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Research Article

A Comparative Interventional Study of Effects of Silicon Oil on Peripapillary Capillary Perfusion in Patients with Rhegmatogenous Retinal Detachmentat Sms Hospital

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ABSTRACT
Background: Rhegmatogenous retinal detachment (RRD) is a vision-threatening condition often managed by pars plana vitrectomy (PPV) and silicone oil (SO) tamponade. While SO stabilizes the retina and facilitates reattachment, its impact on retinal microvasculature, particularly peripapillary capillary perfusion, remains under investigation. Optical Coherence Tomography Angiography (OCTA) enables detailed visualization of these vascular changes. This study evaluates the effects of SO tamponade and subsequent silicone oil removal (SOR) on peripapillary capillary perfusion in RRD patients.
Methods: This prospective, interventional, comparative study included 112 eyes with unilateral RRD undergoing PPV and SO tamponade. Patients were examined pre-SOR and at 1 week, 1 month, and 3 months post-SOR. OCT Angiography (4.5×4.5 mm^2 scans) assessed peripapillary capillary perfusion globally and by sectors (superior and inferior). Best-corrected visual acuity (BCVA) and intraocular pressure (IOP) were also recorded. Statistical significance was set at $p<0.05$.
Results: The global peripapillary perfusion improved from 42.266±0.913 pre-SOR to 42.870±0.884 at 3 months post-SOR ($p<0.001$). Superior and inferior perfusion segments showed similar progressive increases. BCVA improved significantly post-SOR (pre-SOR mean: 0.815±0.335 logMAR; post-SOR: 0.371±0.243; $p<0.001$). IOP normalized after SOR (pre: 18.670±2.002 mmHg; post: 12.348±3.382 mmHg; $p<0.001$). Each follow-up interval demonstrated statistically significant improvement compared to baseline and previous time points.
Conclusion: Silicon Oil tamponade transiently reduces peripapillary capillary perfusion. Following SOR, peripapillary perfusion progressively recovers, accompanied by improved BCVA and normalized IOP. OCTA offers valuable insights into the microvascular dynamics and recovery following SO removal, guiding postoperative management and timing of SOR. Further studies should explore long-term vascular and functional outcomes to refine clinical decision-making for RRD management.

Keywords: Rhegmatogenous retinal detachment, Silicone oil tamponade, Peripapillary capillary perfusion, Optical Coherence Tomography Angiography, Visual outcome.

INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is a common and potentially blinding ophthalmic emergency that requires timely surgical intervention for optimal visual recovery [1,2]. Among the various surgical treatments, pars plana vitrectomy (PPV) combined with intraocular tamponade agents, such as silicone oil (SO), is widely employed to stabilize and reattach the retina, especially in complex or recurrent cases of RRD [3]. Silicone oil offers a long-lasting tamponade effect, supporting the retina against the retinal pigment epithelium while minimizing the risk of redetachment. However, SO is not without drawbacks. Prolonged intraocular presence can lead to complications including elevated intraocular pressure (IOP), cataract formation, and potential alterations in the retinal microvasculature [4,5]. The intricate vascular network supplying the optic nerve head and peripapillary region is critical for maintaining retinal function [6]. Alterations in peripapillary perfusion can affect retinal ganglion cell health and subsequent visual outcomes. With the advent of Optical Coherence Tomography Angiography (OCTA), clinicians can now non-invasively visualize and quantify the

microvasculature of the retina and optic nerve head, providing an opportunity to investigate the hemodynamic changes induced by intraocular tamponade agents [7]. Prior research suggests that SO tamponade may lead to decreased peripapillary vessel density [1]. While some studies indicate that these vascular changes might be partially reversible after silicone oil removal (SOR), the exact timeline, degree of vascular restoration, and clinical relevance remain incompletely understood. Understanding when and how peripapillary perfusion recovers following SOR could help refine clinical decisions regarding the timing of oil removal and the overall postoperative management strategy [8]. Against this backdrop, the present study aims to characterize the changes in peripapillary capillary perfusion before and after SOR in patients who underwent PPV with SO tamponade for RRD repair. By correlating perfusion metrics with visual acuity and IOP measurements, we seek to provide a more comprehensive understanding of the functional significance of vascular alterations in the peripapillary region. We hypothesize that although SO tamponade may initially reduce peripapillary capillary perfusion, SOR leads to progressive vascular recovery over time. Demonstrating such reversibility and correlating it with functional endpoints may offer valuable insights for optimizing surgical timing and follow-up protocols. Ultimately, enhancing our understanding of the microvascular dynamics associated with SO could improve long-term visual outcomes and patient care in RRD management [9,10].

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, longitudinal, interventional comparative study conducted at the Upgraded Department of Ophthalmology, S.M.S. Medical College and Hospital, Jaipur, Rajasthan. The study period was from December 2022 to November 2023, or until the desired sample size was reached.

Study Population

A total of 112 patients (112 eyes) diagnosed with unilateral RRD who underwent uncomplicated PPV and SO tamponade were included. Inclusion criteria were age 25–60 years, IOP 10–21 mmHg, and no significant ocular comorbidities in the fellow eye. Exclusion criteria included recurrent RRD requiring secondary surgery, choroidal neovascularization, retinal vascular diseases, poor OCTA image quality, combined SOR with epiretinal membrane peeling, incomplete follow-up, optic disc abnormalities, systemic vascular diseases (e.g., hypertension, diabetes), and postoperative complications (e.g., vitreous hemorrhage, endophthalmitis).

Ethical Considerations

The Institutional Ethics Committee approved the study. Informed written consent was obtained from all participants. The management followed the standard of care, ensuring no additional financial burden on patients.

Interventions and Follow-up

All patients underwent PPV with SO tamponade. After an interval determined by the surgeon for retinal stabilization, SOR was performed. Data were collected at baseline (pre-SOR) and at 1 week, 1 month, and 3 months post-SOR.

Data Collection and Measurements

A comprehensive ophthalmic examination included BCVA using Snellen's chart, IOP measurement, slit-lamp biomicroscopy, and indirect ophthalmoscopy. OCTA (Zeiss Cirrus 5000 angioplex) was used to obtain ONH 4.5×4.5 mm^2 images of the peripapillary region. Peripapillary capillary perfusion was quantified globally and by sectors (superior and inferior).

Outcome Measures

Primary outcomes: Changes in peripapillary capillary perfusion over time. Secondary outcomes: Changes in BCVA and IOP.

Statistical Analysis

Data were recorded in Microsoft Excel and analyzed using appropriate statistical tests. Continuous variables were expressed as mean ± standard deviation (SD). Repeated measures ANOVA or paired t-tests were applied where suitable. Post-hoc tests determined pairwise significance. A p-value <0.05 was considered statistically significant.

RESULTS

Demographics

The study included 112 patients (112 eyes), mean age 52.16±9.91 years (range: 27–64), with 64 males (57.14%) and 48 females (42.86%).

Peripapillary Capillary Perfusion

Global peripapillary perfusion improved significantly from pre-SOR (42.266±0.913) to 42.394±0.906 at 1 week, 42.589±0.894 at 1 month, and 42.870±0.884 at 3 months post-SOR ($p<0.001$). Both superior and inferior peripapillary perfusion showed a similar progressive increase (Tables 1–3).

IOP and BCVA Changes

IOP decreased from a pre-SOR mean of 18.670±2.002 mmHg to 12.348±3.382 mmHg post-SOR ($p<0.001$), reflecting normalization after oil removal. BCVA improved from 0.815±0.335 logMAR pre-SOR to 0.371±0.243 post-SOR ($p<0.001$), indicating significant visual recovery (Tables 4–5).

Figures 1 and 2 illustrate representative OCTA images of the peripapillary region pre- and post-SOR, as well as trend lines showing progressive improvements in perfusion and BCVA over time.

Table 1. Global Peripapillary Capillary Perfusion

Time Point	N	Mean	SD	P value
Pre-SOR	112	42.266	0.913	p<0.001*
1 Week Post-SOR	112	42.394	0.906	
1 Month Post-SOR	112	42.589	0.894	
3 Months Post-SOR	112	42.870	0.884	

*Significant improvement across all time points (ANOVA)

Table 2. Superior Peripapillary Capillary Perfusion

Time Point	N	Mean	SD	P value
Pre-SOR	112	41.730	0.674	p<0.001*
1 Week Post-SOR	112	41.888	0.677	
1 Month Post-SOR	112	43.008	0.911	
3 Months Post-SOR	112	43.372	0.787	

*Significant improvement across all time points (ANOVA)

Table 3. Inferior Peripapillary Capillary Perfusion

Time Point	N	Mean	SD	P value
Pre-SOR	112	41.041	0.481	p<0.001*
1 Week Post-SOR	112	41.164	0.486	
1 Month Post-SOR	112	41.330	0.513	
3 Months Post-SOR	112	41.491	0.532	

*Significant improvement across all time points (ANOVA)

Table 4. Intraocular Pressure (Iop)

IOP	N	Mean	SD	P value
Pre-SOR	112	18.670	2.002	p<0.001*
Post-SOR	112	12.348	3.382	

*Significant reduction in IOP post-SOR

Table 5. Best-Corrected Visual Acuity (Bcva, Logmar)

BCVA	N	Mean	SD	P value
Pre-SOR	112	0.815	0.335	p<0.001*
Post-SOR	112	0.371	0.243	

*Significant improvement in BCVA post-SOR

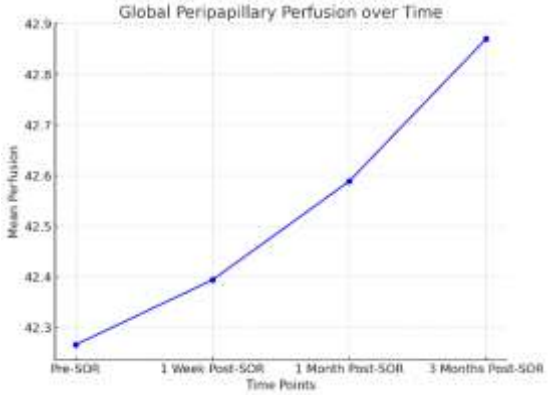

Figure 1. Representative Octa Images of the Peripapillary Region Pre-Sor and At 3 Months Post-Sor, Demonstrating Increased Perfusion Density Post-Sor

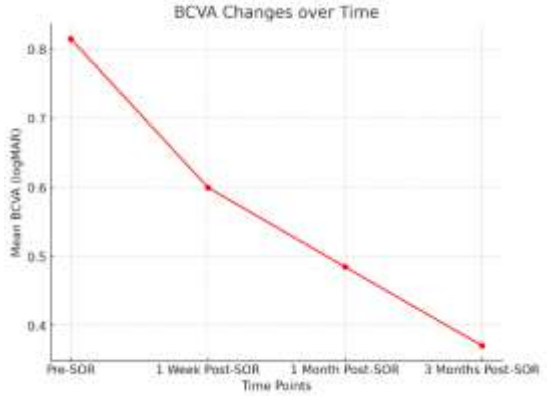

Figure 2. Line Graphs Showing Progressive Improvements in Global Peripapillary Perfusion and Bcva Over the 3-Month Follow-Up Period, Highlighting the Parallel Improvement in Vascular and Functional Outcomes

DISCUSSION

The current study highlights the reversible nature of peripapillary capillary perfusion changes induced by silicone oil tamponade for a limited duration of 3 months in patients with rhegmatogenous retinal detachment. Employing OCTA to quantify microvascular alterations, we observed a significant and progressive increase in peripapillary perfusion following silicone oil removal. Concomitant improvements in BCVA and normalization of IOP further scores the clinical significance of these vascular changes.

Our findings are consistent with prior reports suggesting that SO tamponade can alter intraocular hemodynamics, potentially diminishing retinal and optic nerve head perfusion [1,4,5]. The underlying mechanisms are multifactorial, involving mechanical effects of the silicone bubble, potential subclinical inflammatory responses, and changes in translaminar pressure gradients [6]. Crucially, our data demonstrate that these vascular changes are not permanent. Rather, upon SOR, there appears to be a gradual restoration of the microvascular network, enabling improved oxygen and nutrient delivery to the peripapillary retinal nerve fiber layer and ganglion cell axons [7,8]. The correlation of improved perfusion metrics with enhanced BCVA suggests that restoring peripapillary capillary density supports better functional recovery. Improved perfusion may help maintain neuronal integrity, thereby aiding visual rehabilitation. Likewise, the normalization of IOP post-SOR reduces the biomechanical stress on the optic nerve head, creating a more favorable environment for vascular recovery and neural function [9]. While the immediate postoperative period following SO injection may see reduced perfusion, our longitudinal assessment shows that by 3 months post-SOR, perfusion levels and BCVA approach more favorable values. This temporal pattern is vital for clinicians, implying that early postoperative imaging might underestimate long-term visual potential, and that patients may be counseled about gradual vision improvement correlating with vascular restoration over the months following SOR.[11]

Limitations of this study include the lack of a control group of RRD patients managed without SO tamponade and relatively short follow-up. Although 3 months provides valuable insights into the trajectory of vascular recovery, longer-term studies are warranted to determine whether perfusion fully normalizes and correlates with even greater visual gains. Future research should also explore whether early interventions or modified tamponade techniques can preserve peripapillary perfusion more effectively.[12,13]

In conclusion, this study confirms that SO-induced microvascular changes are largely reversible post-SOR. The use of OCTA provides valuable insights into the vascular dynamics guiding postoperative management. Understanding this recovery timeline may optimize clinical decisions about SOR timing and patient follow-up, ultimately improving long-term visual outcomes for individuals undergoing PPV with SO for RRD repair.

CONCLUSION

In patients undergoing PPV with silicone oil tamponade for rhegmatogenous retinal detachment, we found that while peripapillary capillary perfusion is initially reduced, it progressively improves following silicone oil removal. This restoration of the microvasculature correlates with significant gains in best-corrected visual acuity and normalization of intraocular pressure. OCTA thus emerges as a critical tool for monitoring microvascular changes and guiding clinical decisions about the timing of SOR and follow-up care. Further research should explore long-term vascular outcomes and investigate interventions to enhance or expedite the recovery of peripapillary perfusion, ultimately improving visual prognosis in RRD management.

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