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RESEARCH ARTICLE

The Impact of Delayed Silicone Oil Removal on Visual Acuity after Pars Plana Vitrectomy: A Cross-sectional Study

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Abstract:

Aims:

This study aimed to compare the effects of delayed silicone oil (SO) removal on visual acuity (VA) in eyes that underwent pars plana vitrectomy (PPV) and oil injection for retinal detachment (RD) or vitreous hemorrhage (VH) with patients who retained SO tamponade for longer periods of time.

Methods:

This was a retrospective analysis of 212 consecutive eyes that underwent PPV and had SO tamponade for more than one year. Phakic eyes also underwent phacoemulsification and intraocular lens implantation at the same surgery, rendering all cases pseudophakic. The cases were followed up post-operatively, and VA data were documented before SO, with SO, and after SO, if removed.

Results:

RD was the indication for surgery in 165 eyes (77.8%), while 47 (22.2%) underwent PPV and SO injection for VH. The difference in VA gain was statistically significant between RD cases who had SO removal and those who had not (P= 0.047). Meanwhile, the difference was not statistically significant in the VH group.

Conclusion:

In this cohort of patients who underwent PPV and SO injection, delayed oil removal in cases operated for RD repair resulted in an improvement in VA despite prolonged oil tamponade for one year or more, compared to similar patients who still had the SO *in situ*. For VH cases, this effect was less pronounced.

Keywords: Silicone oil, Pars plana vitrectomy, Retinal detachment, Vitreous hemorrhage, Visual acuity, Vitreous substitutes.

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1. INTRODUCTION

Since the introduction of pars plana vitrectomy (PPV) in 1971, advances in surgical techniques have gone hand in hand with the need for biocompatible vitreous substitutes and tamponading agents [1 - 3]. Depending on the clinical indication, silicone oil (SO) has emerged as a reliable tamponading agent that promotes adhesion between the retina and the underlying pigment epithelium (RPE) [4].

Compared to intraocular gases, the physical characteristics of SO stand in favor of its use: the volume of SO does not change over time, and is immune to the effects of atmospheric pressure, thereby facilitating prolonged anatomical support of the retina [5, 6]. Common indications for SO injection in PPV include retinal detachment (RD), vitreous hemorrhage (VH), viral retinitis, proliferative diabetic retinopathy, hypotony, and ocular trauma [7].

SO is usually removed after 3-6 months to minimize the risk of emulsification, raised intraocular pressure, and proliferative vitreoretinopathy [8]. Other published studies report vision loss, cataract formation, and RD as complications following the use and removal of SO [9 - 11].

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Phacoemulsification with an intraocular lens implant (IOL) may be performed along with PPV, as a combined surgery, in patients with cataracts and RD [12].

Prolonged and even indefinite SO tamponade can be resorted to in certain cases, and few studies have looked into the long-term effects of different oil viscosities used in such cases [13, 14]. This study identified a cohort of patients with prolonged SO tamponade after PPV for two different indications, and aimed to study the impact of delayed SO removal (after one year or more) on visual acuity (VA) in comparison to a similar cohort with retained SO for more than one year.

2. MATERIALS AND METHODS

2.1. Study Design and Data Collection

This study was conducted after the approval of the Institutional Review Board at Jordan University Hospital (Approval no. 871/2022/67). A retrospective observational analysis involving patients who underwent PPV with SO injection for macula-off RD or VH with the SO remaining *in situ* for one year or more between February 2011 and January 2022 was performed. Exclusion criteria were cases who lost follow-up after surgery, had incomplete or missing medical records or a concomitant ocular disease that may affect vision (glaucoma, optic atrophy, corneal pathology, *etc.*), and had undergone surgical intervention indicated for reasons other than RD or VH. This cohort of patients with prolonged SO tamponade was a result of the high surgical load at our center. Furthermore, many patients referred for vitrectomy surgery had limited insurance coverage at presentation. Many cases struggled to obtain financial coverage to perform SO removal surgery afterward. These circumstances contributed to creating this unique cohort of patients with prolonged SO tamponade.

Data collected included the date of the operation, diagnosis/indication for surgery, pre-operative lens status, best-corrected VA, if SO removal was done, and the duration of SO tamponade. We obtained VA pre-operatively within one week before surgery, one year after surgery with silicon *in situ*, and one month after silicon removal (if performed). Counting fingers, hand motion, light perception, and no light perception were quantified, according to the ETDRS and FrACT, as 0.014, 0.005, 0.0016, and 0.0013, respectively [15]. These parameters were retrieved from the patients' surgical records, progress notes, and archive records at the institution and abstracted into a standardized data collection sheet.

2.2. Surgical Setting and Technique

All surgeries were performed by a single vitreoretinal surgeon (NAY) with the same surgical setting for each case. The initial surgical intervention consisted of a 20-gauge three-port vitrectomy system (DORC International BV, Zuidland, Netherlands), complete vitrectomy with shaving of vitreous up to the ora serrata, 360 degrees laser retinopexy and around retinal breaks, and infusion of 1000 centistokes silicon oil for near-complete fill. Additionally, all phakic patients underwent standard phacoemulsification and posterior chamber IOL implantation during the same surgical session. For SO removal, a three-port pars plana surgery was performed on all cases, with the eye filled with atmospheric air or balanced salt solution.

2.3. Statistical Analysis

We used IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA) in our analysis. We used the mean (± standard deviation) to describe continuous variables and the count (frequency) to describe other nominal variables. We categorized the data according to the indication of surgery into the RD group and VH group, and performed the analysis separately. We performed an independent sample t-test to analyze the mean difference between the eyes that had the SO removed *versus* the group with retained SO, and we presented the data in mean difference and standard deviation (±). We used the Chi-square test to analyze the frequency difference between the eyes that had the SO removed and those that had not, and each categorical variable was included in our analysis. All underlying assumptions were met. We adopted a p-value of 0.05 as a significant threshold.

3. RESULTS

From a total of 852 charts for vitrectomy surgery reviewed between February 2010 and January 2022, 212 eyes from 195 patients had SO tamponade for one or more years, and thus were enrolled in this study. One hundred eyes had a combined PPV with phacoemulsification and IOL implantation surgery. The mean age of this series was 54.5 (±16.78) years. Out of the included sample, 102 (53.1%) patients had their SO removed after one year or more with a mean SO tamponade duration of 17 months. Regarding the indication for surgery, 165 (77.8%) patients underwent vitrectomy for rhegmatogenous or combined rhegmatogenous/tractional RD, while 47 (22.2%) underwent the surgery for VH. Table **1** summarizes the characteristics of the sample included.

Table 1. Characteristics of eyes enrolled in the study.

-		Mean	Standard Deviation	Count	Column N %
Age of Patient (years)		54	17	-	-
Eye	Left	-	-	95	45.0%
	Right	-	-	116	55.0%
Lens status pre-op	Aphakic	-	-	9	4.3%
	Pseudophakic	-	-	101	48.1%
	Phakic	-	-	100	47.6%
Indication of vitrectomy	Retinal detachment	-	-	165	77.8%
	Vitreous hemorrhage	-	-	47	22.2%

(Table 1) contd.....

-		Mean	Standard Deviation	Count	Column N %
Mean VA after PPV with silicone oil (one year post-operative)		0.1294	0.2324	-	-
Mean VA with silicone oil (at last documented visit)		0.1012	0.1730	-	-
Mean VA one month after silicone oil removal		0.1517	0.2172	-	-
Silicone oil removed?	No	-	-	90	46.9%
	Yes	-	-	102	53.1%
Mean duration of silicone oil		17	16	-	-

Note: VA: Visual Acuity (in decimals); PPV: Pars plana vitrectomy.

Table 2. The association between silicone oil removal and visual acuity in retinal detachment cases.

-		Mean	SO Retained Count	N %	Mean	SO Removed Count	N %
Age	-	54	-	-	52	-	-
Eye	Left	-	37	46.3	-	34	40.5
	Right	-	43	53.8	-	50	59.5
Lens status pre-op	Aphakic	-	3	3.8	-	6	7.1
	Pseudophakic	-	43	54.4	-	42	50.0
	Phakic	-	33	41.8	-	36	42.9
VA after PPV with SO at one year		0.1132 ± (0.2079)	-	-	0.0967 ± (0.1921)	-	-
VA with SO last		0.0824 ± (0.1610)	-	-	0.1101 ± (0.1606)	-	-
VA after SO removal		-	-	-	0.1433 ± 0.2114	-	-

Note: SO: Silicone oil; VA: Visual acuity (in decimals); PPV: Pars plana vitrectomy.

Table 3. The association between silicone oil removal and visual acuity in vitreous hemorrhage cases.

-		Mean	SO Retained Count	N %	Mean	SO Removed Count	N %
Age	-	60	-	-	54	-	-
Eye	Left	-	16	53.3	-	8	47.1
	Right	-	14	46.7	-	9	52.9
Lens status pre-op	Aphakic	-	0	0.0	-	0	0.0
	Pseudophakic	-	9	30.0	-	7	41.2
	Phakic	-	21	70.0	-	10	58.8
VA after PPV with SO		0.1442 ± (0.2576)	-	-	0.0837 ± (0.1781)	-	-
VA with silicone oil last		0.1404 ± (0.2441)	-	-	0.0698 ± (0.1207)	-	-
VA after silicone oil removal		-	-	-	0.2332 ± (0.2746)	-	-

Note: SO: Silicone oil; VA: Visual acuity (in decimals); PPV: Pars plana vitrectomy.

Out of the 165 eyes operated for RD, 85 (51.5%) had SO removal surgery after a mean of 17.2 (±5.2) months, while 80 (48.5%) did not have SO removal. Both groups had a comparable proportion of lens status preoperatively (p= 0.610), as shown in Table **2**. Upon comparing VA change from pre-operative to last post-operative vision, we observed a statistically significant difference in visual acuity gain between patients who had oil removal and patients who did not have SO removal, with a mean difference of 0.077 (95% CI 0.001 to 0.15), p= 0.047.

Out of the 47 VH eyes, 17 (36.2%) had SO removal surgery after a mean of 15.82 (±2.56) months, while 30 (63.8%) did not have SO removal. Both groups had a comparable proportion of lens status preoperatively (p= 0.528), as shown in Table **3**. We observed a non-statistically significant difference in visual acuity gain between patients who had SO and patients who did not, with a mean difference of 0.153 (95% CI -0.02 to 0.32), p= 0.086. Yet, visual acuity change from the pre-operative to the last post-operative vision was higher for those who had SO removal.

4. DISCUSSION

RD and VH are the main indications for PPV surgery. As a tamponading agent, SO is used to attach the retina on the RPE in RD cases and also prevent vitreous cavity re-bleeding after vitrectomy for VH [16]. Retained SO after PPV surgery may cause complications, such as emulsification and raised intraocular pressure, while removal of SO can also be associated with loss of vision [17, 18]. Previous studies have reported an improvement in VA after SO removal [19, 20]. The improvement of visual acuity after SO removal can be explained by the elimination of the variability in refraction induced by the anterior curve of the silicon oil bubble and light diffraction induced by droplets of emulsified oil [21]. Issa *et al*. noticed an initial rapid improvement in VA during the first 6 months after SO removal, followed by a slower, progressive improvement [10]. Overall, improved VA after SO removal is due to a combination of factors, including the slow recovery of the naturally reattached retina, altered optics during SO tamponade with improved refraction after oil removal, and possible retinal toxicity with improved function after SO extraction. However, the best corrected VA remained unchanged in 56.3% of eyes in the report presented by Shah *et al*. [22]. Williams reported no visual improvement among patients after SO removal compared to their best-recorded acuities under oil tamponade [9]. Worse visual outcomes were reported in other studies, with Roca *et al*. reporting a significant visual loss following SO in 13% of eyes [23]. Similarly, in 34.8% of the cases reported by Oliveira-Ferreira, there was VA loss by at least two Snellen lines [18].

In our study, RD was the major indication of the original PPV with the injection of SO. We observed an overall improvement in VA after the removal of SO in cases where the oil was used as a tamponade for one or more years. Flaxel studied a similar cohort, although with a shorter tamponade time, and reported that 63% had either maintained or improved their VA after SO removal [19]. In contrast, Moisseiev *et al*. reported no visual improvement after silicon removal where RD was the main indication for SO injection [24, 25]. Interestingly, we found a non-statistically significant difference in visual acuity gain between patients who had SO removal *versus* patients who did not have SO removal among VH patients.

This study is inherently limited by its retrospective nature. Incomplete data have precluded addressing details related to intraocular pressure fluctuations and refractive error changes after SO removal. All eyes in this cohort were operated upon by a single surgeon and in the same surgical setting, and the effect of cataract formation on visual acuity changes was stratified as all cases were either pseudophakic to start with or had undergone cataract extraction at the same time of vitrectomy surgery. Lastly, our cohort included a relatively large number of cases from a single tertiary center and they were followed up for more than one year.

CONCLUSION

Despite prolonged SO tamponade for more than one year, delayed oil removal in cases that underwent PPV for RD repair resulted in an improvement in VA in this cohort of consecutive patients when compared to similar patients who still had the SO *in situ*. For VH cases, this effect was less pronounced.

LIST OF ABBREVIATIONS

SO	=	Silicone oil
PPV	=	Pars plana vitrectomy
VA	=	Visual acuity
RD	=	Retinal detachment
VH	=	Vitreous hemorrhage
RPE	=	Retinal pigment epithelium
IOL	=	Intraocular lens

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study has been approved by the Institutional Review Board at Jordan University Hospital (Approval no. 871/2022/67).

HUMAN AND ANIMAL RIGHTS

No animals were used for studies that are the basis of this research. No procedures were performed on humans as this was a retrospective analysis of patients' records.

CONSENT FOR PUBLICATION

A written informed consent form was obtained from patients to review their files for this retrospective study.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available from the corresponding author upon reasonable request and is stored at the Ophthalmology Division archives at Jordan University Hospital.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

REFERENCES

[1] Macherner R. The development of pars plana vitrectomy: A personal account. Graefes Arch Clin Exp Ophthalmol 1995; 233(8): 453-68. [http://dx.doi.org/10.1007/BF00183425] [PMID: 8537019]

[2] Znaor L, Medic A, Marin J, Binder S, Lukic I, George J. Pars plana vitrectomy *versus* scleral buckle for repairing simple rhegmatogenous retinal detachments. Cochrane Libr 2012; 3(3): CD009562. [http://dx.doi.org/10.1002/14651858.CD009562] [PMID: 30848830]

[3] Mondelo-García C, Bandín-Vilar E, García-Quintanilla L, *et al.* Current situation and challenges in vitreous substitutes. Macromol Biosci 2021; 21(8)2100066

[http://dx.doi.org/10.1002/mabi.202100066] [PMID: 33987966]

[4] Barca F, Caporossi T, Rizzo S. Silicone oil: Different physical proprieties and clinical applications. BioMed Res Int 2014; 2014: 1-7. [http://dx.doi.org/10.1155/2014/502143] [PMID: 25013785]

[5] Miller JB, Papakostas TD, Vavvas DG. Complications of emulsified silicone oil after retinal detachment repair. Semin Ophthalmol 2014; 29(5-6): 312-8. [http://dx.doi.org/10.3109/08820538.2014.962181] [PMID: 25325856]

[6] Patel A v, Papakosta TD, Eliott D. Silicone oil emulsification in retina surgery. Retina Today 2015; 6: 29-32.

[7] Mehta Sv, Lin RC, Hariprasad SM. Outcomes of pars plana vitrectomy for vitreous hemorrhage based on duration and etiology of hemorrhage. Invest Ophthalmol Vis Sci 2009; 50: 6061.

[8] Coman Cernat CC, Munteanu M, Malita D, *et al.* Corneal endothelial changes induced by pars plana vitrectomy with silicone oil tamponade for retinal detachment. Exp Ther Med 2021; 22(3): 961. [http://dx.doi.org/10.3892/etm.2021.10393] [PMID: 34335903]

[9] Williams PD, Fuller CG, Scott IU, Fuller DG, Flynn HW. Vision loss associated with the use and removal of intraocular silicone oil. Clin Ophthalmol 2008; 2(4): 955-9. [PMID: 19668452]

[10] Issa R, Xia T, Zarbin MA, Bhagat N. Silicone oil removal: Post-operative complications. Eye 2020; 34(3): 537-43. [http://dx.doi.org/10.1038/s41433-019-0551-7] [PMID: 31406357]

[11] Shousha MA, Yoo SH. Cataract surgery after pars plana vitrectomy. Curr Opin Ophthalmol 2010; 21(1): 45-9. [http://dx.doi.org/10.1097/ICU.0b013e32833303bf] [PMID: 19855278]

[12] Treumer F, Bunse A, Rudolf M, Roider J. Pars plana vitrectomy, phacoemulsification and intraocular lens implantation. Comparison of clinical complications in a combined *versus* two-step surgical approach. Graefes Arch Clin Exp Ophthalmol 2006; 244(7): 808-15. [http://dx.doi.org/10.1007/s00417-005-0146-9] [PMID: 16328429]

[13] Zafar S, Bokhari SA, Kamil Z, Shakir M, Rizvi SF, Memon GM. Outcomes of silicone oil removal. J Coll Physicians Surg Pak 2013; 23(7): 476-9. [PMID: 23823950]

[14] Abu-Yaghi NE, Abu Gharbieh YA, Al-Amer AM, *et al.* Characteristics, fates and complications of long-term silicone oil tamponade after pars plana vitrectomy. BMC Ophthalmol 2020; 20(1): 336. [http://dx.doi.org/10.1186/s12886-020-01608-5] [PMID: 32807120]

[15] Schulze-Bonsel K, Feltgen N, Burau H, Hansen L, Bach M. Visual acuities "hand motion" and "counting fingers" can be quantified with the freiburg visual acuity test. Invest Ophthalmol Vis Sci 2006; 47(3): 1236-40. [http://dx.doi.org/10.1167/iovs.05-0981] [PMID: 16505064]

[16] Feng X, Li C, Zheng Q, *et al.* Risk of silicone oil as vitreous tamponade in pars plana vitrectomy: A systematic review and meta-analysis. Retina 2017; 37(11): 1989-2000. [http://dx.doi.org/10.1097/IAE.0000000000001553] [PMID: 28248823]

[17] Takayama K, Someya H, Yokoyama H, *et al.* Prognostic factors of revitrectomy for complications in eyes with proliferative diabetic retinopathy: A retrospective multicentre study. Acta Ophthalmol 2020; 98(4): e434-9. [http://dx.doi.org/10.1111/aos.14292] [PMID: 31674137]

[18] Oliveira-Ferreira C, Azevedo M, Silva M, *et al.* Unexplained Visual Loss After Silicone Oil Removal: A 7-Year Retrospective Study. Ophthalmol Ther 2020; 9(3): 1-13. [http://dx.doi.org/10.1007/s40123-020-00259-5] [PMID: 32399859]

[19] Flaxel CJ, Mitchell SM, Aylward GW. Visual outcome after silicone oil removal and recurrent retinal detachment repair. Eye 2000; 14(6): 834-8. [http://dx.doi.org/10.1038/eye.2000.232] [PMID: 11584838]

[20] Tangpontirak K, Yospaiboon Y, Sinawat S, *et al.* Predictors for visual outcome after silicone oil removal in eyes with complicated retinal detachment. Clin Ophthalmol 2022; 16: 4335-43. [http://dx.doi.org/10.2147/OPTH.S396188] [PMID: 36601544]

[21] Yang AH, Jin W, Xing YQ. Changes in visual acuity, axial length, and refraction after removal of intraocular silicone oil following retinal reattachment surgery in Chinese patients: An open-label, prospective study. Curr Ther Res Clin Exp 2009; 70(3): 221-7. [http://dx.doi.org/10.1016/j.curtheres.2009.06.002] [PMID: 24683232]

[22] Shah R, Byanju R, Pradhan S. Outcomes of silicone oil removal in complex retinal detachment. Nepal J Ophthalmol 2018; 10(2): 124-9. [http://dx.doi.org/10.3126/nepjoph.v10i2.23012] [PMID: 31056554]

[23] Roca JA, Wu L, Berrocal M, *et al.* Un-explained visual loss following silicone oil removal: Results of the Pan American Collaborative Retina Study (PACORES) Group. Int J Retina Vitreous 2017; 3(1): 26. [http://dx.doi.org/10.1186/s40942-017-0079-6] [PMID: 28748109]

[24] Moisseiev E, Ohana O, Gershovitch L, Barak A. Visual prognosis and complications following silicone oil removal. Eur J Ophthalmol 2013; 23(2): 236-41. [http://dx.doi.org/10.5301/ejo.5000199] [PMID: 23065851]

[25] Khurram D, Ghayoor I. Outcome of silicone oil removal in eyes undergoing 3-port parsplana vitrectomy. Pak J Ophthalmol 2011; 27(1) .