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PERIPAPILLARY MICROVASCULAR ALTERATIONS AFTER SILICONE OIL TAMPONADE ASSESSED BY OPTICAL COHERENCE TOMOGRAPHY ANGIOGRAPHY

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Silicone oil tamponade is widely used in the surgical treatment of complex retinal disorders; however, its possible influence on the microcirculation of the optic nerve remains insufficiently investigated. This exploratory longitudinal study evaluated changes in peripapillary microcirculation after silicone oil removal in patients who underwent vitreoretinal surgery with prolonged silicone oil tamponade. Twenty eyes of nineteen patients were followed after silicone oil removal and divided into two groups according to tamponade duration of one to six months and six to twelve months. Peripapillary microvascular parameters were assessed repeatedly during a twelve-month follow-up period. Both peripapillary vessel density and blood flow index demonstrated gradual improvement after silicone oil removal in both groups. Eyes with a shorter duration of silicone oil tamponade showed a more favorable pattern of microvascular recovery throughout follow-up. These findings suggest that prolonged silicone oil tamponade may be associated with slower restoration of peripapillary microcirculation after surgery.

Key words: vitreoretinal surgery, peripapillary microcirculation, optical coherence tomography angiography, optic nerve, retinal detachment, silicone oil tamponade.

Хаджи І.Ф.

ПЕРИПАПІЛЯРНІ МІКРОСУДИННІ ЗМІНИ ПІСЛЯ ТАМПОНАДИ СИЛІКОНОВОЮ ОЛІЄЮ, ВИЗНАЧЕНІ ЗА ДОПОМОГОЮ ОПТИЧНОЇ КОГЕРЕНТНОЇ ТОМОГРАФІЇ-АНГІОГРАФІЇ

Тампонада силіконовою олією широко застосовується в хірургічному лікуванні складних захворювань сітківки; однак її можливий вплив на мікроциркуляцію зорового нерва залишається недостатньо вивченим. У цьому пошуковому продольному дослідженні оцінювали зміни перипапілярної мікроциркуляції після видалення силіконової олії у пацієнтів, які перенесли вітреоретинальну операцію з тривалою тампонадою силіконовою олією. Після видалення силіконової олії під наглядом перебували двадцять очей дев'ятнадцяти пацієнтів, яких було розподілено на дві групи залежно від тривалості тампонади: від одного до шести місяців та від шести до дванадцяти місяців. Перипапілярні мікросудинні параметри оцінювали повторно протягом 12-місячного періоду спостереження. Як щільність перипапілярних судин, так і індекс кровотоку демонстрували поступове поліпшення після видалення силіконової олії в обох групах. В очах із коротшою тривалістю тампонади силіконовою олією відзначалася сприятливіша динаміка відновлення мікроциркуляції протягом усього періоду спостереження. Отримані дані дають підстави припустити, що тривала тампонада силіконовою олією може бути пов'язана з повільнішим відновленням перипапілярної мікроциркуляції після операції.

Ключові слова: вітреоретинальна хірургія, перипапілярна мікроциркуляція, оптична когерентна томографія-ангіографія, зоровий нерв, відшарування сітківки, тампонада силіконовою олією.

Silicone oil (SO) has been widely used as a long-term intraocular tamponade for several decades in vitreoretinal surgery [5, 6, 9]. Since the introduction of intravitreal silicone oil in 1962, SO has become an integral component of modern vitreoretinal procedures, particularly in the management of complex retinal detachments associated with proliferative vitreoretinopathy, giant retinal tears, proliferative diabetic retinopathy, ocular trauma, and viral retinitis [3, 8, 9].

The main advantages of silicone oil include stable and prolonged endotamponade, the absence of strict postoperative positioning requirements, preservation of optical media transparency allowing continuous fundus visualization, and relatively maintained visual acuity while the tamponade remains in situ [7].

Despite these benefits, silicone oil use has been associated with a spectrum of postoperative complications, such as corneal decompensation, band keratopathy, cataract progression, secondary glaucoma, and unexplained visual loss following oil removal [9, 17, 18]. Silicone oil–associated optic neuropathy has been reported with variable incidence, although its pathophysiological mechanisms remain incompletely understood and are likely multifactorial, involving mechanical compression, metabolic disturbances, and microcirculatory impairment [9].

The introduction of optical coherence tomography angiography (OCTA) has enabled non-invasive, high-resolution visualization of the radial peripapillary capillaries (RPC) and quantitative assessment of microvascular integrity [4, 16]. Alterations in RPC perfusion have been documented in glaucoma, ischemic optic neuropathy, and other optic nerve disorders [2, 11, 14], supporting the role of OCTA-derived vascular parameters as early biomarkers of neurovascular dysfunction. In addition, OCTA provides valuable insight into optic nerve head microcirculation, offering potential prognostic relevance in conditions associated with retinal or optic nerve stress [12, 13].

Given the potential compressive, metabolic, and oxygen diffusion–related effects of silicone oil on the retina and optic nerve, further investigation of silicone oil–associated microcirculatory alterations remains of considerable clinical importance. However, data regarding longitudinal peripapillary microvascular changes associated with different durations of silicone oil tamponade remain limited.

The purpose of the study was to quantitatively evaluate the association between silicone oil tamponade duration and longitudinal changes in peripapillary vessel density and flux index, as measured by OCT angiography.

Materials and methods. This study was designed as a single-center exploratory observational longitudinal cohort intended to generate hypotheses regarding peripapillary microvascular changes associated with silicone oil tamponade and its duration. The study was conducted at the National Ophthalmology Center named after Academician Zarifa Aliyeva (Department of Diabetic Eye Complications) between 2023 and 2024. A total of 28 patients were initially screened. Two patients were excluded due to elevated intraocular pressure, and six patients were excluded because of poor OCTA image quality secondary to posterior capsule opacification. Only scans with a signal strength≥7 were accepted for analysis. One patient was excluded because of advanced silicone oil emulsification resulting from lack of follow-up for two years.

As a result, the final sample consisted of 20 eyes from 19 patients with rhegmatogenous retinal detachment, including 10 males (52.6 %) and 9 females (47.4 %), with a mean age of 49.6±4.94 years (range, 24–70 years). In this cohort, silicone oil tamponade was selected for eyes with complex rhegmatogenous retinal detachment, defined by extensive or inferior retinal breaks, the presence of proliferative vitreoretinopathy, or other intraoperative features necessitating prolonged internal tamponade.

All patients received a comprehensive ophthalmic examination, including best-corrected visual acuity, autorefractometry, tonometry, slit-lamp biomicroscopy, indirect ophthalmoscopy, structural OCT, and OCT angiography (Cirrus HD-OCT 5000, Carl Zeiss Meditec, AngioPlex). Peripapillary OCTA scans (4.5×4.5 mm) were obtained before silicone oil removal and at 1, 3, 6, and 12 months postoperatively. Quantitative parameters included peripapillary vessel density and flux index. The mean OCTA scan quality score was 7.3±1.1 before silicone oil removal and 7.9±0.9 after removal.

Exclusion criteria included high myopia, elevated intraocular pressure, significant OCTA artifacts, ischemic optic neuropathy or other optic nerve disorders, and any history of ocular surgery except cataract or refractive surgery. Only patients with acceptable OCTA image quality were included in the final analysis.

All surgeries were performed by a single vitreoretinal surgeon. The surgical protocol consisted of combined cataract phacoemulsification and standard three-port 23-gauge pars plana vitrectomy with 1000-centistoke silicone oil tamponade under general anesthesia. Additional membrane peeling was performed when clinically indicated based on intraoperative findings. Complete retinal reattachment after primary surgery was achieved in all cases. Posterior capsulotomy was routinely performed during silicone oil removal. Postoperative treatment included topical antibiotics and corticosteroids.

A formal a priori sample size calculation was not performed because this study was designed as an observational longitudinal cohort including all consecutively eligible patients within the study period. A priori power analysis was not feasible due to the exploratory longitudinal design and the absence of established effect-size estimates for OCTA-derived neurovascular parameters in silicone oil tamponade. Inclusion of all eligible cases is a commonly accepted approach in microvascular imaging research. As such, the results should be interpreted as hypothesis-generating rather than confirmatory.

Statistical analysis. Given the exploratory nature of this study and the limited sample size, analyses were primarily descriptive and hypothesis-generating. Formal inferential statistics and multivariable modeling were not performed due to insufficient statistical power inherent to this exploratory study design. Longitudinal trends in peripapillary vessel density and flux index were assessed using mean values and graphical trajectories. Future adequately powered studies are required to validate these observations using inferential statistical approaches.

This study was conducted as part of the PhD dissertation entitled "Vitreoretinal cərrahiyyədə silikon yağı tamponadası aparılan gözlərdə optik koherent tomoqrafiya angioqrafiyası ilə görmə sinirinin vəziyyətinin qiymətləndirilməsi" ("Assessment of the optic nerve condition in eyes with silicone oil tamponade in vitreoretinal surgery using optical coherence tomography angiography"), which was reviewed and approved by the Academic Council of the National Ophthalmology Center named after academician Zarifa Aliyeva on 24 April 2024 (Protocol No. 1). The study used fully anonymized clinical data obtained during routine ophthalmic care and involved no deviation from standard clinical practice. The study adhered to the tenets of the Declaration of Helsinki.

Results of the study. A total of 19 patients (20 eyes) were included in the final analysis. The duration of silicone oil tamponade ranged from 1 to 12 months. Silicone oil removal was performed according to standard clinical indications after confirmation of stable retinal reattachment. Best-corrected visual acuity was not used as an outcome parameter because of substantial variability related to macular pathology, including full-thickness macular holes and postoperative macular structural changes associated with retinal detachment repair.

OCTA imaging was performed on the day of silicone oil removal (immediately before surgery) and subsequently at 1, 3, 6, and 12 months postoperatively.

Group 1 (tamponade duration 1–6 months)

Mean peripapillary vessel density increased progressively from 40.16±1.34 at the time of SO removal to 41.85±1.61 at 1 month, 43.05±1.19 at 3 months, 44.17±1.33 at 6 months, and 45.13±1.52 at 12 months.

Similarly, the mean flux index showed a continuous rise from 0.341±0.044 before removal to 0.360±0.039 at 1 month, 0.391±0.022 at 3 months, 0.408±0.015 at 6 months, and 0.418±0.015 at 12 months.

Group 2 (tamponade duration 6–12 months)

In this group, vessel density increased from 37.94±0.90 at baseline to 39.72±0.97 at 1 month, 42.22±1.26 at 3 months, 42.49±1.05 at 6 months, and 43.67±0.87 at 12 months.

The flux index also demonstrated a gradual improvement, rising from 0.245±0.038 before removal to 0.287±0.039 at 1 month, 0.319±0.033 at 3 months, 0.358±0.029 at 6 months, and 0.392±0.020 at 12 months.

Overall, both groups exhibited a clear postoperative increase in vessel density and flux index, with Group 1 showing a recovery trajectory consistent with shorter silicone oil exposure. Given the exploratory design, results are presented descriptively without formal hypothesis testing (Fig. 1).

The graph illustrates the temporal dynamics of peripapillary vessel density (solid lines) and flux index (dashed lines) in eyes with silicone oil tamponade duration of 1–6 months (Group 1) and 6–12 months (Group 2). Measurements were obtained at the time of silicone oil removal and at 1, 3, 6, and 12 months postoperatively. Both parameters demonstrated a gradual postoperative increase in both groups, with a more favorable recovery pattern in eyes with shorter tamponade duration.

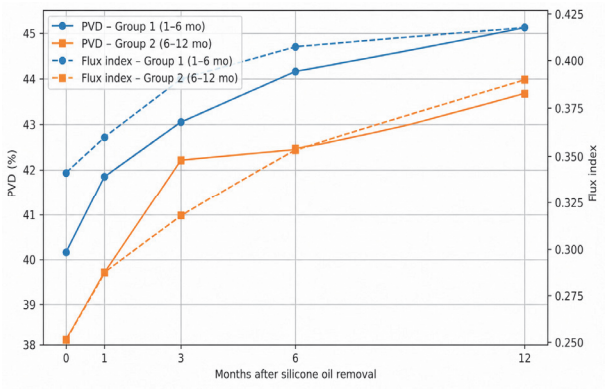

Fig. 1. Longitudinal changes in peripapillary vessel density and flux index following silicone oil removal.

Discussion. Silicone oil remains an essential long-term endotamponade in vitreoretinal surgery; however, its potential impact on retinal and optic nerve physiology continues to be debated. Although considered chemically inert, SO forms a spherical intravitreal bubble that exerts mechanical forces through volume displacement and surface tension at the oil–aqueous interface. These properties allow effective retinal support, yet several studies have reported that SO may be associated with structural, metabolic, and microvascular alterations within the retina and optic nerve head [12].

OCTA allows quantitative assessment of vascular structure and blood flux in the posterior segment, particularly in macular and peripapillary regions. By detecting motion contrast generated by erythrocyte flux, OCTA enables depth-resolved visualization of retinal capillary networks and provides quantitative metrics such as vessel density and flux index, which are sensitive to subtle microvascular alterations [1].

Recent studies published between 2024 and 2025 have further explored the effects of SO tamponade on retinal and optic nerve perfusion. Karakosta et al. reported gradual improvement in macular and optic disc perfusion following SO removal [10]. Nassar et al. described changes in flux density accompanied by functional alterations assessed by microperimetry during silicone oil tamponade [15].

In the present cohort, silicone oil tamponade was selected for complex RRD cases requiring prolonged internal tamponade due to extensive breaks, inferior pathology, or proliferative vitreoretinopathy, in which gas tamponade alone was considered insufficient.

In this exploratory series of patients with complex rhegmatogenous retinal detachment, peripapillary vessel density and flux index showed a consistent increase during the 12-month follow-up period after silicone oil removal in both short- and

long-duration tamponade groups. The gradual and monotonic nature of these changes suggests a temporal association with silicone oil removal, although random measurement variability cannot be entirely excluded. Eyes with shorter tamponade duration demonstrated a more pronounced improvement trend, indicating that tamponade duration may influence the extent of microvascular alteration.

This study was not designed to detect statistically significant intergroup differences, and therefore the results should be interpreted descriptively. Pre-vitrectomy OCTA imaging was not feasible due to media opacity, fixation instability, and segmentation inaccuracies related to retinal detachment, limiting baseline comparisons.

Several limitations of this study should be acknowledged. Although the cohort was restricted to rhegmatogenous retinal detachment to minimize pathophysiological heterogeneity, the sample size was relatively small, which limits the generalizability of the findings and precludes formal statistical comparison between groups. Second, pre-vitrectomy OCTA assessment was not feasible due to media opacities, fixation instability, and segmentation artefacts associated with retinal detachment, preventing baseline microvascular comparison. Third, this study was designed as an exploratory descriptive analysis; therefore, the observed trends should be interpreted as hypothesis-generating rather than confirmatory.

Despite the relatively small sample size, these findings support the potential role of OCTA-derived peripapillary vascular parameters as indicators of microcirculatory changes associated with silicone oil tamponade. These parameters may potentially serve as early imaging biomarkers of optic nerve microvascular alterations in eyes undergoing vitreoretinal surgery with silicone oil tamponade. Further large-scale prospective studies with standardized imaging protocols are required to clarify the clinical relevance and long-term implications of these observations.

Conclusion

Peripapillary optical coherence tomography angiography parameters showed gradual improvement after silicone oil removal, with recovery patterns varying according to the duration of tamponade. Eyes with shorter silicone oil tamponade demonstrated a more favorable trend of microvascular recovery throughout the follow-up period than eyes with longer tamponade duration. These findings suggest that prolonged silicone oil exposure may influence the restoration of peripapillary microcirculation following vitreoretinal surgery. Longitudinal assessment of peripapillary microvascular changes may improve the understanding of postoperative tissue recovery and provide additional information beyond conventional structural examination alone. Optical coherence tomography angiography represents a valuable non-invasive imaging modality for monitoring optic nerve microcirculation after silicone oil removal and may help identify subtle postoperative vascular alterations. Although these findings require confirmation in larger prospective studies with homogeneous patient populations and standardized imaging protocols, the present results support the potential clinical value of serial peripapillary microvascular assessment during postoperative follow-up.

Prospects for further research. Future prospective studies with larger homogeneous cohorts and standardized imaging protocols are warranted to validate these findings and further clarify the role of peripapillary optical coherence tomography angiography in postoperative monitoring after silicone oil removal.

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PHYSICAL THERAPY PROGRAM IN PATIENTS' SURGERY DUE TO PERITONITIS IN THE EARLY POSTOPERATIVE PERIOD

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Mortality in peritonitis ranges from 9.2 to 37.5 % and has remained so over the past decades. We examined 165 patients with acute surgical pathology. The age of the patients ranged from 18 to 93 years. Men were – 75, women – 90. Conducting a rehabilitation program in the postoperative period in patients operated on for peritonitis contributes to the earliest restoration of the work of all vital organs and systems. Implementation of a rehabilitation program (early mobilization, breathing exercises and dosed active movements for the upper and lower extremities) 12–16 hours after the end of the surgical intervention, which were comprehensive and phased, contributed to the reduction of bronchopulmonary complications by 5.6 %, thrombosis by 3.2 %, early intestinal obstruction by 1.1 %. Conducting physical therapy should be focused on the individual characteristics of each patient, taking into account age, concomitant pathology, duration and volume of surgical intervention.

Key words: physical therapy, rehabilitation program, surgical treatment, peritonitis, early postoperative period.

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ПРОГРАМА ФІЗИЧНОЇ ТЕРАПІЇ У ХВОРИХ, ОПЕРОВАНИХ З ПРИВОДУ ПЕРИТОНІТУ, В РАННЬОМУ ПІСЛЯОПЕРАЦІЙНОМУ ПЕРІОДІ

Летальність при перитоніті становить від 9,2 до 37,5 % і залишається на такому рівні протягом останніх десятиліть. Нами було обстежено 165 пацієнтів із гострою хірургічною патологією. Вік хворих коливався від 18 до 93 років. Чоловіків було 75, жінок – 90. Проведення програми реабілітації у післяопераційному періоді у пацієнтів, прооперованих з приводу перитоніту, сприяє якнайшвидшому відновленню роботи всіх життєво важливих органів та систем. Впровадження програми реабілітації (рання мобілізація, дихальні вправи та дозовані активні рухи для верхніх і нижніх кінцівок) через 12–16 годин після закінчення хірургічного втручання, які мали комплексний та поетапний характер, сприяло зниженню частоти бронхолегеневих ускладнень на 5,6 %, тромбозів – на 3,2 %, ранньої кишкової непрохідності – на 1,1 %. Проведення фізичної терапії має бути зорієнтоване на індивідуальні особливості кожного пацієнта з урахуванням віку, супутньої патології, тривалості та обсягу хірургічного втручання.

Ключові слова: фізична терапія, програма реабілітації, хірургічне лікування, перитоніт, ранній післяопераційний період.

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The management of patients with peritonitis presents a challenging and unpredictable task for every surgeon, regardless of their experience and skill. Prevention of complications and the rehabilitation of patients operated on for peritonitis remain largely unresolved issues. Today, as in decades past, peritonitis continues to be a complex and highly unpredictable complication of acute surgical pathologies [1]. Endogenous intoxication plays a key role in the progression of peritonitis,