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Silicone Oil and Intraocular Pressure: Unraveling the Post-Vitrectomy Relationship

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Abstract:-

- ***Aim of the Study:***

To assess the potential influence of silicone oil tamponade following vitrectomy on the early elevation of intraocular pressure (IOP), a critical factor associated with the emergence of secondary glaucoma in individuals with proliferative changes in the vitreous and retina.

- ***Subjects and Methodology:***

This study was carried out in a prospective manner within the Department of Ophthalmology at Katuri Medical College and Hospital from January 2023 to January 2024, lasting for a duration of 1 year. The research involved 110 participants categorized into three groups based on their medical histories. The control cohort, comprising 40 patients, went through vitrectomy with either air or saline solution as a tamponade. The second group, consisting of 40 patients with retinal detachment and proliferative retinopathy changes, have undergone vitrectomy with silicone oil tamponade. The third group, comprising 30 patients diagnosed with diabetic retinopathy, underwent vitrectomy with silicone oil tamponade. This study encompassed the assessment of intraocular pressure's (IOP) and gonioscopic findings one month before and after vitrectomy for all the participants. The primary focus of the analysis was the comparison of IOP values across the different groups.

- ***Conclusion:***

The results indicated that there was no statistically notable contrast in intraocular pressure (IOP) values prior to and following the vitrectomy procedure within the control group (p=0.104). Additionally, there was no substantial difference in preoperative IOP values among the three groups of patients. However, a noteworthy distinction in IOP values was observed during one-month post-vitrectomy, particularly in patients who underwent silicone oil tamponade. This suggests that the use of silicone oil tamponade had a notable impact on intraocular pressure in these patients after the surgical procedure.

The study observed that, a month Following vitrectomy, the mean intraocular pressure (IOP) values in individuals with silicone oil tamponade were notably elevated in comparison to the control group ($p<0.05$).

However, when examining individuals with retinal detachment and individuals with diabetic retinopathy changes, did not exhibit a statistically notable variance in IOP one-month post-vitrectomy (p=0.331). Nevertheless, the qualitative examination exposed a 2 mmHg increase in intraocular pressure (IOP) in the diabetic retinopathy cohort.

This study indicates that there exists no significant variance in angle width prior to and following vitrectomy among various groups included. Silicone oil in emulsified form was identified in 18% of the individuals with retinal detachment and in 17% of those with diabetic retinopathy, found in the chamber angle. Moreover, within the cohort of individuals with diabetic retinopathy, 10% of patients demonstrated this attribute of angle neovascularization one-month post-vitrectomy. The rise in intraocular pressure (IOP) in the initial postoperative phase can be linked to the introduction of silicone oil into the vitreous cavity following vitrectomy. The emulsification of silicone oil might be a factor in the early elevation of intraocular pressure (IOP), particularly in individuals with diabetes exhibiting angle neovascularization, potentially hastening the development of secondary glaucoma.

Keywords:- *Silicone Oil, Vitreoretinal Surgery, Intraocular Pressure, Observations from Gonioscopy, Secondary Glaucoma.*

I. INTRODUCTION

Performing pars plana vitrectomy and employing silicone oil as a tamponade has demonstrated efficacy in addressing complex instances of proliferative retinopathy[1]. The instillation of silicone oil into the vitreous cavity is crucial for stabilizing the eye, reinstating initial intraocular anatomical structures, and preventing continued proliferation. This approach is well-received, and the transparent nature of silicone oil facilitates convenient postoperative observation of posterior segment of the eye[2–5]. While potential complications such as band shaped keratopathy, corneal decompensation, cataract formation, and new tissue growth beneath the oil may occur; a prominent adverse effect associated with silicone oil is the elevation of secondary intraocular pressure (IOP)[6–14]. The timely and

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appropriate management of the elevated IOP as well as its early diagnosis contribute to maintaining the effective postoperative results of vitrectomy and aim to guard against the ongoing and lasting harm to the optic nerve and the continued deterioration of visual acuity which are intensified by the elevation of intraocular pressure (IOP) and the underlying disease process. Recent studies suggest that the rise in IOP following vitrectomy with silicone oil as a tamponade commonly occurs during the early postoperative period[15–17].

A. Study Objectives:

To ascertain whether a notable contrast exists in the values of intraocular pressure (IOP) in each patient group one month prior to and following vitrectomy with silicone oil, as well as whether it may have an impact regarding the morphological features and the extent of angle width in each patient group.

B. Subjects and Methodology:

This prospective study was undertaken in the Department of Ophthalmology at Katuri Medical College and Hospital, covering a duration of one year from January 2023 to January 2024, and it included 110 participants.

- *Conflict of Interest: Nil*

- *Inclusion Criteria:*

All individuals underwent vitrectomy, either with or without the use of silicone oil as a tamponade. The participants were categorized into three groups based on their medical history details:

The initial group (comprised of 40 patients) consisted of individuals with diabetic retinopathy and retinal detachment who underwent intravitreal tamponade using either saline solution or air, serving as the control group.

The second group (comprising 40 patients) included individuals with retinal detachment associated with proliferative vitreoretinopathy (PVR) who went through vitrectomy using silicone oil as a tamponade.

The third group comprised 30 patients who underwent pars plana vitrectomy using silicone oil as a tamponade because of advanced proliferative diabetic retinopathy.

Agents used as tamponade (including air, saline solution, or silicone oil) were chosen depending on the form, size, and positioning of the retinal hole in cases of retinal detachment, as well as the extent of proliferative changes in the detached retina. This selection criteria also applied to cases of diabetic retinopathy.

- *Criteria for Exclusion:*

Patients with a medical history that suggests pre-existing glaucoma, irrespective of its underlying cause, were excluded from the study.

Confirmation or exclusion of glaucoma was carried out using measurements of intraocular pressure (IOP) and gonioscopic findings conducted on each patient prior vitrectomy.

II. STATISTICAL ANALYSIS

The statistical analysis included the use of the t-test to examine the hypothesis of equivalent means for two main sets. Furthermore, analysis of variance (ANOVA) was applied to test the hypothesis of equal mean values across multiple sets. Descriptive statistics were employed to illustrate the characteristics of the observed groups, highlighting measures of central tendency such as the Mean (representing the average values), the Median (representing the middle number in a sorted list of numerals), and the Mode (representing the most frequently occurring value). The identification of a statistically significant difference was based on the p-value, representing the probability of error in accepting the claim of a difference. A p-value less than 0.05 was considered suggestive of a statistically significant variation. The statistical analysis was carried out utilizing the SPSS 12 statistical package.

III. RESULTS

Tested specimens included an equal representation of both sexes (Figure1 and 2) and a diverse range of ages, rendering them suitable for statistical comparison.

A. Evaluation of Intraocular Pressure (IOP) Values Prior to and Following Vitrectomy within Each Patient Group:

Examining the intraocular pressure (IOP) values inside the group serving as a control, where patients underwent vitrectomy either with air or saline solution as a tamponade, in both instances, one month prior and following the surgical procedure, revealed no statistically significant disparity in the Intraocular pressure (IOP) values within the control set (p=0.104)(Table1). The average IOP value one month preceding the surgery was recorded at 13.4mmHg, while one-month post-vitrectomy, it recorded at 13.78mmHg.

The mean intraocular pressure (IOP) prior to vitrectomy in individuals with retinal detachment measured 12.90mmHg, whereas the average IOP one month after vitrectomy using silicone oil as a tamponade escalated to 19.30mmHg. Evaluation of the IOP values in these patients demonstrated a statistically significant distinction in the IOP levels prior to and following the vitrectomy procedure with silicone oil tamponade (p=0.000) (Table 2).

The mean intraocular pressure (IOP) values in patients with diabetic retinopathy changes was recorded at 13.40mmHg one month prior to vitrectomy. Following vitrectomy with the introduction of silicone oil, the IOP value escalated to 21.33mmHg one-month post-surgery. A statistically noteworthy disparity (p=0.000) was noted in the IOP values within this group of patients prior to and following vitrectomy procedure with silicone oil tamponade (Table 3).

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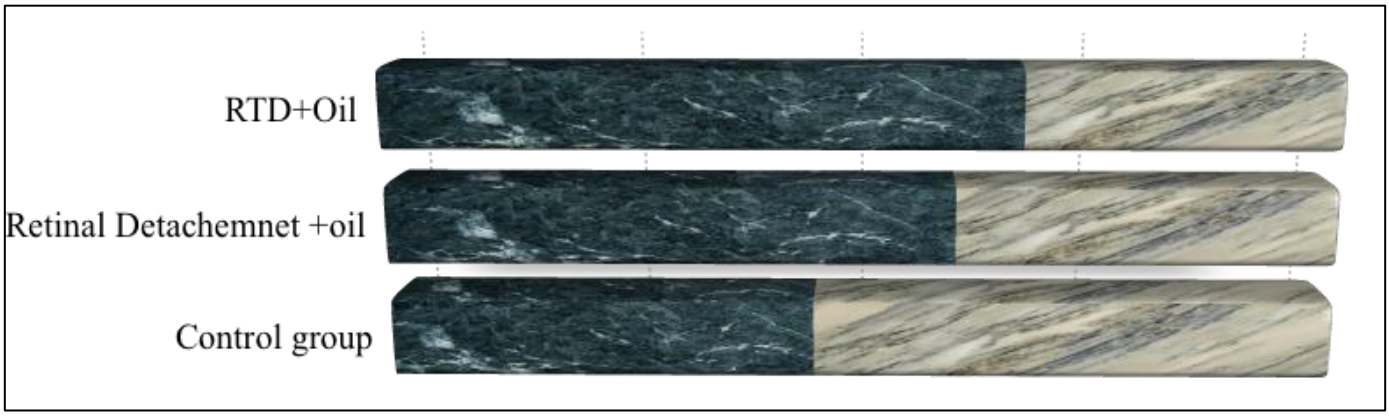

Fig 1: Gender Distribution in the Demographic Profile of the Subjects.
RTD - Diabetic Retinopathy, M - Males (Green), Z - Females (White).

	MEN	WOMEN
RTD+OIL	67%	33%
RD+OIL	60%	40%
CONTROL	45%	55%

Fig 2: Table Showing Demographic Distribution of Gender among Patients

Table 1: Intraocular Pressure (IOP) Measurements Prior to and Following vitrectomy in the Control Cohort.

	N	X	Median	Mode	Std. Dev.
Tapl	040	13.40	1.50	12	2.085
Tapl	$\bar{X}$ 140	13.78	14.00	12(a)	2.130

➢ *T-Test, Paired Samples Test*

Table 1(A): Paired Differences

			Std.Dev	STD. Error mean	95% CI LOWER	95%CI UPPER	t	df	Sig (2-tailed)
Pair1	Tapl-0 Tapl-1	-0.375	1.47	0.226	-0.831	0.081	-1.662	39	0.104

Table 2: Intraocular Pressure (IOP)Values in the Individuals with Retinal Detachment before and Post-Vitrectomy with Silicone Oil Tamponade

Retinal Detachment + Oil				
	X.	Median	Mode	Std. Dev.
Tapl 0	12.90	12.00	12	3.327
Tapl 1	19.30	16.00	16	8.864

➢ *T-test and Paired Samples Analysis*

Table 2(A): Paired Differences

		$\bar{X}$	Std. Dev	STD. Error mean	95% CI LOWER	95%CI UPPER	t	df	Sig (2-tailed)
Pair1	Tapl 0 Tapl-1	-6.400	8.949	1.415	-9.262	-3.538	-4.523	39	0.00

Table 3: Intraocular Pressure (IOP) Observations in the Diabetic Retinopathy Cohort Prior to and following Vitrectomy with Silicone Oil Tamponade

RTD+Oil						
	X.	Median	Mode	Std. Dev.	Valid	Missing
Tapl 0	30	0	13.40	13.00	12	2.253
Tapl-1	30	0	21.33	19.50	14	8.235

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➢ *Histogram, Paired Samples Test*

Table 3(A): Paired Difference

		$\bar{X}$	Std. Dev	STD. Error mean	95% CI LOWER	95%CI UPPER	t	df	Sig (2-tailed)
Pair1	Tapl 0-Tapl-1	-7.983	8.073	1.475	-10.948	-4.919	-5.383	29	0.000

B. Evaluating the Intraocular Pressure (IOP) Measurements Prior to and Following Vitrectomy Across Various Groups Categorized According to Diagnosis

Upon analyzing the intraocular pressures (IOP) among different patient groups based on their vitrectomy-indicated diagnoses, it was concluded that there was no statistically significant difference in preoperative IOP values between the second and third groups of patients, in comparison to the preoperative intraocular pressure values in the group serving as control ($p>0.05$), (Tables 4a,5a,6a).

Upon examining the intraocular pressure (IOP) values one-month after vitrectomy using silicone oil as a tamponade within the second and third patient groups, a statistically significant distinction was observed when compared to the post-operative IOP values of the control group ($p<0.05$), (Tables 4b, 5b). Additionally, the examination of pre-operative and post-operative intraocular pressure's(IOP) in the second group (consisting of individuals with retinal detachment and PVR) and the third group (comprising individuals with diabetic retinopathy changes) exhibited no statistically significant contrast in the IOP values ($p=0.48$, $p=0.33$, (Tables 6a and 6b).

However, the qualitative analysis of the intraocular pressure (IOP) values reveals that, following vitrectomy procedure, there is a 2mmHg rise in the IOP value one month later in the patient group with diabetic retinopathy.

Examination of the gonioscopic results in each patient group both before and after the vitrectomy

No significant disparity was noted in the gonioscopic observations before and after vitrectomy across any patient cohort ($p>0.05$).A qualitative assessment substantiated that within each patient group, there were no significant alterations in the width of the angle prior to and post-vitrectomy. Most subjects examined displayed grade III and IV classifications based on Shaffer's grading system.

Among the cohort of patients who underwent a procedure for the detached retina using silicone oil as a tamponade, 18% observed with emulsified silicone oil bubbles in both the anterior chamber and the trabeculum one month after vitrectomy procedure (Figure3).

Table 4A: Intraocular Pressure (IOP) Observations Prior to Vitrectomy in both the Retinal Detachment Group and the Control Group

	N	$\bar{X}$	Std.Dev	STD. Error	95% CI LOWER	95%CI UPPER	Minimum	Maximum
CONTROL	40	13.40	2.085	0.330	12.73	14.07	9	18
RD+Oil	40	12.90	3.327	0.526	11.84	13.39	8	24
Total	80	13.15	2.770	0.310	12.53	13.77	8	24

Table 4A(i)Homogeneity of Variances Test Tapl-0

Levene statistics	Df1	df2	Sig.
6.181	1	78	0.015

Table 4A(ii)ANOVA Test- (Tapl-0)

	Sum of squares	df	$\bar{X}$ Square	F	Sig.
Between groups	5.000	1	5.000	0.649	0.423
Within groups	601.200	78	7.708		
Total	606.200	79			

Table 4B: Intraocular Pressure (IOP) Measurements Following Vitrectomy in the Retinal Detachment Group with Silicone Oil Tamponade and the Control Group with the Instillation of Either Air or Saline Solution in the Vitreous Cavity

	N	$\bar{X}$	Std. Dev	STD. Error	95% CI LOWER	95%CI UPPER	Minimum	Maximum
CONTROL	40	13.78	2.130	0.337	13.09	14.46	10	19
RD+Oil	40	19.30	8.864	1.402	16.47	22.13	11	52
Total	80	16.54	6.983	0.781	14.98	18.09	10	52

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Table 4B(i)Test of Homogeneity of Variances Tapl-1

Levene statistics	**Df1**	**df2**	**Sig.**
16.066	1	78	0.000

Table 4B(ii)ANOVA Test -(Tapl-1)

	Sum of squares	df	$\bar{x}$ Square	F	Sig.
Between groups	610.513	1	610.513	14.691	0.000
Within groups	3.241.37	78	41.556		
Total	3.851.88	79			

Table 5A: Mean IOP Values before Vitrectomy in the Diabetic Retinopathy Group and Control Group

	N	$\bar{x}$	Std.Dev	STD. Error	95% CI LOWER	95%CI UPPER	Minimum	Maximum
CONTROL	40	13.40	2.085	0.330	12.73	14.07	9	18
RTD+Oil	30	13.40	2.253	0.411	12.56	14.24	10	18
Total	70	13.40	2.143	0.256	12.89	13.91	9	18

Table 5A(i)Test of Homogeneity of Variances Tapl-0

Levene statistics	**df1**	**df2**	**Sig.**
0.276	1	68	0.601

Table 5A(ii)ANOVA Test -(Tapl-0)

	Sum of squares	**df**	$\bar{x}$ **Square**	**F**	**Sig.**
Between groups	0.000	1	0.000	0.000	1.000
Within groups	316.800	68	4.659		
Total	316.800	69			

Table 5B: Intraocular Pressure (IOP) Measurements Post-Vitrectomy and Silicone Oil Tamponade in both the Diabetic Retinopathy Group and the Control Group

	N	$\bar{x}$	**Std. Dev**	**STD. Error**	**95% CI LOWER**	**95%CI UPPER**	**Minimum**	**Maximum**
CONTROL	40	13.78	2.130	0.337	13.09	14.46	10	19
RTD+Oil	30	21.33	8.235	1.504	18.26	24.41	12	50
Total	70	17.01	6.728	0.804	15.41	18.62	10	50

Table 5B(i): Test of Homogeneity of Variances Tapl-1

Levene statistics	**Df1**	**df2**	**Sig.**
16.378	1	68	0.000

Table 5B(ii)ANOVA Test -(Tapl-1)

	Sum of squares	**df**	$\bar{x}$ **Square**	**F**	**Sig.**
Between Groups	979.344	1	973.344	31.066	0.000
Within Groups	2.143.642	68	31.524		
Total	3.122.986	69			

Table 6A: Intraocular Pressure (IOP) Measurements before Vitrectomy in both the Retinal Detachment Group and the Diabetic Retinopathy Group

	N	$\bar{x}$	**Std.Dev**	**STD. Error**	**95% CI LOWER**	**95%CI UPPER**	**Minimum**	**Maximum**
RD+Oil	40	12.90	3.327	0.526	11.84	13.96	8	24
RTD+Oil	30	13.40	2.353	0.411	12.56	14.24	10	18
Total	70	13.11	2.907	0.347	12.42	13.81	8	24

Table 6A(i): Test of Homogeneity of variances Tapl-0

Levene Statistics	**Df1**	**df2**	**Sig.**
3.377	1	68	0.070

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Table 6A(ii): ANOVA Test- (Tapl-0)

	Sum of squares	df	$\bar{x}$ Square	F	Sig.
Between groups	4.286	1	4.286	0.504	0.480
Within groups	578.800	68	8.512		
TOTAL	583.086	69			

Table 6B: Average Intraocular Pressure (IOP) One-Month Post-Vitrectomy in the Retinal Detachment Group and Diabetic Retinopathy Group with Silicone Oil Tamponade

	N	$\bar{x}$	Std.Dev	STD. Error	95% CI LOWER	95%CI UPPER	Minimum	Maximum
RD+Oil	40	19.30	8.864	1.402	16.47	22.13	11	52
RTD+Oil	30	21.33	8.235	1.504	18.26	24.41	12	50
Total	70	20.17	8.599	1.028	18.12	22.22	11	52

Table 6B(i):Test of Homogeneity of Variances Tapl-1

Levene statistics	Df1	df2	Sig.
0.043	1	68	0.837

Table 6B(ii): ANOVA Test (Tapl-1)

	Sum of squares	df	$\bar{x}$ square	F	Sig.
Between groups	70.86	1	70.876	0.958	0.331
Within groups	5.031.06	68	73.986		
Total	5.101.94	69			

COMPLICATION, DETACHMENT GROUP

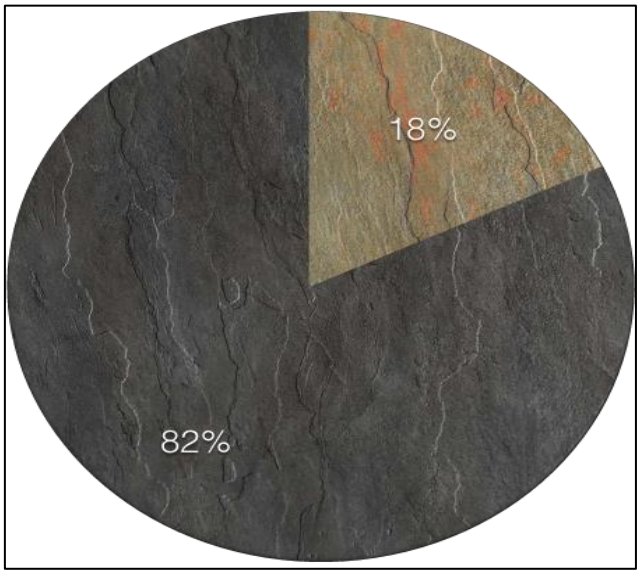

Fig 3: Illustrates the Emulsification of Silicone Oil in the Retinal Detachment Group One Month after Undergoing Vitrectomy and Silicone Oil Tamponade

- YES (silicone oil in the angle)-18%, NO -(82%)COMPLICATION, RTD GROUP.

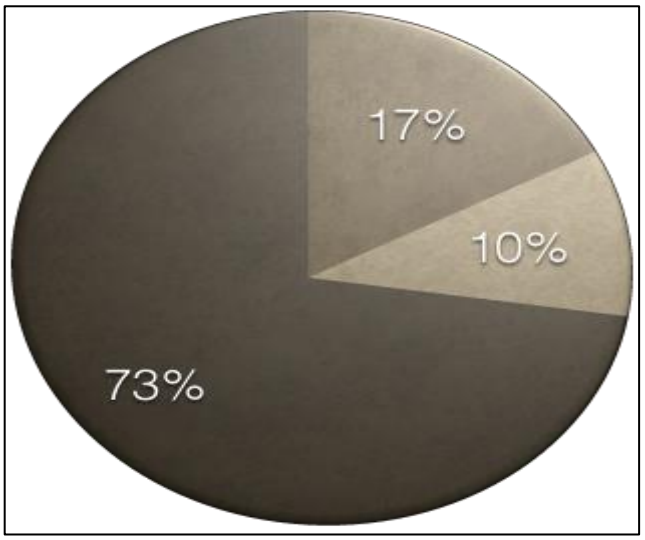

Fig 4: Depicts the Gonioscopic Findings and Angle Complications Observed in the Diabetic Retinopathy Group One Month Post-Vitrectomy Using Silicone Oil as a Tamponade.

- YES- (silicone oil in the angle) 17%., YES. (angle neovascularization)10%, NO -73%

To be precise, within this group, silicone oil in emulsified form was identified in 7 out of 40 patients. Among these cases, 6 patients predominantly exhibited silicone oil bubbles within the trabeculum, while a single patient exhibited three silicone oil bubbles in the anterior chamber one-month following the vitrectomy. Significantly, only two patients underwent a modification in the angle width (transitioning from Shaffer's grade-IV to grade-II), with all other patients maintaining the same angle width grade as seen

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before the surgical intervention. Furthermore, 17% of patients with diabetic retinopathy changes, after undergoing vitrectomy using silicone oil as a tamponade, displayed emulsified silicone oil in the anterior chamber angle (Figure 4). A qualitative examination showed emulsified silicone oil bubbles in the trabecular meshwork in five subjects. Among all the subjects only one individual demonstrated an iridotomy block at the 6 o'clock position, where silicone oil bubbles were present both in the trabecular meshwork region and in the anterior chamber. In this case, an emulsified silicone oil bubble filled the entire anterior chamber, resembling an inverse hypopyon (Figure 5).

Fig 5: Image Showing Inverse Hypopyon

Three patients, comprising 10% of the individuals in this group, manifested neovascularization(Figure 6) identified during gonioscopy one month following vitrectomy. Among these cases, only one patient with diabetic retinopathy presented with numerous goniosynechiae in the angle one-month following the surgery, while others retained same angle width as it was prior to the surgical intervention.

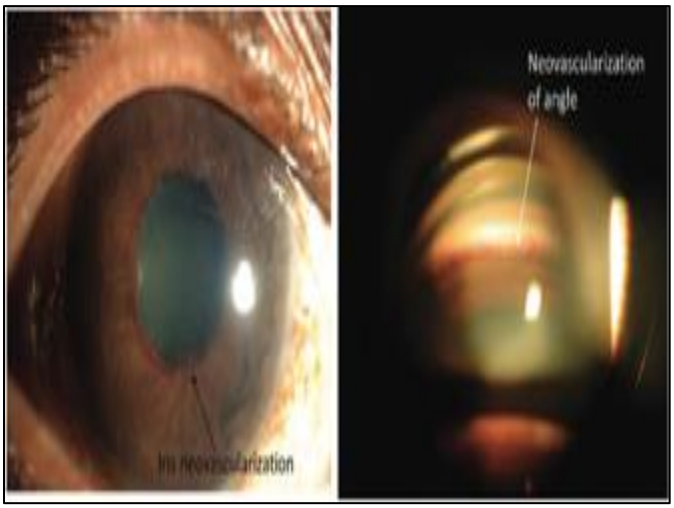

Fig 6: Image Illustrating Neovascularization of the Iris and the Angle

IV. DISCUSSION

Employing silicone oil as a tamponade agent in the early stages after pars plana vitrectomy(Figure 7) can lead to elevated intraocular pressure (IOP) in certain patients[18]. Individuals prone to the development of secondary glaucoma after undergoing silicone oil tamponade include those with diabetes, aphakic individuals, and also with pre-existing glaucoma. Various processes, such as pupillary block due to peripheral iridectomy obstruction[19], the presence of silicone oil bubbles emulsified in the chamber angle[20] , closure of the angle due to anterior synechiae, inflammation, rubeosis iridis, and unexplained elevation of intraocular pressure (IOP) following silicone oil instillation, as well as surgical oversights and excessive filling of the globe with silicone oil, contribute to the development of secondary glaucoma. The majority of cases can be effectively managed with topical antiglaucoma therapy, while a small percentage may require draining silicone oil to restore normal intraocular pressure (IOP). For the most challenging cases, penetrating filtration surgery may be necessary for long-term IOP control [21]. Some authors have reported a rise in intraocular pressure (IOP), in cases ranging from 7 to 48% during the initial postoperative period. This increase is attributed to the unique dynamics of proliferation and the movement of silicone bubbles toward the lens and the iris[15,16]. After the complete removal of the pathological substrate from the vitreous cavity during vitrectomy, there is a huge potential for the reproliferation process to occur underneath the silicone oil. This alteration in the typical anterior-posterior direction results in a tangential shift, leading to shallow retinal detachments. Another significant concern is the oil's tendency to emulsify, forming additional smaller bubbles may form in addition to pre-existing larger ones. As these bubbles traverse the anterior chamber, the anterior lens capsule, or through the surface of the anterior iris, they have a great potential to reach the trabeculum. This can result in disruptions to the outflow of aqueous humor and subsequently lead to an increase in intraocular pressure (IOP). Research findings indicate diverse occurrences of silicone oil emulsification following vitrectomy, with reported incidences ranging from 0.7% [22]to as high as 56%[23]. Despite debates among authors regarding the correlation between the quantity of emulsified oil in the anterior chamber and the elevation of intraocular pressure (IOP)[16], Leaver [22]et al. discovered silicone oil in 9 out of 14 individuals. Furthermore, they verified the existence of macrophages loaded with silicone within the trabecular meshwork, although there were no evident indications of structural harm to the collagen fibers of the trabeculum.

Our results suggest that the initial rise in intraocular pressure (IOP), measured one-month following the pars plana vitrectomy procedure, is equally evident in patients with retinal detachment and also in patients with diabetic retinopathy changes . However, a qualitative assessment of both sets of patients disclosed a more prominent increase in intraocular pressure (IOP) during the early post-operative stage in the diabetic retinopathy group. The increased intraocular pressure (IOP) values in this specific patient subgroup one month after the vitrectomy procedure are somewhat associated with the underlying pathological

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process of diabetes. Diabetes-induced retinal ischemia will result in neovascularization of the chamber angle, detected in 10% of the patients, and may additionally play an effective role in the onset of secondary glaucoma[24]. Although we did not find a statistically significant difference in the angle width before and after vitrectomy among the observed groups, the discovery of emulsified silicone oil in 18% of patients with retinal detachment and 17% in the diabetic retinopathy group suggests a potential influence on the initial escalation in the intraocular pressures (IOP).

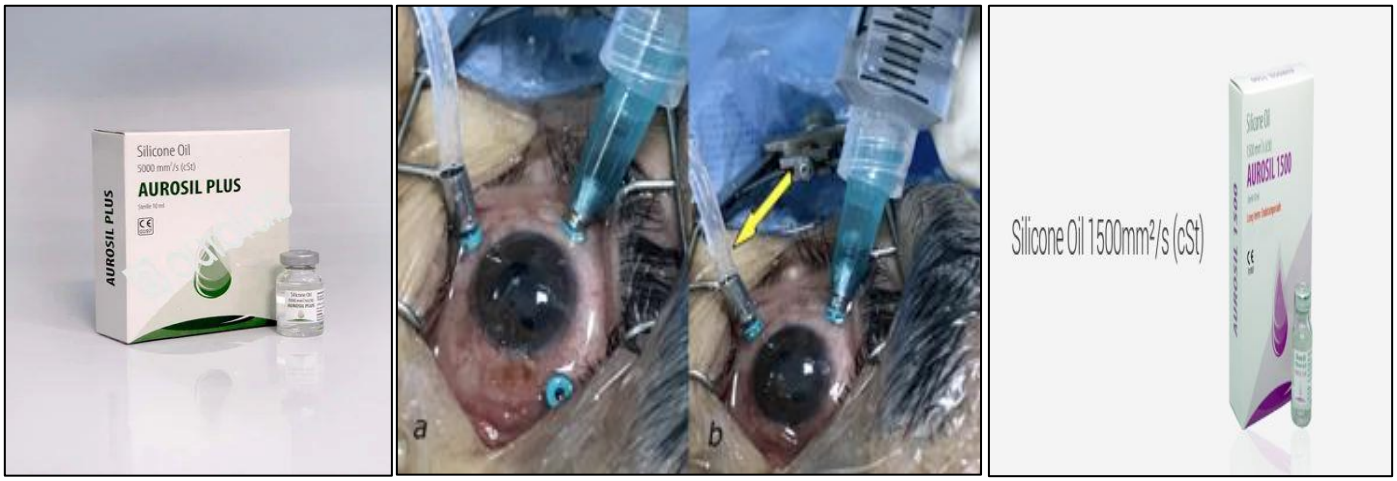

Fig 7: Illustration Depicting the Types of Silicone Oil Viscosity and the Procedure Involving Instillation of Silicone Oil

To summarize, the use of silicone oil as a tamponade agent following pars plana vitrectomy may show elevation of intraocular pressure (IOP) values during the early postoperative stage in a few individuals. Therefore, a prompt recognition and implementation of appropriate Anti glaucomatous treatment is crucial, as any elevation in IOP may affect the positive outcomes of the surgical intervention and the functional visual outcome. The early increase in intraocular pressure (IOP) in these intricate cases stands as a notable risk factor for the emergence of secondary glaucoma.

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