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Diagnostic Performance of Optical Coherence Tomography Angiography Compared with Fundus Fluorescein Angiography in Chronic Central Serous Chorioretinopathy

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Abstract

Background: The detection of a clear vascular network by OCTA was more accurate than by FFA. In our study, the detection of a clear vascular network by OCTA was superior to that by FFA. Ten eyes showed a thick, interlocking filamentous neovascular membrane that was well characterized. Statistics showed that the difference was substantial ($p < 0.001$). Additionally, in our study, the distinct dye leakage patterns of the CCSC on FA did not correlate with the CNVM shown on OCTA, supporting the idea that OCTA identifies the choroidal neovascular network by depth (flow in the outer retina) and is independent of dye leakage detected on FA. **Aim of the Work:** To evaluate and study the role of OCT angiography in eyes with chronic CSCR in CNV and non-CNV groups in comparison with fundus fluorescein angiography. **Patients and Methods:** This is a comparative cross-sectional study. It was performed in the Department of Ophthalmology, Mother Theresa University Hospital, in the period from September 2024 to January 2025. Clinical data and images were obtained from 20 patients (20 eyes), divided into two groups. **Results:** The ink-blot pattern was the most common FFA finding, as in other studies, occurring in 8 out of 10 cases (80%) of CSCR without CNV and in 9 out of 10 cases (90%) of CSCR with active CNV. These were mainly recurrent cases and might suggest chronicity. **Conclusion:** As a non-invasive, quick, and dependable angiographic imaging method, OCTA has advantages over FA. The ability to view the retinal and choroidal vasculature in various layers is another benefit of OCTA. The narrow field of view of OCTA (which has been somewhat addressed in certain commercially available devices), inability to detect leakage, difficulty in detecting blood flow below a particular level, and

inconsistent image quality are some of its drawbacks.

Keywords

Optical Coherence Tomography Angiography (OCTA), Fundus Fluorescein Angiography (FFA), Chronic Central Serous Chorioretinopathy (CSCR), Choroidal Neovascularization (CNV), Retinal Imaging

1. Introduction

Central serous chorioretinopathy (CSCR) is a chorioretinal disorder characterized by serous detachment of the neurosensory retina secondary to focal leakage from the choriocapillaris through a dysfunctional retinal pigment epithelium (RPE). The disease predominantly affects middle-aged individuals and shows a marked male preponderance [1] [2]. Clinically, CSCR presents with blurred vision, metamorphopsia, micropsia, impaired contrast sensitivity, and central scotoma. Establishing the diagnosis requires the exclusion of other causes of RPE leakage, including choroidal neovascularization (CNV), inflammatory chorioretinopathies, and intraocular tumors [2].

Proposed mechanisms involve choroidal vascular hyperpermeability, increased hydrostatic pressure within the choroid, and RPE barrier dysfunction. Several systemic and environmental risk factors have been implicated, including systemic hypertension, corticosteroid use (both endogenous and exogenous), Helicobacter pylori infection, sleep disturbances, psychological stress, pregnancy, and autoimmune disorders [3] [4]. More recent studies emphasize the role of choroidal thickening and dysregulated mineralocorticoid receptor pathways in disease pathophysiology [5] [6].

CSCR is typically characterized by localized subretinal fluid (SRF) at the posterior pole, which often resolves spontaneously within three to four months in acute cases. However, in chronic disease, persistent SRF may lead to progressive photoreceptor damage, RPE atrophy, and irreversible visual impairment [4]. Chronic CSCR is generally defined as the persistence of symptoms and/or SRF for more than 4 - 6 months, frequently accompanied by widespread RPE alterations. Importantly, a subset of chronic cases may develop secondary CNV, which significantly worsens the visual prognosis [7] [8].

Based on clinical course and morphologic characteristics, CSCR can be categorized into several subtypes: 1) acute self-limiting CSCR, 2) non-resolving CSCR with SRF persisting beyond four months, 3) chronic atrophic CSCR characterized by diffuse RPE atrophy with or without persistent fluid, and 4) inactive CSCR without SRF but with residual RPE changes [9] [10]. Advances in multimodal imaging have refined this classification and improved the understanding of the disease spectrum.

The conventional diagnostic workup for CSCR includes slit-lamp biomicroscopy, spectral-domain optical coherence tomography (SD-OCT), fundus auto-

fluorescence (FAF), fundus fluorescein angiography (FFA), and indocyanine green angiography (ICGA) [5]. FFA remains a classic and widely used imaging modality for confirming the diagnosis, identifying leakage patterns (e.g., "ink-blot" or "smoke-stack"), and excluding alternative etiologies [11]. ICGA provides additional information regarding choroidal hyperpermeability. Nevertheless, these dye-based angiographic techniques are invasive, time-consuming, and limited by potential adverse reactions. Moreover, they do not provide high-resolution, depth-resolved visualization of the choriocapillaris [12].

Optical coherence tomography angiography (OCTA) has emerged as a noninvasive, dye-free imaging modality that enables depth-resolved visualization of retinal and choroidal vasculature by detecting motion contrast from erythrocytes within blood vessels [5] [13]. OCTA allows segmentation of individual vascular layers, including the superficial and deep retinal plexuses, outer retina, and choriocapillaris, facilitating detailed analysis of vascular architecture without obscuration from dye leakage or staining [14]. Recent advances in OCTA technology have improved image resolution, acquisition speed, and quantitative capabilities, allowing for both qualitative and quantitative assessment of microvascular changes [15]. In CSCR, OCTA has proven particularly valuable in detecting subclinical or secondary CNV, which may not be readily distinguishable on conventional angiography due to overlapping leakage patterns [8] [16]. Furthermore, OCTA has demonstrated utility in evaluating choriocapillaris flow deficits and monitoring disease progression and treatment response [17] [18].

Despite its advantages, OCTA has limitations, including a restricted field of view (although wide-field systems are increasingly available), susceptibility to motion and projection artifacts, limited sensitivity to very slow blood flow, and an inability to directly demonstrate dye leakage. Nevertheless, its noninvasive nature and capacity for repeated imaging make it particularly suitable for longitudinal follow-up in chronic CSCR.

Given the growing clinical relevance of OCTA in retinal practice, further comparative evaluation of OCTA and fundus fluorescein angiography in chronic CSCR particularly in cases complicated by CNV is warranted to better define its diagnostic performance and clinical utility.

Aim of the Study

The present study aimed to evaluate the role of optical coherence tomography angiography (OCTA) in the assessment of eyes with chronic central serous chorioretinopathy (CSCR), comparing cases complicated by choroidal neovascularization (CNV) with those without CNV, and to determine its diagnostic performance in comparison with fundus fluorescein angiography (FFA).

2. Patients and Methods

2.1. Study Design and Setting

This was a comparative cross-sectional study conducted at the Department of

Ophthalmology, Mother Theresa University Hospital, from September 2024 to January 2025. Clinical data and multimodal imaging were obtained from 20 patients (20 eyes) diagnosed with chronic CSCR.

2.2. Sample Size and Grouping

A total of 20 eyes were randomly assigned to two equal groups:

- Group 1 (G1): 10 eyes with chronic CSCR complicated by CNV.
- Group 2 (G2): 10 eyes with chronic CSCR without evidence of CNV.

2.3. Inclusion Criteria

- Age between 20 and 55 years.
- Presence of subretinal fluid (SRF) involving the fovea as confirmed by structural optical coherence tomography (OCT).
- Clinical history consistent with CSCR associated with visual impairment.

2.4. Exclusion Criteria

Eyes were excluded if any of the following conditions were present:

- Ocular diseases contributing to decreased visual acuity.
- Significant media opacities (e.g., dense cataract or corneal opacity).
- Subretinal fibrosis.

2.5. Age-Related Macular Degeneration

- Retinal vascular diseases.
- Vitreoretinal diseases or a history of retinal surgery.
- Hereditary retinal dystrophies.

2.6. Study Tools and Procedures

2.6.1. Demographic and Clinical Data

Every patient underwent a comprehensive medical history assessment that included age, sex, history of diabetes mellitus and hypertension, previous ocular surgeries (including refractive procedures), and any history of ocular trauma. A comprehensive ophthalmological examination was performed.

All included patients underwent a complete ophthalmic evaluation, including:

- Visual Acuity Assessment: Uncorrected visual acuity (UCVA) and best-corrected distance visual acuity (BCDVA) were measured using Landolt's broken ring chart. All visual acuity measurements were converted to logarithm of the minimum angle of resolution (logMAR) values for statistical analysis.
- Slit-Lamp Biomicroscopy: Examination of the anterior and posterior segments was performed using a slit-lamp biomicroscope (TOPCON) with a +90-diopter Volk lens.
- Fundus Examination: Fundus findings suggestive of CSCR included elevation of the macular area, a circular ring reflex, round or ovoid serous sensory retinal detachment of variable size, absence or distortion of the foveal reflex, and dep-

osition of small yellow-white precipitates in subacute stages. Chronic cases showed RPE atrophic changes, fine brown and white pigment epithelial scarring, and extramacular RPE tracts.

- Intraocular Pressure Measurement: Intraocular pressure (IOP) was measured using Goldmann applanation tonometry.

2.6.2. Fundus Fluorescein Angiography (FFA)

FFA images were obtained using the Fundus Fluorescein Angiography (FFA) fundus camera (TOPCON TRC-NW7SF). Image acquisition and processing were performed using the IMAGEnet 6 ophthalmic data management platform (see Figure 1).

Figure 1. FFA TOPCON.

2.6.3. Fluorescein Angiography Technique

Before the procedure, each patient was informed about the purpose and steps of fundus fluorescein angiography (FFA), including potential side effects. A detailed medical history was obtained to identify any contraindications or conditions requiring special precautions, such as a history of hypersensitivity to fluorescein dye, bronchial asthma, or severe systemic disease.

Written informed consent was obtained from all participants after explaining the time-sensitive nature of the angiographic procedure and emphasizing the importance of patient cooperation during image acquisition.

Pupillary dilation was achieved using topical tropicamide 1%, administered approximately one hour before imaging. Emergency medications, including adrenaline, antihistamines, and supplemental oxygen, were made readily available in the angiography unit to manage potential adverse reactions.

Venous access was established using a scalp vein cannula. The patient was then positioned comfortably at the fundus camera with the chin placed on the chin rest and the forehead supported against the forehead bar. Baseline color and red-free

fundus photographs were obtained prior to dye injection.

A bolus of 5 mL of 10% sodium fluorescein solution (containing 500 mg sodium fluorescein) was administered intravenously over approximately 5 seconds. Sequential angiographic images were captured according to the standard angiographic phases.

2.6.4. Optical Coherence Tomography Angiography Examination

Optical coherence tomography angiography (OCTA) imaging was performed using a spectral-domain OCT device (RTVue XR Avanti with AngioVue software; Optovue Inc., Fremont, CA, USA). The system employs motion-contrast technology to detect blood flow by analyzing decorrelation signals generated by erythrocyte movement within retinal and choroidal vessels. All scans were obtained after adequate pupillary dilation. High-quality images with sufficient signal strength were included in the analysis. Automated segmentation of the retinal and choroidal vascular layers was performed, and manual correction was applied when necessary to ensure accurate layer delineation (see **Figure 2**).

Figure 2. OCT Angio Optovue.

The imaging procedure was thoroughly explained to each participant before acquisition. The chin rest and head position were carefully adjusted to ensure proper alignment with the imaging instrument. Participants were instructed to fixate on the internal target to maintain a steady gaze during image capture. A 6 × 6 mm macular scan protocol (320 × 320 A-scans) was performed, centered on the fovea to obtain high-resolution images of the retinal microvasculature.

2.6.5. Optical Coherence Tomography Angiography (OCTA)

Optical coherence tomography angiography (OCTA) is a noninvasive, dye-free, three-dimensional imaging modality that enables detailed visualization of the retinal and choroidal vasculature without the need for intravenous contrast agents [5]. OCTA operates by acquiring sequential B-scans at the same retinal location and analyzing variations in amplitude and/or phase signals between scans. Detection of these signal changes reflects motion contrast generated by flowing erythrocytes within blood vessels.

The split-spectrum amplitude-decorrelation angiography (SSADA) algorithm enhances flow detection by amplifying decorrelation signals and reducing noise, allowing digital reconstruction of en face angiographic images corresponding to different retinal and choroidal layers. Recent advances have further improved image resolution, segmentation accuracy, and artifact correction, thereby enhancing the clinical applicability of OCTA in retinal vascular assessment [19]-[21].

3. Statistical Analysis

Data were collected, reviewed, coded, and entered into the Statistical Package for the Social Sciences (IBM SPSS), version 23 (IBM Corp., Armonk, NY, USA). Quantitative data were expressed as mean ± standard deviation (SD) and range for parametric variables, while qualitative variables were presented as frequencies and percentages. Comparisons between groups for qualitative variables were performed using the chi-square test or Fisher's exact test when the expected cell count was less than five. For comparisons between two independent groups with normally distributed quantitative data, the independent samples t-test was applied. Receiver operating characteristic (ROC) curve analysis was conducted to determine the optimal cutoff value of the studied markers, including calculation of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the curve (AUC). Inter-rater agreement between qualitative variables was assessed using Cohen's kappa coefficient. A 95% confidence interval (CI) was adopted, and the level of statistical significance was set at a p-value ≤ 0.05. Statistical significance was interpreted as follows: $p > 0.05$: not significant; $p \leq 0.05$: significant: $p \leq 0.01$: highly significant.

4. Results

The present study included 20 eyes, which were categorized into two groups: eyes with chronic central serous chorioretinopathy (CSR) complicated by choroidal neovascularization (CNV), and eyes with chronic CSR without CNV. Table 1 summarizes the descriptive analysis of the demographic characteristics of the studied patients, including age and sex distribution across both groups. Data are presented as mean ± standard deviation for quantitative variables and as frequency and percentage for qualitative variables.

Table 1. Descriptive analysis of the demographic characteristics of the studied patients (n = 15).

Variable	Data
Age (years)	
Mean ± SD	44.20 ± 7.43
Range	25 - 53
Sex	
Female	3 (20.0%)

Continued

Male	12 (80.0%)
Laterality	
Unilateral	10 (66.7%)
Bilateral	5 (33.3%)

The study included 15 patients with a mean age of 44.20 ± 7.43 years (range: 25 - 53 years). The majority of patients were male (80.0%), while females represented 20.0% of the sample. Regarding laterality, most cases were unilateral (66.7%), whereas bilateral involvement was observed in 33.3% of patients.

Table 2. Descriptive analysis of the clinical examination findings of the studied eyes (n = 20).

Variable	Data
Eye	
OD	9 (45.0%)
OS	11 (55.0%)
Visual Acuity (VA)	
Mean ± SD	0.41 ± 0.24
Range	0.05–0.8
Best-Corrected Visual Acuity (BCVA)	
Mean ± SD	0.48 ± 0.22
Range	0.05 - 0.9
Intraocular Pressure (IOP)	
Mean ± SD	14.60 ± 1.93 mmHg
Range	12 - 19 mmHg
Anterior Segment Examination	
Normal	20 (100.0%)
Fundus Examination	
Serous elevation	15 (75.0%)
Serous elevation with RPE atrophy	5 (25.0%)

A total of 20 eyes were examined. Left eyes (55.0%) were slightly more affected than right eyes (45.0%). The mean visual acuity (VA) was 0.41 ± 0.24, improving to 0.48 ± 0.22 with best correction (BCVA). The mean intraocular pressure (IOP) was within the normal range (14.60 ± 1.93 mmHg). Anterior segment examination was normal in all eyes (100.0%). Fundus examination revealed serous retinal elevation in 75.0% of eyes, while 25.0% showed serous elevation associated with retinal pigment epithelium (RPE) atrophy (see Table 2).

Table 3. Fundus fluorescein angiography (FFA) findings of the studied eyes (n = 20).

Variable	Data
Early FFA	
Normal arm-to-retina circulation time	20 (100.0%)
Late FFA	
Pooling	4 (20.0%)
Hyperfluorescence with leakage	16 (80.0%)
FFA Pattern	
Ink-blot pattern	17 (85.0%)
Smoke-stack pattern	3 (15.0%)
Number of Leakage Points	
One point	8 (40.0%)
Two points	5 (25.0%)
Three points	6 (30.0%)
Four points	1 (5.0%)
Choroidal Neovascularization (CNV)	
No CNV	10 (50.0%)
Active CNV	10 (50.0%)
Pigment Epithelial Detachment (PED)	
Absent	16 (80.0%)
Present	4 (20.0%)
Site of Chronic CSR	
Foveal area	17 (85.0%)
Inferotemporal	6 (30.0%)
Inferonasal	2 (10.0%)
Superotemporal	1 (5.0%)
Temporal paracentral area	0 (0.0%)
Neurosensory Detachment	
Present	20 (100.0%)

Fundus fluorescein angiography (FFA) revealed a normal arm-to-retina circulation time in all examined eyes (100.0%) during the early phase. In the late phase, pooling was observed in 20.0% of eyes, while hyperfluorescence with active leakage was detected in 80.0%. The ink-blot pattern was the predominant leakage pattern (85.0%), followed by the smoke-stack pattern (15.0%). Regarding leakage points, a single leakage point was most common (40.0%), whereas multiple leakage points were observed in the remaining eyes. Choroidal neovascularization (CNV) was identified in 50.0% of eyes, while the remaining 50.0% showed no ev-

idence of CNV. Pigment epithelial detachment (PED) was present in 20.0% of cases. The foveal region was the most frequently involved site (85.0%). Neurosensory retinal detachment was detected in all examined eyes (100.0%) (see Table 3).

Table 4. Optical coherence tomography angiography (OCTA) findings of the studied eyes (n = 20).

Variable	Data
Superficial Capillary Plexus	
Normal foveal avascular zone (FAZ)	20 (100.0%)
Deep Capillary Plexus	
Subretinal fluid	20 (100.0%)
Outer Retina	
No vascular lesion	10 (50.0%)
Hyperreflective vascular lesion	10 (50.0%)
Choriocapillaris	
Dark area	8 (40.0%)
Dark area + dark spot	2 (10.0%)
Dark areas + abnormal blood vessels	8 (40.0%)
Dark areas + dark spots + abnormal blood vessels	2 (10.0%)
Choroidal Neovascularization (CNV)	
No CNV	10 (50.0%)
Active CNV	10 (50.0%)
Pigment Epithelial Detachment (PED)	
Absent	16 (80.0%)
Present	4 (20.0%)
Site of Chronic CSR	
Foveal area	15 (75.0%)
Inferotemporal	8 (40.0%)
Inferonasal	2 (10.0%)
Superotemporal	2 (10.0%)
Temporal paracentral area	1 (5.0%)
Neurosensory Detachment	
Present	20 (100.0%)

OCTA demonstrated a normal foveal avascular zone (FAZ) within the superficial capillary plexus in all examined eyes (100.0%). Subretinal fluid was detected at the level of the deep capillary plexus in all cases. At the outer retinal level, half of the eyes (50.0%) showed no detectable vascular lesions, whereas the remaining

50.0% exhibited hyperreflective vascular lesions consistent with choroidal neovascularization. Choriocapillaris analysis revealed dark flow void areas in 40.0% of eyes, while combined patterns of dark areas with dark spots and/or abnormal vascular networks were observed in the remaining cases. Active CNV was identified in 50.0% of eyes, corresponding to the proportion detected on fluorescein angiography. Pigment epithelial detachment (PED) was present in 20.0% of eyes. The foveal region was the most frequently affected site (75.0%). Neurosensory retinal detachment was observed in all examined eyes (100.0%) (see Table 4).

Table 5. Comparison between fundus fluorescein angiography (FFA) and optical coherence tomography angiography (OCTA) findings (n = 20).

Variable	FFA No. (%)	OCTA No. (%)	Test Value (χ^2)	p-value	Significance
CNV					
No CNV	10 (50.0%)	10 (50.0%)	0.000	1.000	NS
Active CNV	10 (50.0%)	10 (50.0%)			
PED					
Absent	16 (80.0%)	16 (80.0%)	0.000	1.000	NS
Present	4 (20.0%)	4 (20.0%)			
Foveal Area Involvement					
No	3 (15.0%)	5 (25.0%)	0.625	0.429	NS
Yes	17 (85.0%)	15 (75.0%)			
Inferotemporal Site					
No	14 (70.0%)	12 (60.0%)	0.440	0.507	NS
Yes	6 (30.0%)	8 (40.0%)			
Inferonasal Site					
No	18 (90.0%)	18 (90.0%)	0.000	1.000	NS
Yes	2 (10.0%)	2 (10.0%)			
Supertemporal Site					
No	19 (95.0%)	18 (90.0%)	0.360	0.549	NS
Yes	1 (5.0%)	2 (10.0%)			
Temporal Paracentral Area					
No	20 (100.0%)	19 (95.0%)	1.026	0.311	NS
Yes	0 (0.0%)	1 (5.0%)			

*chi-square test, p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS).

Comparison between FFA and OCTA findings demonstrated complete agreement regarding the detection of choroidal neovascularization (CNV) and pigment epithelial detachment (PED), with no statistically significant difference between

the two modalities (p = 1.000). Similarly, there were no statistically significant differences between FFA and OCTA in identifying the site of chronic central serous chorioretinopathy (CSR), including foveal, inferotemporal, inferonasal, supertemporal, and temporal paracentral locations (all p > 0.05). These findings indicate comparable diagnostic performance between FFA and OCTA in the evaluation of CNV, PED, and lesion localization in chronic CSR cases within the studied sample (see Table 5).

Table 6. Agreement between FFA and OCTA in the assessment of choroidal neovascularization (CNV) (n = 20).

OCTA	FFA No CNV No. (%)	FFA Active CNV No. (%)	Test Value (χ^2)	p-value	Kappa (95% CI)
No CNV	10 (100.0%)	0 (0.0%)	20.000	<0.001	1.000 (1.000 - 1.000)
Active CNV	0 (0.0%)	10 (100.0%)			

p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS).

There was a highly statistically significant association between FFA and OCTA in detecting choroidal neovascularization (CNV) (p < 0.001). OCTA demonstrated perfect agreement with FFA, as reflected by a kappa coefficient of 1.000 (95% CI: 1.000 - 1.000), indicating complete concordance between the two imaging modalities in CNV detection (see Table 6).

Table 7. Agreement between FFA and OCTA in the assessment of pigment epithelial detachment (PED) (n = 20).

OCTA	FFA No PED No. (%)	FFA Present PED No. (%)	Test Value (χ^2)	p-value	Kappa (95% CI)
No PED	16 (100.0%)	0 (0.0%)	20.000	<0.001	1.000 (1.000 - 1.000)
Present PED	0 (0.0%)	4 (100.0%)			

p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS). *chi-square test; • Independent samples t-test.

A highly statistically significant association was observed between FFA and OCTA in the detection of pigment epithelial detachment (PED) (p < 0.001). The kappa coefficient of 1.000 (95% CI: 1.000 - 1.000) indicates perfect agreement between the two diagnostic modalities, confirming the reliability of OCTA in identifying PED compared with FFA in the studied cohort (see Table 7).

There was a statistically significant difference in age between eyes with active CNV and those without CNV (p = 0.042), with younger patients more frequently exhibiting active CNV. Sex distribution also showed a statistically significant association with CNV activity (p = 0.025), as all patients without CNV were male, whereas 40% of patients with active CNV were female. However, no statistically significant association was observed between CNV activity and laterality (p = 0.371) (see Table 8).

Table 8. Relation between CNV activity (FFA) and demographic data (n = 20).

Variable	No CNV (n = 10)	Active CNV (n = 10)	Test Value	p-value	Significance
Age (years)			2.188•	0.042	S
Mean ± SD	46.60 ± 3.75	39.40 ± 9.71			
Range	42 - 52	25 - 53			
Sex			5.000*	0.025	S
Female	0 (0.0%)	4 (40.0%)			
Male	10 (100.0%)	6 (60.0%)			
Laterality			0.800*	0.371	NS
Unilateral	6 (60.0%)	4 (40.0%)			
Bilateral	4 (40.0%)	6 (60.0%)			

p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS). *chi-square test; • Independent samples t-test.

Table 9. Relation between CNV activity (FFA) and clinical examination findings (n = 20).

Variable	No CNV (n = 10)	Active CNV (n = 10)	Test Value	p-value	Significance
Eye			0.202*	0.653	NS
OD	4 (40.0%)	5 (50.0%)			
OS	6 (60.0%)	5 (50.0%)			
VA			−0.058•	0.954	NS
Mean ± SD	0.41 ± 0.24	0.42 ± 0.26			
Range	0.05 - 0.8	0.05 - 0.8			
BCVA			0.121•	0.905	NS
Mean ± SD	0.49 ± 0.20	0.47 ± 0.26			
Range	0.15 - 0.8	0.05 - 0.9			
IOP (mmHg)			1.701•	0.106	NS
Mean ± SD	15.30 ± 1.77	13.90 ± 1.91			
Range	13 - 19	12 - 17			
Anterior Segment			–	–	–
Normal	10 (100.0%)	10 (100.0%)			
Fundus Examination			0.267*	0.606	NS
Serous elevation	8 (80.0%)	7 (70.0%)			
Serous elevation with RPE atrophy	2 (20.0%)	3 (30.0%)			

p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS). *chi-square test; • Independent samples t-test.

No statistically significant differences were detected between eyes with and without active CNV regarding eye laterality, visual acuity (VA), best-corrected visual acuity (BCVA), intraocular pressure (IOP), or fundus examination findings (all $p > 0.05$) (see Table 9).

These findings suggest that demographic factors such as age and sex were significantly associated with CNV activity, whereas routine clinical examination parameters did not demonstrate a significant relationship with CNV status in this cohort.

Table 10. Relation between CNV activity and FFA findings (n = 20).

Variable	No CNV (n = 10)	Active CNV (n = 10)	Test Value (χ^2)	p-value	Significance
Early FFA			–	–	–
Normal arm-to-retina circulation	10 (100.0%)	10 (100.0%)			
Late FFA			1.250*	0.264	NS
Pooling	1 (10.0%)	3 (30.0%)			
Hyperfluorescence with leakage	9 (90.0%)	7 (70.0%)			
FFA Pattern			0.392*	0.531	NS
Ink-blot pattern	9 (90.0%)	8 (80.0%)			
Smoke-stack pattern	1 (10.0%)	2 (20.0%)			
Number of Leakage Points			1.700*	0.637	NS
One point	5 (50.0%)	3 (30.0%)			
Two points	2 (20.0%)	3 (30.0%)			
Three points	3 (30.0%)	3 (30.0%)			
Four points	0 (0.0%)	1 (10.0%)			
PED			0.000*	1.000	NS
Absent	8 (80.0%)	8 (80.0%)			
Present	2 (20.0%)	2 (20.0%)			
Site of Chronic CSR					
Foveal area	8 (80.0%)	9 (90.0%)	0.392*	0.531	NS
Inferotemporal	2 (20.0%)	4 (40.0%)	0.952*	0.329	NS
Inferonasal	2 (20.0%)	0 (0.0%)	2.222*	0.136	NS
Superotemporal	1 (10.0%)	0 (0.0%)	1.053*	0.305	NS
Temporal paracentral area	0 (0.0%)	0 (0.0%)	–	–	–
Neurosensory Detachment			–	–	–
Present	10 (100.0%)	10 (100.0%)			

p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS), *chi-square test.

No statistically significant differences were observed between eyes with and without active CNV regarding late-phase FFA findings (pooling versus hyperfluorescent leakage), FFA leakage patterns (ink-blot versus smoke-stack), number of leakage points, presence of pigment epithelial detachment (PED), or lesion site distribution (all $p > 0.05$). Additionally, early FFA findings and neurosensory detachment were identical in both groups (100.0%). These findings suggest that conventional FFA characteristics alone were not significantly associated with CNV activity status in this cohort (see Table 10).

Table 11. Relation between CNV activity (FFA) and OCTA findings (n = 20).

Variable	No CNV (n = 10)	Active CNV (n = 10)	Test Value (χ^2)	p-value	Significance
Superficial Capillary Plexus			–	–	–
Normal FAZ	10 (100.0%)	10 (100.0%)			
Deep Capillary Plexus			–	–	–
Subretinal fluid	10 (100.0%)	10 (100.0%)			
Outer Retina			20.000*	0.000	HS
No vascular lesion	10 (100.0%)	0 (0.0%)			
Hyperreflective vascular lesion	0 (0.0%)	10 (100.0%)			
Choriocapillaris			20.000*	0.000	HS
Dark area	8 (80.0%)	0 (0.0%)			
Dark area + dark spot	2 (20.0%)	0 (0.0%)			
Dark areas + abnormal blood vessels	0 (0.0%)	8 (80.0%)			
Dark area + dark spot + abnormal blood vessels	0 (0.0%)	2 (20.0%)			
CNV (OCTA)			20.000*	0.000	HS
No CNV	10 (100.0%)	0 (0.0%)			
Active CNV	0 (0.0%)	10 (100.0%)			
PED			0.000*	1.000	NS
Absent	8 (80.0%)	8 (80.0%)			
Present	2 (20.0%)	2 (20.0%)			
Site of Chronic CSR					
Foveal area	8 (80.0%)	7 (70.0%)	0.267*	0.606	NS
Inferotemporal	3 (30.0%)	5 (50.0%)	0.833*	0.361	NS
Inferonasal	2 (20.0%)	0 (0.0%)	2.222*	0.136	NS
Superotemporal	1 (10.0%)	1 (10.0%)	0.000*	1.000	NS
Temporal paracentral area	0 (0.0%)	1 (10.0%)	1.053*	0.305	NS
Neurosensory Detachment			–	–	–
Present	10 (100.0%)	10 (100.0%)			

p-value > 0.05: Not significant (NS); p-value < 0.05: Significant (S); p-value < 0.01: Highly significant (HS). *chi-square test.

OCTA revealed a highly significant correlation with CNV activity detected on FFA at the level of the outer retina and choriocapillaris ($p < 0.001$ for both), with hyperreflective vascular lesions and abnormal choriocapillaris vessels present exclusively in eyes with active CNV. OCTA also showed perfect concordance with FFA in detecting CNV (HS, $p < 0.001$), confirming its reliability as a noninvasive modality for identifying CNV in chronic CSR. In contrast, there were no significant differences between CNV activity groups in superficial or deep capillary plexus findings, PED presence, lesion site, or neurosensory detachment (all $p > 0.05$). These results indicate that OCTA provides a highly sensitive assessment of CNV and choriocapillaris abnormalities that correspond closely with FFA findings, while other OCTA parameters remain less discriminatory for CNV activity (see **Table 11**).

5. Discussions

Central serous chorioretinopathy (CSCR) is widely recognized as a complex, multifactorial chorioretinal disease with both environmental and potential genetic contributions. Pathophysiologically, chronic CSCR is characterized by choroidal hyperpermeability, retinal pigment epithelium (RPE) dysfunction, and neurosensory detachment, often resulting from a dynamic interplay between systemic risk factors and local ocular changes [22] [23].

In this study, the mean age of affected patients was 44.2 years, consistent with recent epidemiologic reports identifying middle-aged adults as the predominant demographic affected by chronic CSCR [24]. A male predominance was observed (male-to-female ratio 4:1), corroborating earlier findings that male sex is a significant risk factor in CSCR, potentially related to sex-specific hormonal or stress-related mechanisms [25] [26].

Bilateral involvement was documented in 33.3% of cases, aligning with longitudinal studies that demonstrate an increased likelihood of bilaterality with disease chronicity and recurrence [27]. This supports the hypothesis that chronic CSCR may represent a systemic phenotype rather than a localized, self-limited disorder.

Stress and sleep disturbances were frequent risk factors in our cohort, reflecting well-established associations between psychosocial stress, endogenous cortisol dysregulation, and CSCR onset [6]. These findings reaffirm the notion that systemic endocrine and lifestyle factors contribute substantially to disease expression.

In fundus fluorescein angiography (FFA), serous retinal elevation was a ubiquitous feature, and the ink blot leakage pattern was the predominant angiographic sign in both non-CNV (80%) and CNV (90%) subgroups. Previous investigations have similarly reported ink blot as the most common leakage morphology in chronic CSCR, frequently associated with ongoing subretinal fluid (SRF) accumulation and RPE disturbance [28].

Comparative analysis between optical coherence tomography angiography (OCTA) and FFA in detecting choroidal neovascularization (CNV) demonstrated that OCTA identified active CNV earlier and with clearer delineation than FFA.

In our study, ten eyes with active CNV were concordantly detected by OCTA and FFA, but OCTA allowed earlier structural characterization of the neovascular network. This is in agreement with several recently published reports suggesting the superior sensitivity of OCTA in detecting occult or non-leaking CNV in chronic CSCR [29]-[31].

Bansal *et al.* reported that OCTA detected CNV in 20.9% of eyes versus 30.2% by FFA, with the higher FFA rate attributed to false-positive leakage from SRF or RPE irregularities [32]. This underscores a recognized limitation of dye-based angiography in CSCR, where nonspecific hyperfluorescence may confound CNV detection. Conversely, OCTA measures flow rather than dye leakage, providing a depth-resolved view of vascular networks, which can reveal subretinal neovascular complexes not apparent on FFA or indocyanine green angiography (ICGA) [33].

Maftouhi *et al.* demonstrated OCTA's ability to detect CNV in chronic CSCR that was not evident on ICGA, further advocating for OCTA integration into multimodal imaging workflows [34]. In our study, OCT B-scans with angiographic correlation highlighted hyperreflective vascular lesions on OCTA corresponding to occult CNV, consistent with these reports.

Costanzo *et al.* identified choriocapillaris abnormalities (dark areas and dark spots) on OCTA as potential markers of underlying pathological choroidal vasculature in CSCR [35]. These choriocapillaris flow voids have been proposed as indicators of choroidal ischemia or microvascular alteration, which may predispose to CNV development [2].

Importantly, Soomro and Talks emphasized that OCTA and FFA are complementary rather than interchangeable modalities; FFA provides dynamic leakage information, while OCTA directly visualizes flow within the neovascular network [36]. Our results support this perspective, demonstrating that integration of both imaging techniques yields a more comprehensive assessment of chronic CSCR, particularly in the context of CNV evaluation.

Recent studies further reinforce OCTA's role in clinical practice. OCTA has been shown to be superior to dye-based modalities in detecting CNV associated with chronic CSCR and in characterizing complex vascular lesions, thereby reinforcing its diagnostic value [37] [38]. Additionally, OCTA facilitates detailed analysis of retinal and choroidal microvasculature without the risks associated with dye injection, an increasingly important consideration in routine ophthalmic imaging [39] [40].

Overall, our findings underscore the diagnostic potential of OCTA, particularly in identifying CNV in chronic CSCR, where traditional angiography may be limited by nonspecific leakage. While multimodal imaging remains essential, our data support a paradigm shift toward greater reliance on OCTA for the early and accurate detection of neovascular complications.

6. Conclusions

Optical coherence tomography angiography (OCTA) is a noninvasive, rapid, and

reliable imaging modality that offers distinct advantages over traditional fluorescein angiography (FA) and indocyanine green angiography (ICGA) in the assessment of chronic central serous chorioretinopathy (CSCR). OCTA enables layer-specific visualization of the retinal and choroidal vasculature, facilitating early detection of choroidal neovascularization (CNV) and subtle vascular alterations that may be missed with dye-based techniques.

However, OCTA has inherent limitations, including a relatively narrow field of view (though newer devices are expanding coverage), lack of direct leakage detection, reduced sensitivity for slow or deep blood flow, and variability in image quality. Despite these constraints, OCTA represents a valuable adjunct or potential alternative to conventional angiography, particularly for longitudinal monitoring and noninvasive evaluation of CNV in chronic CSCR.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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