• Brief Report •

Analysis of the causative factors related to earlier emulsification of silicone oil

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Abstract

• The aim of this study is to report and analyze the factors related with earlier occurrence of silicone oil (SO) emulsification in patients underwent pars plana vitrectomy and SO injection in our hospital. We retrospectively reviewed consecutive case series undergone both SO injection and removal in our hospital, and 182 ones were eligible. Possible related independent factors included: macula status (on/off), concomitant phacoemulsification with the surgery of SO tamponading, concomitant status of proliferative vitreoretinopathy, combined surgery of retinotomy, time to have emulsification (<6mo/≥6mo after primary SO injection), route of SO injection (anterior/posterior), lens status (aphakic/pseudophakic/phakic), anesthesia (local/general), brands and type of SO, with/without episcleral cryotherapy, with/without hypertension, with/without diabetes, with/without intraoperative use of triamcinolone acetonide. The study revealed that brand and type of SO was the significant factor related with earlier emulsification of SO. Further study was warranted to find out the underlying causes.

• **KEYWORDS:** early; emulsification; pars plana vitrectomy; silicone oil

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INTRODUCTION

Silicone oil (SO) has been commonly used as a long-term tamponade agent after pars plana vitrectomy for more than fifty years[1-2]. Although SO endotamponade acts effectively for retinal reattachment, the occurrence of postoperative complications was one of the main concerns for the surgeons. The well-known complications of SO included: secondary glaucoma, cataract formation/deterioration, band-shaped degeneration of the cornea, emulsification, migration to the anterior chamber or subretinal space, retinal toxicity, *etc*[1,3-11]. Therefore, SO removal is usually scheduled once anatomic success is achieved, or at the inevitable occurrence of complication. The most advised time to have SO removal is 4-6mo after SO injection[1,5,9,12-14]. In our clinical practice two years ago, we noticed that the occurrence of SO emulsification became earlier and more frequent than before. SO emulsification has been found to be related with various factors, including intravitreal hemorrhage and inflammatory reaction, *etc*[1,4,12,15-17]. Although SO emulsification is an inherent problem if it remains intravitreally for prolonged duration, the earlier occurrence of which would cause more unscheduled surgical interventions and possibly unsatisfactory retinal reattachment. Therefore, we conducted the current study to find out the factors related to earlier SO emulsification.

SUBJECTS AND METHODS

Ethical Approval The study was approved by the Institutional Review Board of Zhongshan Ophthalmic Center affiliated to Sun Yat-sen University (Guangzhou, China), and performed in accordance with the World Medical Association's Declaration of Helsinki. Informed consent was waived due to the retrospective nature of the study.

SO emulsification was defined as the appearance of significant emulsified droplets (by fundoscopy) in the vitreous cavity when the eyes were currently tamponaded with SO. And earlier SO emulsification in our current study was limited within six months after primary SO injection. We retrospectively examined the files of all patients who underwent both SO injection and SO removal (from August 2014 to August 2015). Patients undergone SO removal because of emulsification were included. Exclusion criteria were as follows: SO removal for various postoperative complications other than emulsification within 6mo after SO injection; undergone other ophthalmic surgeries during the period between primary SO injection

Table 1 The statistical analysis of the brand and type of SO related with earlier SO emulsification

Types of SO	Viscosity (mPa·s)	*B*	*Wald*	*P*	OR	95%CI for OR
VRL600[a]	5000-5900	-	37.859	0.000	-	-
RT SIL-OL 500[b]	5000-5500	0.055	0.014	0.907	1.057	0.420-2.656
Siluron 2000c[c]	5000-5400	3.367	16.172	0.000	29.000	5.619-149.675
Siluron 5000c[d]	2000-2400	2.169	14.692	0.000	8.750	2.886-26.528

[a]Bausch&Lomb®; Bausch&Lomb, Incorporated; Waterford, Ireland; [b]Carl Zeiss®; Carl Zeiss Meditec AG; Berlin, Germany; [c]Gueder®; Fluoron GmbH; Ulm, Germany; [d]Gueder®; Fluoron GmbH; Ulm, Germany.

and removal; scheduled SO removal when complete retinal reattachment was achieved within 6mo after SO injection; with uncomplete follow-up data.

All primary vitrectomy with SO injection surgeries were done by the surgeons in our hospital. Standard 3-port pars plana vitrectomy was performed with the Alcon Constellation (Alcon Laboratories, Fort Worth, TX, USA) or Bausch & Lomb's Stellaris (Bausch & Lomb Incorporated, Rochester, New York, USA) vitrectomy platform. Noncontact wide-angle viewing system (Carl Zeiss Meditec AG, Jena, Germany) or contact lens was used on all patients according to the surgeons' using habit. According to the patients' file records, the possible related factors were collected for further analysis. We collected the following independent factors: macula status (on/off), concomitant phacoemulsification with the surgery of SO tamponading, concomitant status of proliferative vitreoretinopathy (PVR), combined surgery of retinotomy, time to have emulsification (<6mo or ≥6mo after primary SO injection), route of SO injection (anterior or posterior), lens status (aphakic, pseudophakic or phakic), anesthesia (local or general), brands and type of SO, with/without episcleral cryotherapy, with/without hypertension, with/without diabetes, with/without intraoperative use of triamcinolone acetonide.

All data were analyzed using the SPSS 19.0 statistical software (SPSS Inc., Chicago, IL, USA). Binary logistic regression and Chi-square analysis were used to analyze the factors related to earlier SO emulsification as appropriate. All the continuous data were expressed as mean±standard deviation (SD). *P* values <0.05 was considered statistically significant.

RESULTS

Six hundred and fifty-seven consecutive patients who underwent SO removal in our hospital between the period mentioned above were reviewed. Finally, 182 ones (136 males and 46 females) were eligible and recruited into the study, with the mean age of 38.6±17.83y. Among the recruited cases, 81 ones began to have SO emulsification more than six months after primary SO injection, and the other 101 ones less than six months. Emulsified SO in the anterior chamber was detected in 82 eyes (45.05%). Phacoemulsification was performed in 34 patients (18.68%) with the surgery of SO tamponade. The percentage to have concomitant retinotomy was 6.59% (12 patients).

Among all the patients, 52 eyes (28.6%) were found to be macula-off before surgery of SO tamponading, and 80 eyes (44.0%) were with PVR. Elevated intraocular pressure (IOP) was measured in 20 eyes (11.0%) when found to have emulsified SO in the vitreous cavity. Totally 26 eyes (14.3%) underwent the primary surgery of SO tamponading for reoperation due to recurrent retinal detachment.

We found gender had no statistically significant role in the time (<6mo or ≥6mo after primary SO injection; χ^2=0.026, *P*=0.505). Binary logistic regression revealed that type and brand of SO was the statistically significant factor related to earlier SO emulsification (χ^2=55.136, *P*<0.001). The results of the logistic regression were listed in Table 1.

DISCUSSION

Emulsification of SO can lead to various complications, including glaucoma, inflammation, and PVR formation and progression[1,5,8-10]. The current study is up to date the first one reporting earlier SO emulsification related to one specific brand and type of SO. SO was firstly introduced as an internal tamponading agent in 1961[2]. It has served as an invaluable tool to the retinal surgeon in the surgical treatment of vitreoretinal disorders under complex status, especially those with severe PVR.

Nowadays, various types and brands of SO have obtained approval for ophthalmic use. However, there is still no international standard for the manufacturing process and the purity grading of SO product. In China, multiple kinds of SO are being used in the large number of vitreoretinal patients[5,13-14,18-19]. SO is generally classified into different types according to their average viscosities and specific gravities. While we should keep in mind that the commercially available SOs are of mixture of compounds, viscosity is judged by measuring the overall average value. The lower-molecular-weight SO tends to occur emulsification, which is consistent with the result in the current study[1,4,17].

Emulsification of SO is an inherent problem. Emulsification is reported to occur as quickly as 1wk after the initial surgery[1]. Although SO emulsification seems an inevitable postoperative complication of SO tamponading, it should be noted that earlier emulsification would be a negative effect for the vitreoretinal recovery. The ideal timing for SO emulsification is

generally considered as more than three months after surgery. We should have some physic knowledge of SO emulsification at the current scenario. Dispersion of SO refers to the breaking up of large bubbles into the smaller ones. Emulsifications only occurs when surface tension of the droplets is reduced in the presence of surfactants. The potential surfactants include phospholipid, protein, lipoprotein. Therefore, the current study collected the general characteristics and specific factors into considerations, to find out the underlying factor related to the phenomenon of earlier SO emulsification. Finally, we found out that the Siluron 2000c (Gueder®; Fluoron GmbH; Ulm, Germany) SO was one independent factor related with earlier emulsification of SO. The underlying mechanism is warranted further investigations. Apart from that, other unusual but challenging complications of SO tamponade should be paid attention[20-22].

Although we have tried our best effort to find out the independent factor causing the unfavorable complication, there are several limitations of the current study should be acknowledged. As earlier emulsification of SO is a unfavorable condition, the current study could only be designed as a retrospective one. Prospective or randomized design was not acceptable at that scenario. It would not be highly convincing to have the conclusion that one specific type of SO was directly correlated with earlier emulsification of SO in the current study, due to the known limitations of the current study.

In conclusion, the current study revealed that the Siluron 2000c (Gueder®; Fluoron GmbH; Ulm, Germany) SO is the independent significant factor related to earlier SO emulsification in our hospital. The application of it has be paused after we observed this unusual phenomenon. We are looking forwards to a multi-center analysis of different brands and types of SO to have better conclusion of the factors related to earlier emulsification of SO.

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