



FLUORESCEIN ANGIOGRAPHY-GUIDED FOCAL LASER PHOTOCOAGULATION FOR CHRONIC CENTRAL SEROUS CHORIORETINOPATHY: A REVIEW ARTICLE

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ABSTRACT

Chronic central serous chorioretinopathy is defined as a persistent serous neurosensory retinal detachment more than 3 months. Chronic central serous chorioretinopathy can lead to permanent photoreceptor damage thus permanent loss of central vision. Focal laser photocoagulation guided by fundus fluorescein angiography was the first treatment described for this clinical entity, it aims to photocoagulate the leakage points in the retinal pigment epithelium by argon laser. This review summarizes the pathophysiological basis, angiographic principles, treatment technique, clinical evidence, safety profile and current rule of angiography-guided focal laser in the management of chronic central serous chorioretinopathy. Early randomised trials showed that focal laser photocoagulation can shorten the duration of serous detachment, but long-term follow-up did not demonstrate a consistent impact on final visual acuity or even the rate of recurrency. Later comparative studies found that focal laser achieved better result in eyes with well-defined extrafoveal leaks, but with more recurrency rate than photodynamic therapy. Well-known complications of focal laser photocoagulation include central scotoma, retinal pigment epithelium atrophy and most seriously secondary choroidal neovascularization. Those complications restrict its usage mainly to extrafoveal lesions. Most recent evidence-based guidelines favor half-dose or half-fluence photodynamic therapy as first-line treatment for chronic disease. Fluorescein angiography-guided focal laser remains a practical option for proper patients with extrafoveal leaking points, especially where photodynamic therapy is unavailable or unaffordable.

KEYWORDS: Central serous chorioretinopathy; Fluorescein angiography; Laser photocoagulation; Photodynamic therapy; Retinal pigment epithelium; Subretinal fluid.

INTRODUCTION

Central serous chorioretinopathy (CSCR) is a common chorioretinal disorder characterized by serous detachment of the neurosensory retina, frequently accompanied by one or more detachments of the retinal pigment epithelium (RPE). It predominantly affects men of working age and is an important cause of central visual disturbance in this group.^[1-3] Population-based data have confirmed a clear male predominance in incidence,^[4] and exposure to exogenous corticosteroids is the most consistently identified risk factor, alongside other reported associations such as psychological stress and endogenous hypercortisolism.^[5,6]

Many acute episodes resolve spontaneously within a few months. However, a substantial proportion of patients

develop persistent, recurrent or chronic disease with widespread RPE changes, progressive photoreceptor loss and, in some cases, severe and permanent visual impairment.^[1,7] The aim of treatment in chronic CSCR is therefore to achieve complete and durable resolution of subretinal fluid (SRF) before irreversible damage to the outer retina occurs.^[8]

Historically, the first treatment used for CSCR was thermal photocoagulation of the leakage point identified on fundus fluorescein angiography (FFA).^[9-11] Over the past two decades, attention has shifted towards the choroid as the primary site of disease, and treatments such as photodynamic therapy (PDT) with verteporfin, subthreshold micropulse laser (SML) and oral mineralocorticoid receptor antagonists have been

evaluated in large randomised controlled trials.^[12-14] These trials have reshaped current recommendations.^[8] Nevertheless, conventional focal laser remains inexpensive and widely available, and interest in it has been renewed by limited access to PDT in many regions and by shortages of verteporfin.^[15,16]

The purpose of this review is to summarize the pathophysiological rationale, angiographic principles, technique, clinical evidence and safety of FFA-guided focal laser photocoagulation for chronic CSCR, to compare it with contemporary alternatives, and to define its place in current practice.

DEFINITION AND CLASSIFICATION OF CHRONIC CENTRAL SEROUS CHORIORETINOPATHY

Central serous chorioretinopathy has been classically divided into acute and chronic forms according to the duration of SRF and RPE alterations on imaging.^[2,3] Most authors defined chronic CSCR as the persistence of subretinal fluid for greater than 3 months, but this is not the definition for others. This variation made interpreting the literature more difficult, because treatment trials have used different criteria; the VICI trial, for example, enrolled patients with active disease persisting for more than four months.^[13]

The Central Serous Chorioretinopathy International Group suggested a classification based on multimodal imaging. It distinguishes simple from complex disease according to the extent of RPE alteration. Describing the episodes as primary, recurrent or resolved, and records atypical features separately.^[17] This classification is directly relevant to laser treatment. Eyes with simple disease and a single, discrete leak are the best candidates for focal photocoagulation. But eyes with complex disease; diffuse RPE changes or multiple ill-defined leakage areas, are poor candidates to a focal approach. Laser treatment of diffuse retinal pigment epitheliopathy has been described,^[18] but the outcome is less predictable.

PATHOPHYSIOLOGICAL BASIS OF FOCAL PHOTOCOAGULATION

It is widely believed nowadays that the primary pathology in CSCR is in the choroid. Enhanced depth optical coherence tomography (ED-OCT) has shown increased choroidal thickness in CSCR,^[19] and indocyanine green angiography (ICGA) demonstrates choroidal vascular congestion and hyperpermeability. These findings are considered a part of the pachychoroid disease spectrum and have led to the hypothesis of venous overload choroidopathy.^[1,20] Increased hydrostatic pressure in the choroid is thought to cause RPE detachment and, eventually, focal breakdown of the outer blood-retinal barrier at the level of the RPE. The fluorescein leakage point represents this site of barrier failure.^[1,8] Hormonal factors, particularly activation of the glucocorticoid and mineralocorticoid pathways, are believed to contribute to

this choroidal dysfunction.^[1,6]

Thermal photocoagulation to the leakage point results in a localized injury followed by RPE healing and proliferation. This is presumed to heal the leakage defect and allow the remaining RPE pump to clear the SRF.^[2,3] It is important to understand that focal laser photocoagulation does not treat the underlying choroidal pathology, this is why new leakage sites may develop even after treatment.^[8,21,22] In contrast, the PDT effect is directed toward the choroidal pathology itself.^[8] Understanding those differences in mechanism of action helps to understand much of the clinical evidence discussed in the following sections.

ROLE OF FLUORESCEIN ANGIOGRAPHY IN TREATMENT PLANNING

Angiographic patterns of leakage

On FFA, CSCR classically shows one or more focal hyperfluorescent leakage points at the level of the RPE. The most common pattern is the ink-blot pattern, in which a pinpoint of hyperfluorescence appears in the early frames and enlarges gradually. The less common smokestack pattern, in which dye ascends within the detachment, was found in 14.4% of 479 consecutive cases in one large series and occurred mostly in first acute episodes and only rarely in the chronic stage.^[23] Chronic CSCR more often shows multiple subtle leaks, granular or mottled hyperfluorescence from widespread RPE dysfunction, window defects from RPE atrophy and, in some patients, descending gravitational tracts.^[1,2] In such eyes a single treatable leak may be difficult or impossible to identify.

Localizing the leak for treatment

The early phase of FFA is the most important in localizing the leakage site. Early phase will show the exact leakage spot before spreading into the area of detachment. Taking in consideration the distance between the leakage spot and the foveal avascular zone is very crucial as well. Also mapping the leakage spot to a common anatomical landmark is very important.^[3,11] In the landmark randomised trial by Robertson and Ilstrup, eyes were stratified according to whether the leak lay within the papillomacular or within 500 (microns OR μm) of the capillary-free zone, illustrating the long-standing importance of leak position in deciding whether direct treatment is safe.^[11]

Complementary multimodal imaging

Modern practice combines FFA with other imaging modalities. OCT confirms and quantifies SRF, frequently reveals a small pigment epithelial detachment or RPE irregularity at the site of leakage, and is the main tool for monitoring the response to treatment.^[1,16] ICGA shows areas of choroidal hyperpermeability, helps exclude polypoidal choroidal vasculopathy and is used to guide PDT.^[24] OCT angiography helps detect macular neovascularisation, and its diagnostic accuracy in CSCR has been assessed in a recent systematic review and

meta-analysis.^[25] Fundus autofluorescence helps document chronicity and gravitational tracts. Excluding choroidal neovascularization before laser is essential, because it changes the management and because some early reports of neovascularization after laser may partly reflect lesions that were already present but not recognized.^[26]

TECHNIQUE OF FLUORESCEIN ANGIOGRAPHY-GUIDED FOCAL LASER PHOTOCOAGULATION

Patient selection

Careful selection is the most important determinant of a safe and effective outcome. The criteria generally applied

in the literature are summarized in Table 1. In brief, the ideal candidate has symptomatic SRF involving the macula that has persisted beyond the usual period of spontaneous resolution, one or a few well-defined leaks on early-phase FFA, a leak located at a safe distance from the fovea, and no evidence of choroidal neovascularization or polypoidal choroidal vasculopathy.^[3,8] Patients should be informed that the burn produces a permanent scotoma and that recurrence is possible.

Table 1: Suggested selection criteria for fluorescein angiography-guided focal laser in chronic central serous chorioretinopathy.^[3,8,11]

Sr. No.	Parameter	Favorable	Unfavorable or contraindicated
1.	Disease duration and activity	Symptomatic SRF persisting beyond 3-4 months, or recurrent/chronic disease	Recent-onset disease likely to resolve spontaneously
2.	Number and definition of leaks	Single or few discrete, well-defined leaks on early-phase FFA	Diffuse, multifocal or ill-defined leakage; no identifiable leak
3.	Location of leak	Extrafoveal leak at a safe distance from the foveal center and outside the papillomacular bundle	Subfoveal or juxtafoveal leak; leak within the papillomacular bundle
4.	Neovascular status	No choroidal neovascularisation or polypoidal lesions on multimodal imaging	Choroidal neovascularisation or polypoidal choroidal vasculopathy present
5.	Access to alternatives	PDT or verteporfin unavailable, unaffordable or declined	Half-dose or half-fluence PDT readily available and suitable

FFA, fundus fluorescein angiography; PDT, photodynamic therapy; SRF, subretinal fluid. The distance considered safe varies between authors and should follow local practice.

Laser wavelength and parameters

A range of lasers has been used, including ruby, argon green, krypton and dye lasers of various wavelengths; in the long-term series by Burumcek and colleagues, eyes were treated with argon green, dye yellow or dye orange lasers.^[9,27] In a pilot randomised trial of 30 patients, Verma and co-workers compared diode (810 nm) and argon green (514 nm) laser applied to the leakage site using the same parameters. Visual recovery at four weeks was significantly faster after diode treatment, and all diode-treated patients were free of scotoma at four weeks, whereas six patients in the argon group still reported one.^[28] Yellow wavelengths are also commonly preferred near the macula because they are poorly absorbed by macular xanthophyll.

Published settings vary, but treatment generally uses a small spot size, a short exposure time and the lowest power that produces a light grey-white burn directly over the leak, with the aim of covering the leak with as few applications as possible.^[2,3] Excessive power, very small spots or very short exposures increase the risk of rupture of Bruch membrane and should be avoided. The importance of targeting the leak itself was shown by Robertson and Ilstrup: eyes receiving direct photocoagulation of the leak had a mean duration of

detachment of 6.0 ± 2.2 weeks, compared with 13.2 ± 6.1 weeks after indirect treatment at a site away from the leak and 16.3 ± 6.3 weeks after sham treatment.^[11] Earlier work by Watzke and colleagues also compared direct and indirect approaches.^[29]

Navigated laser photocoagulation

A practical difficulty of conventional treatment is the transfer of the leak location from the angiogram to the live fundus view at the slit lamp. Navigated laser systems address this problem by importing the early fluorescein angiogram into the laser device, superimposing it on the live fundus image and maintaining alignment with eye tracking, so that treatment can be planned directly on the angiogram.^[16] In a retrospective study of 19 patients with chronic CSCR treated with navigated laser, mean logMAR best-corrected visual acuity (BCVA) improved from 0.49 ± 0.24 to 0.24 ± 0.15 , and SRF resolved completely in 13 of 19 eyes (68%) at three months.^[16]

Follow-up and retreatment

After treatment, patients are usually reviewed with OCT after several weeks. Resolution of SRF after focal laser typically occurs over one to two months; in one comparative series the mean time to resolution was 1.8 ± 1.5 months.^[22] Eyes with persistent fluid should undergo

repeat angiography to determine whether the treated leak remains active or a new leak has appeared. Options then include retreatment of a well-defined extrafoveal leak or a switch to PDT.^[8,30]

CLINICAL EVIDENCE

Early controlled trials

Controlled studies of photocoagulation for CSCR date from the 1970s.^[9,29] In a prospective trial of argon laser, Leaver and Williams reported faster resolution of SRF in treated eyes.^[10] However, the long-term follow-up of this trial by Ficker and colleagues found that laser treatment did not affect the final visual outcome, the recurrence rate or the proportion of patients who developed chronic disease.^[21] The randomised trial by Robertson and Ilstrup included 42 eyes with leaks smaller than 250 (microns OR μm) and confirmed that direct treatment of the leak shortened the detachment.^[11] Long-term observational series comparing treated and untreated eyes gave mixed signals on recurrence and did not establish a consistent visual benefit.^[31,32] Together, these studies established that focal laser accelerates fluid resolution but raised doubts about its effect on long-term visual outcome. It should be noted that most of these patients had acute rather than chronic disease.

Persistent and chronic disease

Evidence in persistent disease is more directly relevant to chronic CSCR. Burumcek and colleagues evaluated 45 eyes of 38 patients with CSCR that had not resolved after four months of observation. Twenty-nine eyes received laser photocoagulation and 16 eyes of patients who

declined treatment served as controls. Over a mean follow-up of 4.8 years, treated eyes had a significantly shorter duration of serous detachment ($P < 0.0001$) and a better final BCVA ($P = 0.006$).^[27] Although this study was not randomised, it suggests that eyes with persistent fluid may gain a functional benefit from sealing the leak, which contrasts with the neutral long-term results in acute disease.

Comparison with photodynamic therapy

Lim and colleagues prospectively compared 12 eyes treated with focal laser and 14 eyes treated with half-dose PDT. One month after treatment, all but one eye in the PDT group showed complete absorption of SRF, whereas five eyes in the focal laser group still had residual fluid.^[30] In a larger retrospective study, Shin and colleagues analyzed 62 patients: 33 treated with focal laser for focal extrafoveal leaks and 29 treated with PDT for subfoveal, juxtafoveal or indistinct leaks. The mean time to SRF resolution was 1.8 ± 1.5 months after focal laser and 1.2 ± 0.5 months after PDT. BCVA and central macular thickness remained stable for three years in both groups, but PDT was associated with a lower recurrence rate after three or more years of follow-up.^[22] A recent case report described complete resolution of SRF one month after focal laser in a patient with persistent CSCR whose vision was deteriorating while awaiting half-dose PDT.^[15]

The main studies of focal laser for CSCR are summarized in Table 2.

Table 2: Summary of key clinical studies of focal laser photocoagulation in central serous chorioretinopathy.

Sr. No.	Study	Design and population	Intervention	Main findings
1.	Leaver and Williams, 1979; Ficker et al., 1988 ^[10,21]	Prospective trial with long-term follow-up	Argon laser vs no treatment	Faster SRF resolution; no effect on final visual acuity, recurrence or chronic disease at long-term follow-up
2.	Robertson and Ilstrup, 1983 ^[11]	Randomised trial; 42 eyes with leaks < 250 (microns OR μm)	Direct vs indirect vs sham argon laser	Detachment lasted 6.0 ± 2.2 weeks after direct treatment vs 13.2 ± 6.1 (indirect) and 16.3 ± 6.3 weeks (sham)
3.	Burumcek et al., 1997 ^[27]	Non-randomised comparative; 45 eyes with CSCR persisting > 4 months	Argon green, dye yellow or dye orange laser (29 eyes) vs observation (16 eyes)	Shorter detachment ($P < 0.0001$) and better final BCVA ($P = 0.006$); mean follow-up 4.8 years
4.	Verma et al., 2004 ^[28]	Pilot randomised trial; 30 patients	Diode (810 nm) vs argon green (514 nm) laser	Faster visual recovery and less residual scotoma at 4 weeks with diode laser
5.	Lim et al., 2011 ^[30]	Prospective comparative; 26 eyes	Focal laser (12) vs half-dose PDT (14)	At 1 month, all but one PDT eye dry; residual SRF in 5 focal laser eyes
6.	Shin et al., 2020 ^[22]	Retrospective; 62 patients	Focal laser for extrafoveal leaks (33) vs PDT (29)	SRF resolution 1.8 vs 1.2 months; stable BCVA for 3 years; lower long-term recurrence with PDT
7.	Zhou et al., 2022 ^[16]	Retrospective; 19 patients with chronic CSCR	Navigated laser photocoagulation	logMAR BCVA 0.49 to 0.24; complete SRF resolution in 68% at 3 months

BCVA, best-corrected visual acuity; CSCR, central serous chorioretinopathy; PDT, photodynamic therapy; SRF, subretinal fluid.

SAFETY AND COMPLICATIONS

Conventional photocoagulation destroys the outer retina at the treated site and therefore produces a permanent scotoma, which may be noticeable when the burn lies close to fixation. The resulting chorioretinal scar and area of RPE atrophy can enlarge over time. In the case described by Kiraly, fundus autofluorescence showed an enlarged area of hypoautofluorescence at the treated site, although the patient reported no visual field defect.^[15] These considerations are the main reason why focal laser is restricted to extrafoveal leaks.^[3]

The most serious complication is secondary choroidal neovascularisation. It was described after argon laser for CSCR in the 1970s, when the authors also questioned whether some cases reflected misdiagnosis of pre-existing lesions.^[26] A multicenter series has since reported the use of anti-vascular endothelial growth factor agents to treat choroidal neovascularisation that developed after laser treatment in CSCR.^[33] Rarer risks include inadvertent foveal burns and rupture of Bruch membrane when high-energy settings are used. Fluorescein angiography itself is generally safe but can cause nausea and, rarely, severe allergic reactions. Overall, the safety profile of focal laser is acceptable only when patient selection and technique are careful, and its visual risks explain much of the shift towards treatments that do not destroy retinal tissue.^[3,8]

COMPARISON WITH CONTEMPORARY TREATMENTS

Photodynamic therapy

PDT with verteporfin, applied to areas of choroidal hyperpermeability identified on ICGA, targets the choroid rather than the RPE leak.^[24] Reduced-dose protocols were developed to limit the risk of choroidal ischemia and RPE atrophy, and a randomised trial by Chan and colleagues showed the efficacy of half-dose PDT in acute CSCR.^[34] In chronic CSCR, the PLACE trial showed that half-dose PDT was superior to high-density SML, and the SPECTRA trial showed that it was superior to eplerenone.^[12,14] On this basis, the most recent evidence-based guideline concluded that half-dose

or half-fluence PDT is the treatment best supported by current evidence for chronic CSCR.^[8] Unlike focal laser, PDT can be used for subfoveal and diffuse leakage. Its main limitations are cost, the need for ICGA and specialized equipment, and limited availability of verteporfin in some settings.^[15]

Subthreshold micropulse laser

SML delivers repetitive short pulses separated by cooling intervals, with the aim of stimulating the RPE without producing a visible burn, so that it can be applied close to or under the fovea.^[35] In the PLACE trial, however, complete resolution of SRF at the final visit was achieved in 67.2% of patients after half-dose PDT compared with only 28.8% after high-density SML ($P < 0.001$).^[12] SML therefore offers a safer alternative near fixation but has shown limited efficacy in chronic disease.

Mineralocorticoid receptor antagonists

Oral eplerenone and spironolactone were widely used on the basis of the mineralocorticoid hypothesis. In the VICI trial, 104 patients with chronic CSCR at 22 hospitals in the United Kingdom were randomised to eplerenone or placebo, and eplerenone was not superior to placebo for improving BCVA at 12 months.^[13] The SPECTRA trial subsequently confirmed that half-dose PDT was more effective than eplerenone.^[14]

Other treatments and evidence syntheses

Selective retina therapy uses microsecond pulses to target the RPE while sparing the photoreceptors and has been studied mainly in acute CSCR.^[36] Intravitreal anti-vascular endothelial growth factor agents are principally indicated when CSCR is complicated by neovascularisation.^[37,38] A 2024 Ophthalmic Technology Assessment by the American Academy of Ophthalmology reviewed 31 studies of laser-based, intravitreal and systemic treatments,^[38] and the Cochrane network meta-analysis of interventions for CSCR was updated in 2025.^[37] Table 3 compares the main treatment options for chronic CSCR.

Table 3: Comparison of fluorescein angiography-guided focal laser with other treatments for chronic central serous chorioretinopathy.

Sr. No.	Treatment	Primary target and guidance	Suitable lesions	Principal limitations
1.	FFA-guided focal laser ^[11,22,27]	RPE leakage point; FFA (optionally navigated)	Single or few well-defined extrafoveal leaks	Permanent scotoma; risk of CNV; does not treat the choroid; recurrence
2.	Half-dose or half-fluence PDT ^[8,12,14]	Dysfunctional choroid; ICGA (with FFA)	Focal, multifocal, subfoveal or diffuse leakage	Cost; need for ICGA and verteporfin; limited availability
3.	Subthreshold micropulse laser ^[12,35]	RPE, without a visible burn; FFA/ICGA or OCT	Juxtafoveal and subfoveal leaks	Inferior to half-dose PDT in a randomised trial
4.	Mineralocorticoid receptor antagonists ^[13,14]	Systemic mineralocorticoid pathway	Any pattern	No benefit over placebo in the VICI trial; systemic side effects

CNV, choroidal neovascularisation; FFA, fundus fluorescein angiography; ICGA, indocyanine green angiography; OCT, optical coherence tomography; PDT, photodynamic therapy; RPE, retinal pigment epithelium.

CURRENT ROLE AND PRACTICAL APPROACH

Current evidence places half-dose or half-fluence PDT at the center of the management of chronic CSCR.^[8] Within this framework, FFA-guided focal laser may still be considered in selected patients with a focal leak located at a sufficient distance from the fovea, particularly when PDT is not available.^[3,8] This situation is common in many low- and middle-income settings, where the cost of verteporfin and access to ICGA and PDT are real barriers, and where conventional laser is often the only intervention available.^[15,16]

A practical approach can be summarized as follows. First, the diagnosis and chronicity should be confirmed with multimodal imaging, and choroidal neovascularisation and polypoidal choroidal vasculopathy should be excluded. Second, where half-dose or half-fluence PDT is available and suitable, it should be considered the preferred option. Third, where PDT is unavailable, unaffordable or declined, and early-phase FFA shows a single or few well-defined extrafoveal leaks, focal laser directed to the leak is a reasonable alternative, ideally with navigated delivery when available. Fourth, the response should be monitored with OCT and, if fluid persists, the eye should be re-evaluated with angiography before retreatment or a change of therapy. Eyes with subfoveal or diffuse leakage should not receive conventional focal laser.

LIMITATIONS OF THE EVIDENCE AND FUTURE DIRECTIONS

The evidence for focal laser has important limitations. Most controlled trials are small, were performed several decades ago and included mainly patients with acute disease, before the introduction of OCT and modern multimodal imaging.^[11,21] Definitions of chronicity and outcome measures vary widely between studies, and many used visual acuity alone rather than complete resolution of SRF or measures of retinal function.^[3,17] No adequately powered randomised trial has compared focal laser with half-dose PDT specifically in chronic CSCR with a well-defined extrafoveal leak, and the available comparisons are small or retrospective, with inherent selection bias because leak location often determined the treatment chosen.^[22,30]

Future studies should use standardized multimodal definitions of disease, report complete resolution of SRF, recurrence, microperimetry and quality of life, and include long-term follow-up. Pragmatic trials comparing navigated focal laser with half-dose PDT in eyes with suitable extrafoveal leaks, and cost-effectiveness analyses in settings with limited resources, would be particularly valuable. Improvements in targeting accuracy through navigated systems and better image registration may also reduce the risks associated with conventional treatment.

CONCLUSION

FFA-guided focal laser photocoagulation is the oldest

treatment for CSCR and remains effective at sealing well-defined leaks and shortening the duration of serous detachment. However, it does not address the underlying choroidal dysfunction, has not consistently improved long-term visual outcome, and carries risks of scotoma and choroidal neovascularisation that limit its use to extrafoveal leaks. Half-dose or half-fluence PDT is now the best-supported treatment for chronic CSCR. Nevertheless, in carefully selected patients with a discrete extrafoveal leak, and especially where PDT is unavailable, focal laser remains a practical, inexpensive and useful option.

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