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The clinical evaluation of the effectiveness of various minimally invasive methods in the treatment of central serous chorioretinopathy

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***Aim**: clinical evaluation of the effectiveness of various lasers in treating acute and chronic central serous chorioretinopathy.*

***Methods**. The study involved 50 patients (53 eyes) with central serous chorioretinopathy (CSCR): 32 (60.4%) with the acute form and 18 (39.6%) with the chronic form. Patients were divided into three groups based on treatment and the leakage point's (LP) location. Group 1; 19 patients (19 eyes) received focal laser coagulation. Group 2 included 24 patients (24 eyes) who underwent subthreshold micropulse laser treatment (SMLT) for retinal neuroepithelial detachment. Group 3; 7 patients (10 eyes) with chronic disease underwent focal coagulation combined with SMLT, with LP confirmed via fluorescein angiography (FA). The observation lasted 6 months.*

***Results**. At the 4-week follow-up, Group 1's best corrected visual acuity (BCVA) improved by 60.2% to 0.75±0.01, with central retinal thickness (CRT) decreasing by 72.8% to 257.2±13.1 μm ($p<0.05$). Group 2 experienced a 30% BCVA improvement to 0.5±0.02, and a 32.1% CRT reduction to 266.6±10.3 μm ($p<0.05$). Group 3 showed a 26.5% BCVA increase to 0.35±0.01, with CRT decreasing by 27.3% to 280.6±14.5 μm ($p<0.05$).*

***Conclusions.** When the leakage point (LP) is located in the subfoveal region, in cases of the chronic form of the disease with large-area diffuse hyperfluorescence, in situations where the filtration point is not detected by fluorescein angiography (FA), and in cases of disease recurrence, subthreshold micropulse laser treatment, the use of subthreshold micropulse mode laser devices with a yellow wavelength (577 nm) is considered a safe and effective therapeutic method.*

Key words:

central serous chorioretinopathy, leakage point, subthreshold micropulse laser therapy, optical coherence tomography, fluorescent angiography

Introduction. The social significance of central serous chorioretinopathy (CSCR) is that this disease primarily affects working-age individuals (20-50 years). Temporary disability caused by CSCR can, in some cases, lead to irreversible vision loss [1].

According to numerous literary sources, suprathreshold laser coagulation of the fluid leakage point effectively treats this pathology. However, the use of this method is limited by the development of several side effects, such as the formation of localized scotomas (caused by the death of photoreceptors and apoptosis of retinal pigment epithelium (RPE) cells) and further enlargement of atrophic laser lesions [2].

These aforementioned factors have driven the development of a new laser treatment technology: subthreshold micropulse laser therapy (SMLT) [3]. SMLT is typically recommended after the first month of disease onset. However, in some cases, where patients require high visual acuity for work, early application of SMLT is possible [4, 5].

Aim. Clinical evaluation of the effectiveness of various types of lasers in treating acute and chronic central serous chorioretinopathy.

Material and methods

This is a prospective observational study conducted at the Republican Specialized Scientific and Practical Medical Center for Eye Microsurgery from June to December 2024. The study included 50 patients (53 eyes) diagnosed with CSCR. Of these, 12 patients (24%) were women, and 38 patients (76%) were men. The average age of the patients was 39.4 ± 5.2 years for women and 34.8 ± 3.6 years for men. Out of the patients, 32 (32 eyes, 60.4%) had the acute form of the disease, while 18 (21 eyes, 39.6%) had the chronic form. To carry out the scientific study, approval was obtained from the Ethics Commission for Medical Research of the EiPK of the Republic of Uzbekistan, by the Declaration of Helsinki. Additionally, the voluntary informed consent of the patients was secured for their participation in the research.

The diagnosis of CSCR was established based on clinical examination, biomicro-ophthalmoscopy, fundoscopy, optical coherence tomography with angiography (DRI Triton Plus Topcon, Japan), and fluorescein angiography (TRC-NW8 Topcon, Japan).

The study included only affected eyes of patients with acute CSCR (disease duration less than 3 months) and chronic CSCR (disease duration more than 3 months). If both eyes met the inclusion criteria, they were included

in the analysis. The exclusion criteria were: (1) Acute or chronic CSCR in patients who had previously undergone photodynamic therapy (PDT), focal photocoagulation, or intravitreal anti Vascular Endothelial Growth Factor (anti-VEGF) injections; (2) use of systemic steroid therapy; (3) presence of other retinal diseases, including pathological myopia, choroidal neovascularization (CNV), polypoidal choroidal vasculopathy (PCV), as well as a history of intraocular surgery; (4) incomplete follow-up data and clinical records.

All patients underwent examinations at baseline and at 1, 3, and 6 months after treatment. The diagnostic assessment included slit-lamp biomicroscopy, dilated fundus examination, intraocular pressure measurement, best corrected visual acuity (BCVA) assessment, and optical coherence tomography (OCT).

The central retinal thickness (CRT) was measured using OCT to determine the distance between the internal limiting membrane and the inner border of the retinal pigment epithelium (RPE), including subretinal fluid (SRF) if present. The subfoveal choroidal thickness (SFCT) was assessed using enhanced depth imaging (EDI) OCT by measuring the vertical distance between the hyper-reflective line of Bruch's membrane and the innermost hyper-reflective line of the choroid-scleral interface.

In the study of fluorescein angiography (FA), a 10% sodium fluorescein solution with a volume of 5 ml was used. The drug was administered intravenously to stain the vessels of the eye. Starting from the moment of leaving the vein, photographs of the fundus were taken in a certain time range (during the first minute every 3 seconds, starting from the second minute every 30 seconds).

Primary outcomes: reduction in central retinal thickness (CRT), reduction in subretinal fluid (SRF), changes in best corrected visual acuity (BCVA), and evaluation of the effectiveness of various laser treatment methods.

Secondary outcomes: recurrence rate after treatment, changes in subfoveal choroidal thickness (SFCT), fluorescein angiography (FA) assessment of dye leakage changes, safety of laser procedures, and comparative effectiveness of different treatment methods.

For all patient groups, the choice of laser types for treatment was based on the clinical form of the disease (acute or chronic) and the projection of leakage points (LPs) on the retina; patients were divided into 3 main groups.

In the first group, 19 patients (19 eyes) with the acute form of the disease underwent focal laser coagulation (FLC) of the leakage point (LP) using a "Green" laser device with a wavelength of 532 nm (PASCAL, Iridex, USA). In the selected patients, the LP was located outside the foveal area, specifically in the extrafoveal region (beyond a 1500 μm radius from the center of the retina). The LP was targeted with 4-7 laser coagulates using laser energy of 80-100 mW, a spot diameter of 100-200 μm, and an exposure time of 0.1-0.15 seconds. Laser coagulation was performed to achieve a grade II burn effect on the L'Esperance scale (Fig. 1).

The second group included 24 patients (24 eyes) with acute and chronic forms of the disease. SMLT was applied to the area of retinal neuroepithelial detachment using a "Yellow" laser device with a wavelength of 577 nm (Easy Ret, Quantel Medical, France). In 12 patients (12 eyes) with the acute form, the LP was located in the fovea, while in 1 patient (1 eye), no LP was identified. In the chronic form, diffuse dye leakage is visualized in 6 patients (6 eyes), whereas in 5 patients (5 eyes), the LP was located in the foveal region. In the subthreshold mode, a coagulate with a diameter of 70-100 μm and laser power of 700-900 mW was created outside the vascular arcade to achieve a grade I burn effect. 50% of the selected laser energy was used, with a micropulse "duty cycle" of 5% and a pulse exposure time of 0.1-0.2 seconds. Laser applications were delivered in square-shaped patterns, with an interval of 500 μs between pulses. Using these parameters, laser treatment was applied to the area of serous neuroepithelial detachment and the hyperfluorescent zones identified on FA (Fig. 2).

In the third group of patients, identified LP underwent FLC using the EasyRet laser device (577 nm, Quantal Medical, France); the parameters of the laser are the same as in group 1, combined with micro-pulse laser treatment applied to the area of neuroepithelial detachment of the retina. SMPLT was applied to the area of neuroepithelial detachment following the same parameters as those used for the second group of patients. In this group, 7 patients (10 eyes) with the chronic form of the disease had LP confirmed by FA. All LPs were located extrafoveally.

For statistical data processing, the MedCalc 18.4.1 software package (MedCalc Software, Belgium) was used. Data are presented as mean ± standard deviation. One-way analysis of variance with repetitions was used to assess the statistical significance of differences in VA before treatment and after treatment. The difference was considered statistically significant at $p < 0.05$.

Results

Before treatment, the first group had an average visual acuity of 0.15±0.04 and a central retinal thickness (CRT) of 410.2±11.6 μm. In the second group, the average visual acuity was 0.2±0.02, with a CRT of 385.7±17.2 μm. The third group had an average visual acuity of 0.09±0.03 before treatment, while their CRT measured 350.98±15.7 μm.

The SFCT in all patients with the acute form of the disease averaged 520.41±12.7 μm, while in the chronic form, the SFCT averaged 497.8±10.3 μm, indicating a notable thickening in both cases.

The number, location, type of fluorescence, and other conditions identified during the FA examination were presented in tabular form (Table 1).

As a result of the FA procedure, 46 LPs were detected in 43 eyes. Among them, 43 eyes (81.1%) had one LP, 3 eyes (5.66%) had two LPs, one eye (1.89%) had no LP identified, and diffuse dye leakage was visualized in 6 eyes (11.3%).

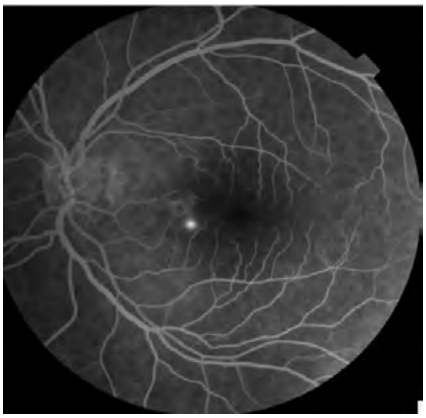
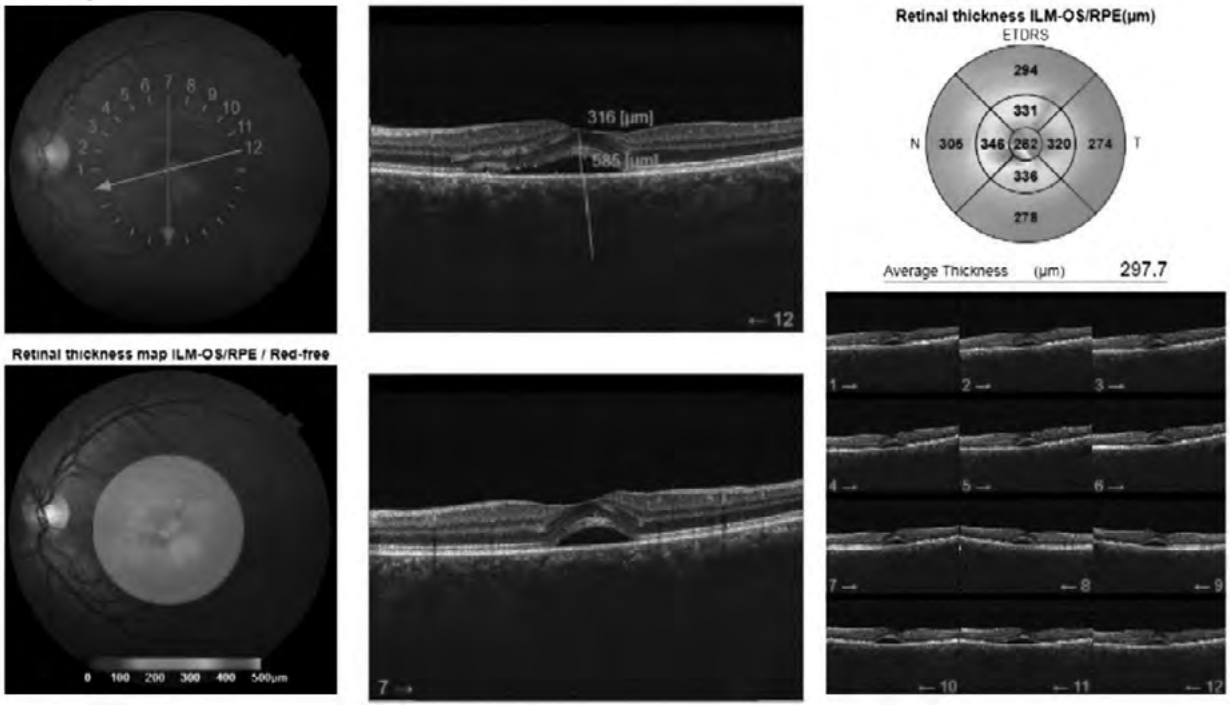


Fig. 1. Results of FA and OCT before the use of SMLT with the acute form of the CSCR.
A – FA reveals a localized LP perifoveal on the inferonasal side.
B – OCT of the central macula shows a serous detachment of the neuroepithelium, with an increase in choroidal thickness due to Haller's layer expansion, compressing the choriocapillaris.



After 4 weeks of treatment, the first group showed a 60.2% improvement in visual acuity, reaching 0.75±0.01, while CRT decreased by 72.8% to 257.2±13.1 µm ($p<0.05$) compared to baseline data (Fig. 3). In the second group, visual acuity increased by 30% to 0.5±0.02, and CRT was reduced by 32.1% to 266.6±10.3 µm ($p<0.05$) compared to baseline data. The third group demonstrated a 26.5% enhancement in visual acuity, reaching 0.35±0.01, while CRT declined by 27.3% to 280.6±14.5 µm ($p<0.05$) compared to baseline data (Fig. 4).

After the procedure, clinical symptoms and parameters of the retinal neuroepithelium (normalization of central retinal thickness, resorption of subretinal fluid) gradually normalized in all patients, as observed through instrumental examinations. No unexpected adverse events were noted during the observation period.

During dynamic monitoring after laser procedures, based on the resorption of SRF observed on OCT scans, the FA procedure was repeated for some patients. By the 4th week of observation, one LP with a "black ink spot" appearance was re-identified in the second group, while in the third group, one LP with a "black ink spot" and two LPs with a "smokestack" appearance were re-detected. In patients where LPs were re-identified, repeat laser procedures were performed.

All groups demonstrated a consistent improvement in BCVA across all observation periods. In the first group during the follow-up period after the laser procedure, no recurrence of the disease was observed.

Group 1 exhibited the most drastic CRT reduction, particularly within the first three months, which emphasizes its suitability for acute cases with extrafoveal leakage points. Meanwhile, Group 2 demonstrated steady but less dramatic improvements, suggesting that SMLT is effective for both acute and chronic forms, although it may require longer observation periods to yield substantial results. In contrast, Group 3 achieved the lowest CRT due to the damage to the photoreceptor layer by six months, highlighting the potential of combining focal coagulation and SMLT for chronic cases with diffuse leakage or recurrence (Fig. 5).

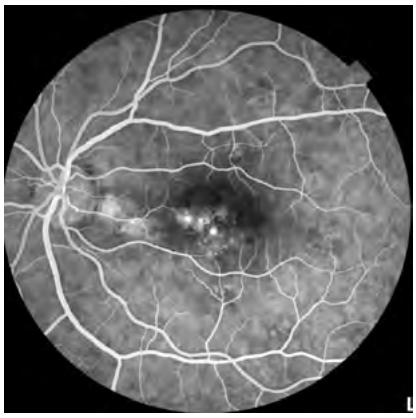


Fig. 2. Results of FA and OCT, OCT angiography before the use of SMLT with the chronic form of the CSCR. A – FA diffuse dye leakage is visualized. B – OCT of the central macula shows a serous detachment of the neuroepithelium, with an increase in choroidal thickness due to Haller's layer expansion, compressing the choriocapillaris. Destruction of the photoreceptor layer and the RPE.
C – OCT angiography: no neovascular vessels are detected.

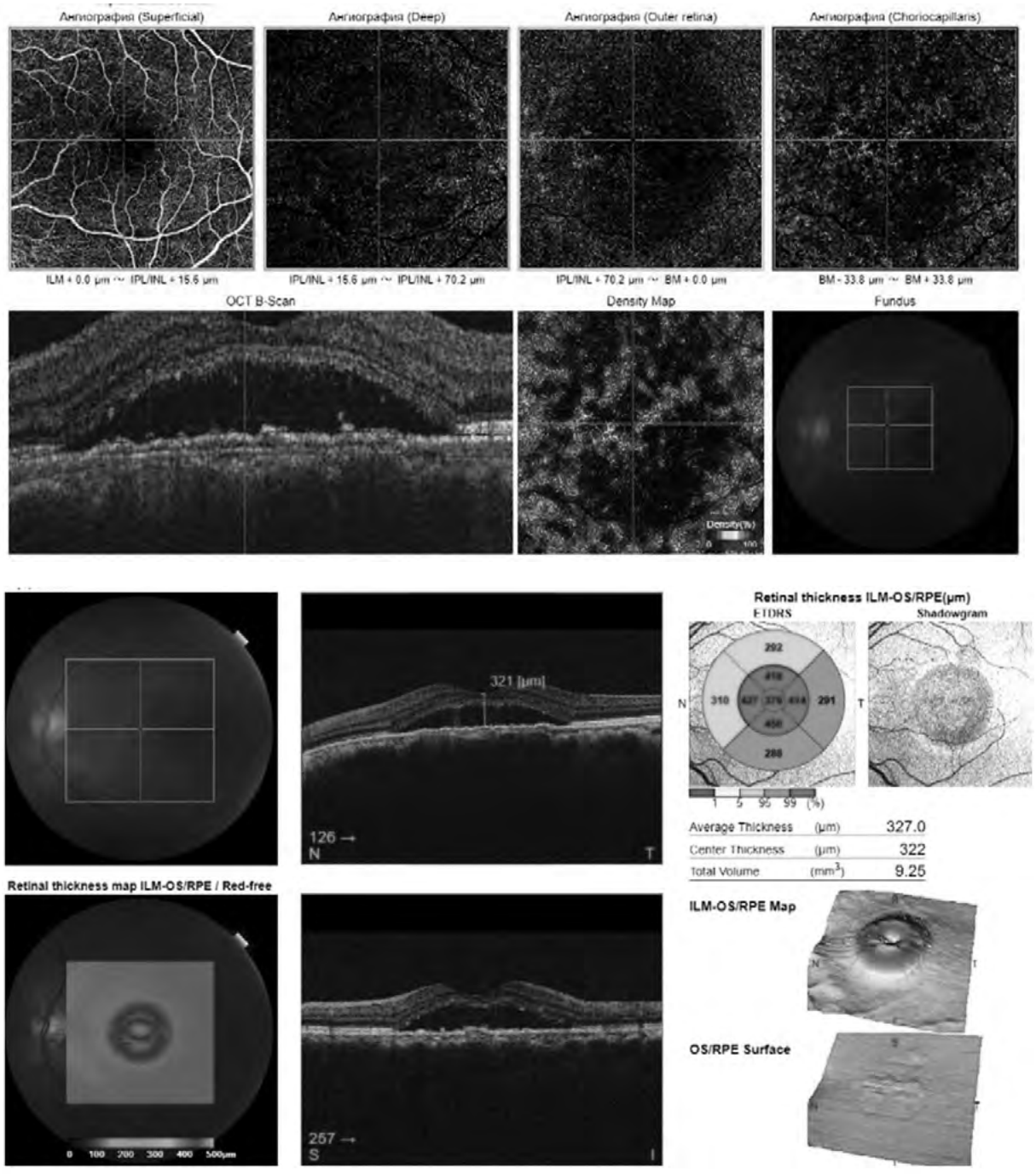


Table 1. The number, location, and type of fluorescence

№	Conditions identified during an examination	Groups		
		First group	Second group	Third group
1	Number of eyes with detected filtration point (LP)	19	17	7
	Number of detected LPs	19	17	10
2	Location of LPs Foveal Parafoveal Perifoveal	 - 7 (36.8%) 12 (63.2%)	 17 (100%)	 - 3 (30%) 7 (70%)
3	Distribution of detected LPs by quadrants upper temporal upper nasal lower temporal lower nasal	 2 (10.5%) 14 (73.7%) 2 (10.5%) 1 (5.3%)	 5 (29.4%) 4 (23.5%) 8 (47.1%) -	 2 (20%) 6 (60%) 1 (10%) 1 (10%)
4	Types of fluorescence Window defect Smoke plume Inkblot	 15 (78.9%) 4 (21.1%) -	 7 (41.2%) 6 (35.3%) 4 (23.5%)	 - 4 (40%) 6 (60%)
5	Recurrence of LPs after laser treatments (6 months)	-	1	2

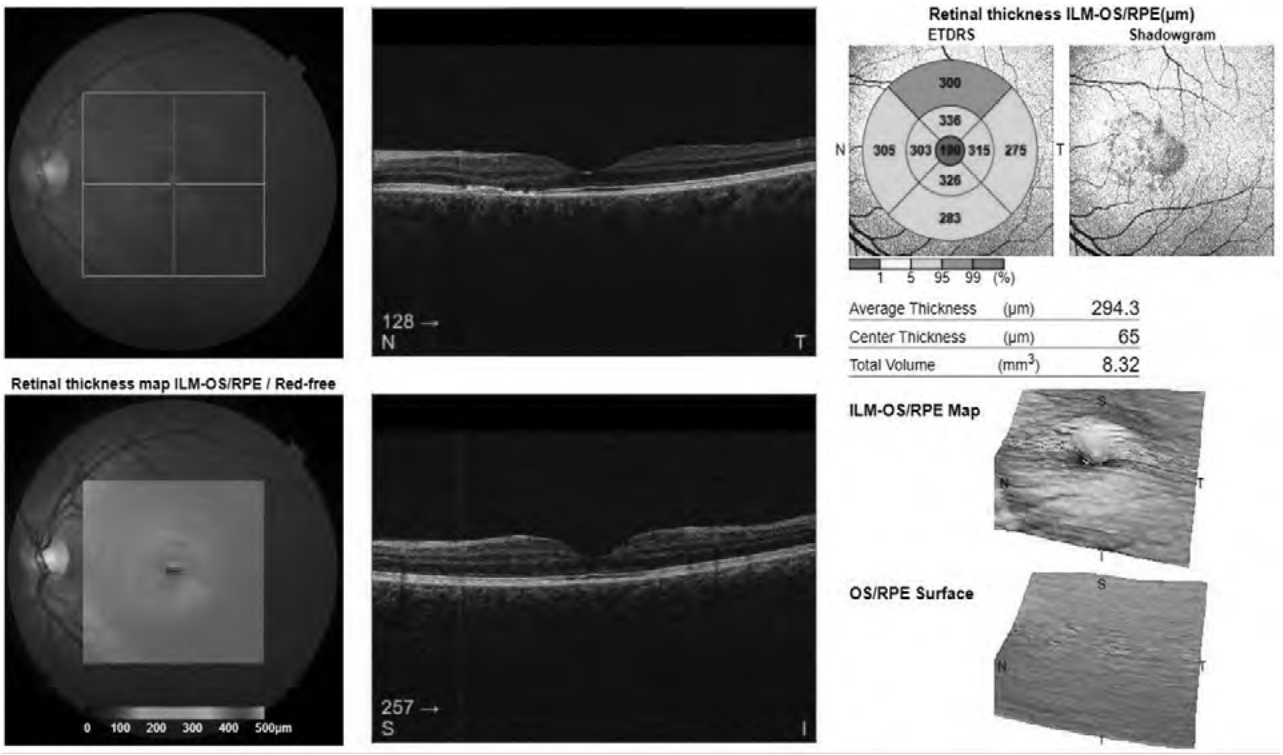


Fig. 3. Results of OCT after 4 weeks of the use of SMLT with the acute form of the CSCR. Complete resorption of SRF observed. Perifoveally on the nasal side, there is localized destruction of the photoreceptor layer and the RPE.

By the sixth month, in the second and third groups, in three patients (8.8%) with chronic forms of the disease and identified LPs, follow-up FA was performed in the fourth week due to a lack of progress in the resorption of SRF observed on OCT. SMLT was carried out at the detected LP sites (Table 2).

Although FLC was not performed to directly affect the LP responsible for the serous detachment of the neurosensory epithelium in the two groups of patients treated with SMLT, significant dynamic effects were observed at 6 months of follow-up, as evidenced by OCT and BCVA.

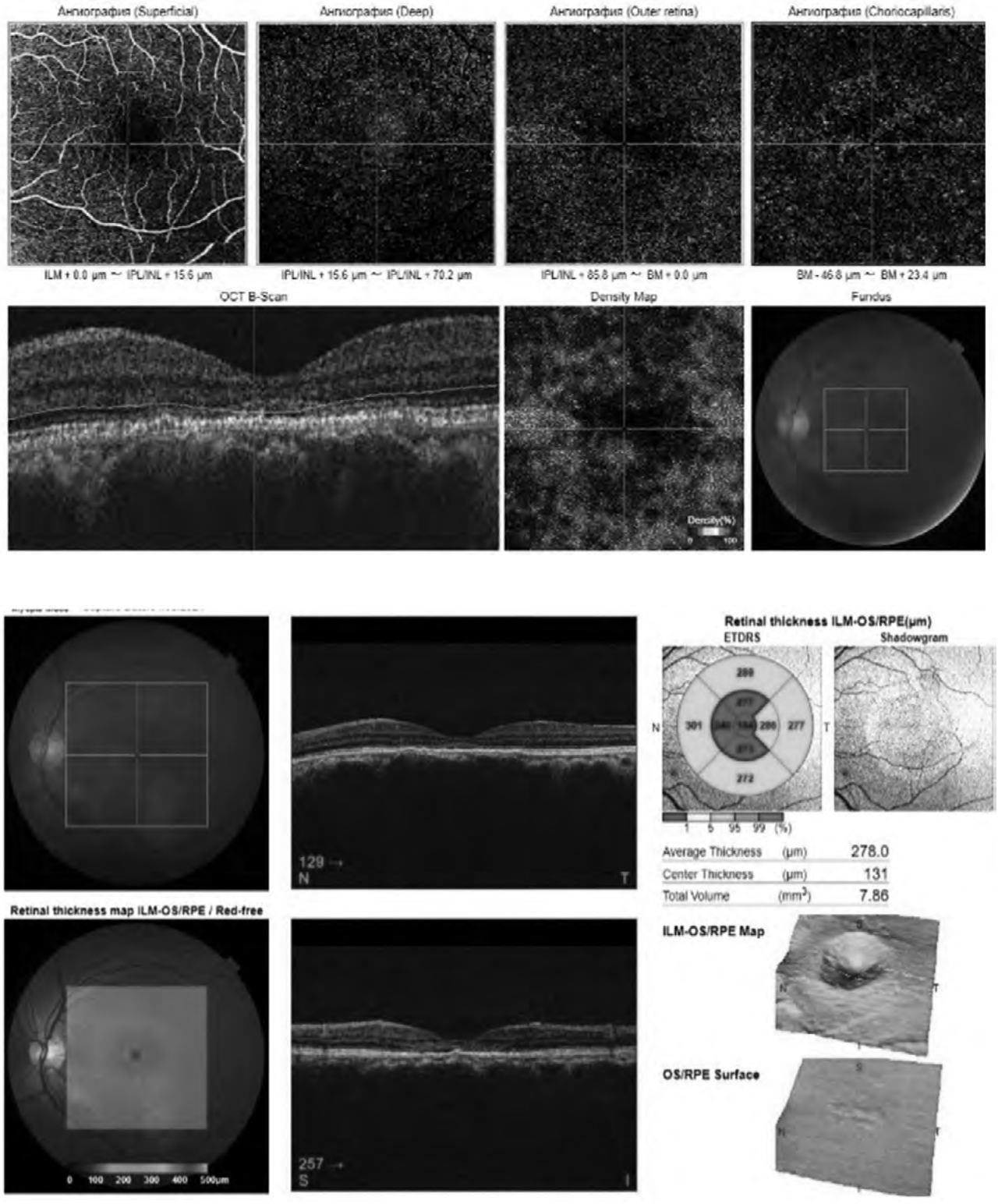


Fig. 4. Results of OCT and OCT angiography after 4 weeks of the use of SMLT with the chronic form of the CSCR. A – OCT complete resorption of SRF is observed. The central and parafoveal regions of the neuroepithelium are thinned due to the destruction and degeneration of the photoreceptor layer and the RPE. B – OCT angiography: no neovascular vessels are detected.

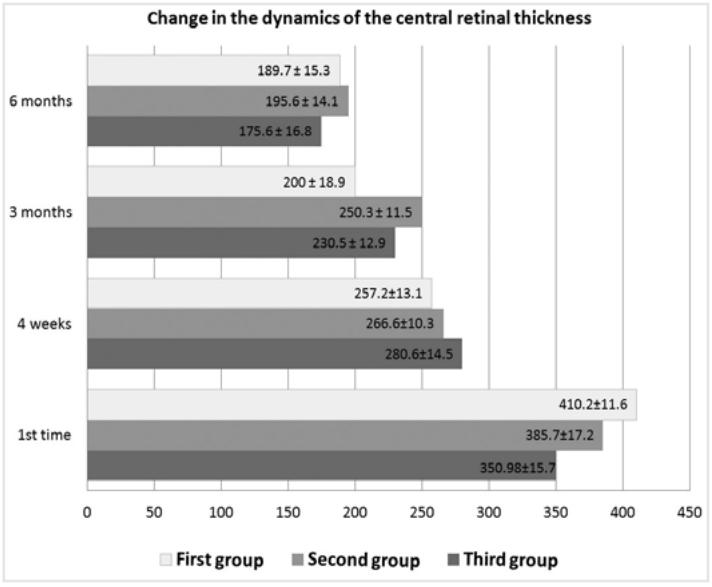


Fig 5. Change in the dynamics of the central retinal thickness of the patients in the groups (before treatment, 4 week, 3 and 6 month follow-up visits)

Table 2. Visual acuity and the central retinal thickness of the patients (6 months follow-up visits)

	Groups	1st time	6 month
Visus	1st	0.15 ± 0.04	0.85±0.0*
	2nd	0.2 ± 0.02	0.7±0.03*
	3rd	0.09 ± 0.03	0.45±0.02*
The central retinal thickness, μm	1st	410.2 ± 11.6	189.7 ± 15.3*
	2nd	385.7 ± 17.2	195.6 ± 14.1*
	3rd	350.98 ± 15.7	175.6 ± 16.8*

* Statistical significance was $p < 0.05$

Discussion

Observation and conservative management are frequently regarded as the initial strategy for addressing acute CSCR, as the condition often resolves on its own in many instances. Nevertheless, the timing of active intervention remains a subject of ongoing discussion, particularly in light of emerging therapeutic advancements and the growing emphasis on individualized patient care [6, 7].

The current "gold standard" for treating CSCR is threshold FLC of the retina, targeting fluid LPs located outside the foveal avascular zone. FLC aims to address the leakage. The primary objective of this approach is to "seal" the RPE defect identified through FA [8, 9].

One of the treatment options for CSCR is PDT. The use of photosensitizers in PDT for CSCR is based on their direct impact on the endothelium of choroidal capillaries, leading to their occlusion. This process reduces fluid leakage into the subretinal space. Thus, PDT can be considered a pathogenetic treatment for CSCR. According to indocyanine green angiography data, patients with CSCR treated with verteporfin-based PDT demonstrated the resolution of neuroepithelial detachment in 60% of cases [10, 11].

However, the widespread use of PDT in CSCR has led to the emergence of negative therapeutic effects, such as pigmentation in the area of photodynamic therapy, atrophy of the RPE, nonperfusive ischemia of the choroidal capillaries, and CNV [12, 13].

Unlike traditional laser photocoagulation treatment, which can lead to retinal scarring and permanent visual defects, SMLT does not cause thermal damage. This makes it safe for use even in sensitive areas such as the macula [14].

The established safety profile of SMLT in its use as an early treatment option for patients with CSCR. Recent research indicates that patients with CSCR lasting less than six months experienced improved functional outcomes when SMLT was applied at an earlier stage [6, 7].

Given these risks, the selection of treatment for CSCR requires careful evaluation. SML has demonstrated its ability to decrease SRF and enhance visual acuity while preserving retinal tissue integrity. In this instance, a 577 nm yellow laser, recognized for its low absorption by macular xanthophyll pigment, was safely applied over the fovea, safeguarding sensitive retinal structures and effectively resolving subretinal fluid [15, 16].

This study examines the critical role of early diagnosis and prompt intervention in managing CSCR, especially for patients with established risk factors like corticosteroid use. Although conservative management is suitable for many cases, extended observation without active treatment can result in lasting retinal damage in more persistent instances [17]. SMLT serves as a safe and effective alternative to more invasive techniques. However, additional research is necessary to evaluate the long-term effectiveness of SMLT for CSCR, particularly in comparison to other therapeutic approaches such as PDT and anti-VEGF injections.

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Author's contribution. *Yusupov A.F. – Reviewing and editing. Karimova M.Kh. – Conceptualisation; formal analysis; review and revision. Djamalova Sh. A. – Software; writing – review and revision. Ibodullayeva D.CH. – Conceptualisation; writing – drafting. Aktamov A.SH. – Methodology; writing – review and revision. All authors have read and approved the final version of the manuscript.*

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Availability of data and materials: *The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.*

Abbreviation. *CSCR – central serous chorioretinopathy; LP – leakage point; SMLT – subthreshold micropulse laser therapy; FA – fluorescein angiography; MCVA – maximum corrected visual acuity; OCT – optical coherence tomography; OCT angiography – optical coherence tomography + angiography; anti-VEGF – anti-vascular endothelial growth factor; CNV – choroidal neovascularization; PCV – polypoidal choroidal vasculopathy; PDT – photodynamic therapy; CRT – central retinal thickness; RPE – retinal pigment epithelium; FLC – focal laser coagulation; SRF – including subretinal fluid; SFCT – subfoveal choroidal thickness; EDI – enhanced depth imaging; BCVA – best corrected visual acuity.*

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