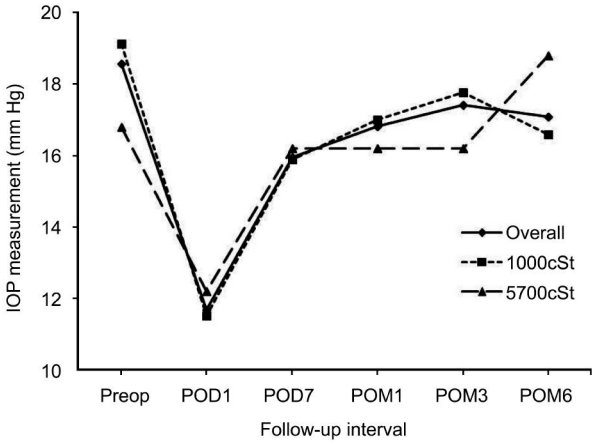

Figure 2 Change of intraocular pressure depending on the type of silicone oil during the six-month follow up period after surgery POD: Postoperative day; POM: Postoperative month; Preop: Preoperative.

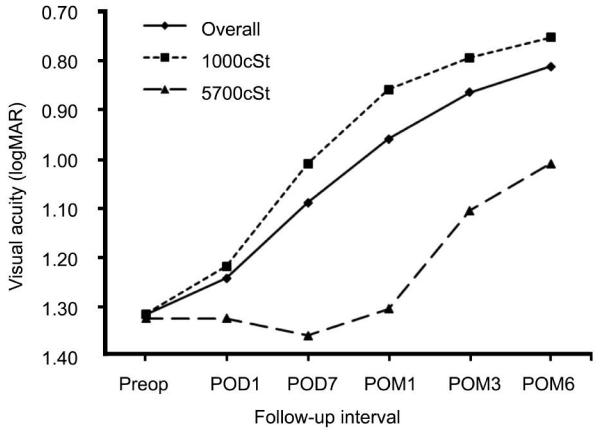

Figure 3 Change of best corrected visual acuity depending on the type of silicone oil during the six-month follow up period after surgery POD: Postoperative day; POM: Postoperative month; Preop: Preoperative.

DISCUSSION

Many techniques for removal of silicone oil have been suggested. There are anterior and posterior approaches. The anterior approach can be performed through a superior limbal or clear corneal incision and the infusion can be provided through pars plana or from an anterior chamber maintainer. However, this precludes any manipulation of the posterior segment. Some authors [9] have also described passive silicone oil removal through the pupillary area combined with cataract surgery requiring the intentional rupture of the posterior capsule, which may be disadvantageous. On the other hand, removal of silicone oil through a posterior approach *via* the pars plana route is preferred by many vitreoretinal surgeons [17,18] because it allows adequate intraoperative examination and various posterior segment manipulations, such as epiretinal membrane peeling, endolaser augmentation, membranectomy, and posterior capsulotomy. However, this necessitates performance of conjunctival dissection and three sclerotomies, which are often difficult and time-consuming due to scarred conjunctiva and sclera caused by repeated vitreoretinal procedures.

The transconjuctival sutureless vitrectomy system, which introduced a new concept in vitreoretinal surgery as a less invasive technique, has the advantages of extracting the silicone oil from pars plana and avoiding conjunctival peritomies and suturing of conjunctiva, sclera. Use of this technique is associated with less irritation, less inflammation, and more rapid patient rehabilitation. In addition, it can be performed in all eyes with pseudophakia, aphakia, or phakia. Kapran and Acar [15] not only described passive removal removal of 1000 cSt silicone oil, but also suggested a more efficient method for active removal of both 1000 and 5000 cSt silicone oil [16]. In their technique, specially designed 25-gauge microcannulas were used for active removal of silicone oil. However, these microcannulas are not commercially available. Song *et al* [10] described active removal of 5000 cSt silicone oil through a standard 23-gauge microcannula using suction pressure from a vitrectomy machine. However, it was evaluated retrospectively only for silicone oil with high viscosity. Thus, we introduced here the practical technique of active removal of silicone oil with low and high viscosity through a 23-gauge microcannula with higher suction pressure from an external vacuum pump and performed a prospective evaluation of its efficacy and safety.

The preparation process for our technique is very simple. No additional or specially designed cannula is needed for removal of silicone oil. The tubing adaptor used in joining the microcannula and the silicone vacuum tube is easily obtained from the commercially supplied package for vitrectomy. The silicone oil was then removed actively using an external vacuum pump, which is easily available in the operation room and has higher suction of 650 to 700 mm Hg

vacuum than that of a vitrectomy machine. In addition, in cases that do not require posterior segment manipulations, silicone oil can be removed using only an external vacuum pump without use of a vitrectomy machine. Therefore, in such situations, this technique can be more economical than other active removal techniques using a vitrectomy console with inherent cost.

In our technique, the tubing adaptor covered the outer portion of the collars of a 23-gauge cannula, enabling access to its entire lumen. According to the law of Hagen-Poiseuille, one of the most important factors affecting the flow of liquids is the radius of the lumen through which it must pass. Hence, in our study, mean silicone oil removal time was significantly shortened to 1.49±0.43min for 1000 cSt silicone oil and 7.12±1.27min for 5700 cSt silicone oil. Yildirim *et al*[9] reported that the mean removal time through corneal tunnel incision was approximately 9min for passive washout of 1300 cSt silicone oil and 7.6min for active aspiration of 5700 cSt silicone oil. In studies reported by Kapran and Acar [15,16], the mean time for passive removal of 1000 cSt silicone oil using 25-gauge microcannulas was 7.3min and the mean times for active removal using a specially designed 25-gauge cannula of 1000 and 5000 cSt silicone oil were 3.3min and 10.3min, respectively. In a study reported by Patwardhan *et al* [19], the time taken for passive removal of 1000 cSt silicone oil using two 23-gauge microcannulas was 6.9min. Song *et al* [10] reported that the mean time for active removal of 5000 cSt silicone oil using a 23-gauge microcannula was 6.8min, which was compatible with our data.

During silicone oil removal using the described method, an infusion cannula was connected to a VGFI pump, which was set 45 to 50 mm Hg to prevent the eyeball from collapsing with high suction pressure. It is unlikely to cause any long-term optic nerve damage as the infusion pressure was relatively low and the operation time was short compared to other studies. No corneal edema or retinal perfusion abnormality during the surgery was observed. As reported in the literature, several studies have demonstrated that retina can tolerate 60min without blood flow as a result of elevated pressure, and, in primates, irreversible damage begins after 90min of complete central retinal artery occlusion. The retina can tolerate occlusion of the central retinal artery for 10min, without visual impairment, in the setting of scleral buckling without drainage of subretinal fluid. Kaplan and Acar [15] also have not observed any optic nerve damage during passive removal of silicone oil for approximately 6min with the height of the infusion bottle raised to 95 cm, which corresponds to an IOP of approximately 70 mm Hg.

In our study, visual acuity improved in 18 eyes (81.8%) and remained unchanged in 4 eyes (18.2%). However, preoperative visual acuity was poor, with a median visual acuity of 20/400, and this median visual acuity had improved to only 20/125 at the final visit. This poor visual acuity was attributed to the severity of causative diseases consisting of diabetic tractional RD with long duration and RD associated with severe PVR, trauma, or atophy. And, our study demonstrated the eyes with high viscosity have lagged visual recovery after the oil removal compared to those with low viscosity, which was also resulted from the difference of severity of causative diseases.

The potential disadvantage of small gauge vitrectomy is postoperative wound leakage related to the sutureless sclerotomy. O'Reilly and Beatty [7] reported transient hypotony in 10 of 39 eyes (25.6%). In addition, Amato and Akduman [8] reported that 4 of 38 eyes (10.5%) required additional sutures intraoperatively on the leaking sclerotomy sites and 2 of 38 eyes (5.3%) experienced postoperative hypotony. Therefore, in our study, all sclerotomy sites were sutured in order to prevent postoperative hypotony. We only observed a transient decrease in postoperative IOP on day 1 in both groups of 1000 cSt and 5700 cSt, and all postoperative IOPs returned to normal on week 1 and remained stable thereafter without additional surgical intervention. Hypotony (IOP≤6 mm Hg) was observed in only one eye on day 1 after surgery, which was due to accidental release of a suture placed at the sclerotomy, and was restored spontaneously on day 2.

This study has limitations of a nonrandomized, non-controlled nature of the study, and relatively short follow-up.

In conclusion, active removal of silicone oil through a 23-gauge cannula using an external vacuum pump is a new, simple, and practical technique. This technique enables fast, efficient, and safe removal of both 1000 cSt and 5700 cSt silicone oil in phakic and pseudophakic eyes as well as in aphakic eyes. It also facilitates performance of posterior segment manipulations, if necessary, and promotes postoperative recovery by decreasing surgical time and postoperative inflammation. Another advantage of this technique is that, if necessary, it can be performed using only an external vacuum pump without use of a vitrectomy console with inherent cost. Conduct of further studies with a larger series and longer follow-up is warranted in order to ensure the long-term benefit and safety of this technique.

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