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Assessing Choroidal Thickness in Central Serous Chorioretinopathy Using Swept-Source Optical Coherence Tomography

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ABSTRACT

Background: Central serous chorioretinopathy (CSC) is a retinal condition marked by the build-up of fluid beneath the retina., disrupting vision. This study evaluates the use of Swept-Source Optical Coherence Tomography (SS-OCT) to measure choroidal thickness, which could help in understanding and managing CSC. **Study objectives:** To determine the differences in choroidal thickness between affected eyes by active CSC and the unaffected contralateral eyes, and a control group. **Methods:** A case-control study involving 23 CSC patients and 37 healthy controls. Choroidal thickness was measured using SS-OCT. Statistical analysis was used to compare measurements across the groups.
Results: The study found significantly increased choroidal thickness in eyes of patients with CSC compared to both contralateral unaffected and control eyes, suggesting the utility of SS-OCT in identifying and managing CSC.
Conclusion: SS-OCT is an effective tool for distinguishing CSC from other conditions and monitoring its progression. Increased choroidal thickness is a notable feature of CSC-affected eyes, highlighting the importance of choroidal evaluation in CSC diagnosis and treatment.

Keywords: Central Serous Chorioretinopathy, Choroidal Thickness, Swept-Source Optical Coherence Tomography, Diagnostic Imaging

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INTRODUCTION

Central serous chorioretinopathy (CSC) is a significant retinal with an estimated incidence is 10 per 100,000 individuals annually. The condition leads to serous neurosensory retinal detachment due to fluid leakage from the choroidal vasculature through the retinal pigment epithelium (RPE), resulting in visual disturbances such as blurred vision and metamorphopsia (Liegl & Ulbig, 2014: Fung, A. Yang, & Kam, 2023)

The exact etiology remains multifactorial, with associations to stress, corticosteroid use, and type-A personality traits. Elevated levels of endogenous or exogenous corticosteroids are thought to contribute to choroidal vascular permeability alterations, leading to fluid accumulation. other potential risk factors include genetic predispositions, sleep disturbances, and certain lifestyle factors such as high caffeine or alcohol intake and certain medications, particularly sympathomimetic agents (Gemenetzi, De Salvo, & Lotery, 2010: Nicholson, et al., 2013).

While many cases of CSC resolve spontaneously within a few months, recurrent cases can lead to chronic CSC, with lasting damage to the retina and permanent visual impairments, such as reduced visual acuity or contrast sensitivity. Patients with chronic CSC may experience persistent RPE changes, which can contribute to further complications over time (Liegl & Ulbig, 2014).

Treatment options are evolving. Photodynamic therapy (PDT) and mineralocorticoid receptor antagonists (like eplerenone) are currently under investigation for their potential to treat chronic or recurrent CSC by targeting choroidal vasculature changes. Selective laser therapy and newer pharmacologic agents targeting choroidal blood flow and vascular permeability offer hope for future interventions (Nicholson, et al., 2013).

The diagnosis of CSC is primarily clinical, supported by imaging studies: **Fundoscopy**: Reveals a serous retinal detachment, often with RPE alterations. **Fluorescein Angiography (FA)**: Identifies leakage points ("smokestack" or "inkblot" patterns) indicative of RPE dysfunction.. **Indocyanine Green Angiography (ICGA)**: that shows vascular abnormalities in the choroid and increased permeability. **Optical Coherence Tomography (OCT)**: reveals multiple cross-sectional visuals with better details of both the retina and choroid, essential for

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assessing fluid accumulation and structural changes (Costanzo, et al., 2015: Chan, et al., 2016).

Swept-Source Optical Coherence Tomography (SS-OCT)

SS-OCT is an advanced imaging technology that utilizes longer wavelength light (typically around 1050 nm) compared to traditional spectral-domain OCT. with deeper radiological penetration into ocular tissues, providing high-resolution images of the choroidal body and the retina (Ferrara, et al., 2014: Sulzbacher, et al.,2019: Zhang, 2023).

METHODOLOGY

Ethical considerations obtained On December 2023, the study was approved by the Arabic Board of Health Specialization/ Local scientific council of ophthalmology in Iraq and Gazi Al-Hariri specialized surgeries hospital in Baghdad medical city. Informed consent was obtained from all patients and control participants. After explaining the research objectives, data confidentiality, surgical procedures, potential complications, and benefits.

Study design: a case-control study was conducted on a group of Iraqi patients that were diagnosed with central serous chorioretinopathy according to senior ophthalmologist decision and were visiting the out-patient clinic at Ghazi Al-Hariri Hospital for follow up or treatment.

Data collection started at March 2024 till September 2024 for a period of one year. The study involved 23 patients and 37 healthy controls with matching the Age and Gender of the patients, data collection is illustrated in Figure 2.

Inclusion criteria

1. Patients that were diagnosed with CSC of both sex and at any age with active disease, diagnosed according to senior ophthalmologists' decision.
2. The diagnosis is confirmed by swept-source OCT imaging with the presence of subretinal fluid.
3. With signs of the disease lasting for more than six months to confirm chronicity of the disease.

Exclusion criteria

1. Patients with refractive errors with spherical equivalent above 1 dioptre.

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2. Patients with poorly controlled hypertension.
3. Patients with history of diabetic retinopathy who have received treatment with intravitreal anti-vascular endothelial growth factors.
4. Patients with past surgical history involving the intraocular region.
5. Patients with poor images quality during OCT examination (cataract, glaucoma, uveitis, previous trauma, etc.)

Data Collection

All the patients were collected from the hospital outpatient clinic while they were visiting during the study period, while the control group were healthy controls that accompanied the patients to the clinic (usually the patients' relatives) or patients visiting the clinic for reasons other than central serous chorioretinopathy.

All the patients and controls gave formal consent before undergoing the thorough ophthalmological examination.

Data included detailed history regarding chronic medical conditions, previous surgeries, trauma, drugs and ophthalmological diseases.

The researcher prepared a paper form questionnaire for each patient and control that was filled with the prospective data including demographic characteristics of age and gender by direct interviewing.

Physical examination included measuring the height in meters (m) without shoes using a stadiometer, and weight was measured in kilogram (Kg), patients were weighed on a mechanical scale that was calibrated for accuracy and they were asked to remove any heavy clothes and stand without shoes.

Body mass index was obtained according to the following equation:

(BMI= weight in Kilograms/square hight in meters)

Physical examination also included measurements of blood pressure.

Ophthalmological examination was then proceeded if the subject was involved in the inclusion criteria and not excluded, the examination included assessment of the acuity of vision was also done using a traditional Snellen chart.

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Autorefractor was used to assess refraction, followed by intraocular pressure (IOP) was determined with an air puff tonometer.

To reduce variations in choroidal thickness between day and night, all measurements were conducted exclusively in the morning, specifically between 9:00 AM and 12:00 PM.

A comprehensive assessment of the anterior segment was then performed. After applying a single drop of 1% Tropicamide to achieve pupil dilation, allowing for an in-depth examination of the posterior eye segments. With the utilization of a slit lamp in conjunction with a +78-diopter condensing lens.

Choroidal thickness measurements followed, conducted via deep-range imaging swept-source optical coherence tomography (SS-OCT) manufactured by Topcon Corp., Tokyo, Japan, using the device default settings.

All measurements were carried out by a skilled technician using the integrated software (version 10.0x), with results displayed on an Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Choroidal thickness was systematically evaluated across nine designated sectors of the posterior pole, as illustrated in Figure 1.

The following equipment were used during assessment of the participants:

1. CT-1P/ Computerized tonometer
2. KR-800/ Auto kerato-refractometer
3. DRI-OCT/ triton plus/ 3D OCT
4. SL-3C/ SLIT Lamp
5. TRC 50DX/type1 / Retinal camera

All the collected data that were recorded in the prepared questionnaire and then transformed into a Microsoft excel format sheet and sent for statistical analysis.

Statistical analysis

Statistical analysis was done using IBM SPSS version 27. Data were expressed as simple measures of frequency, percent, mean and standard deviation and illustrated as tables and figures.

To analyse differences between an independent samples paired t-test was used for continues, chi-square test or Fisher’s exact test was used for categorical variables.

Kruskal-Walli’s test and Dunn-Bonferroni pairwise comparisons were used to assess variations in choroidal thickness among the groups.

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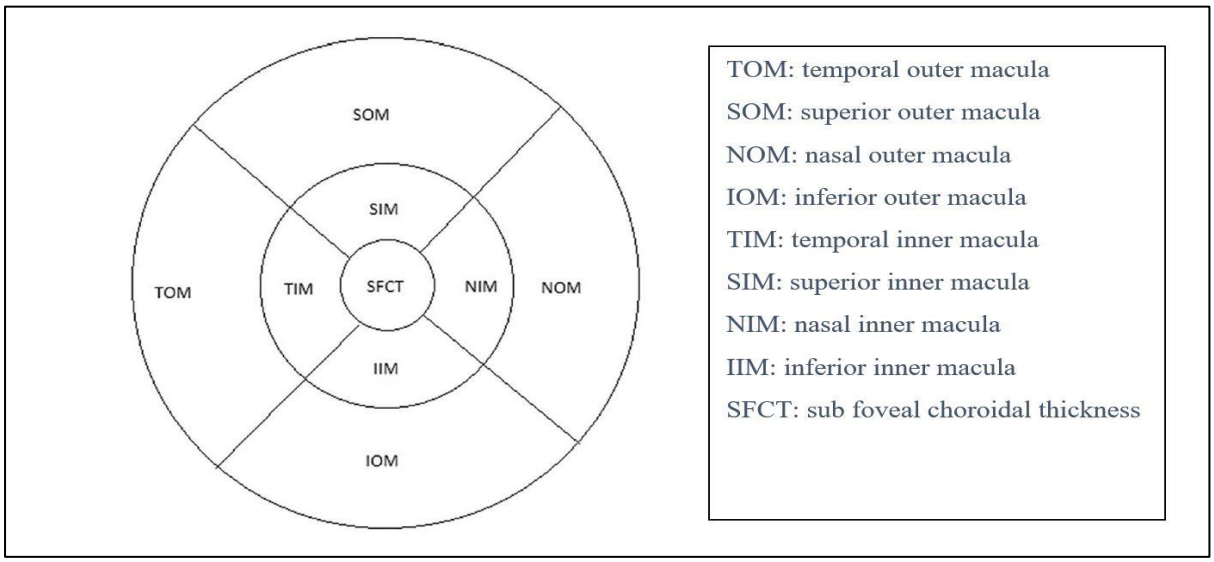

Figure 1: demonstration of the nine sectors of the posterior pole.

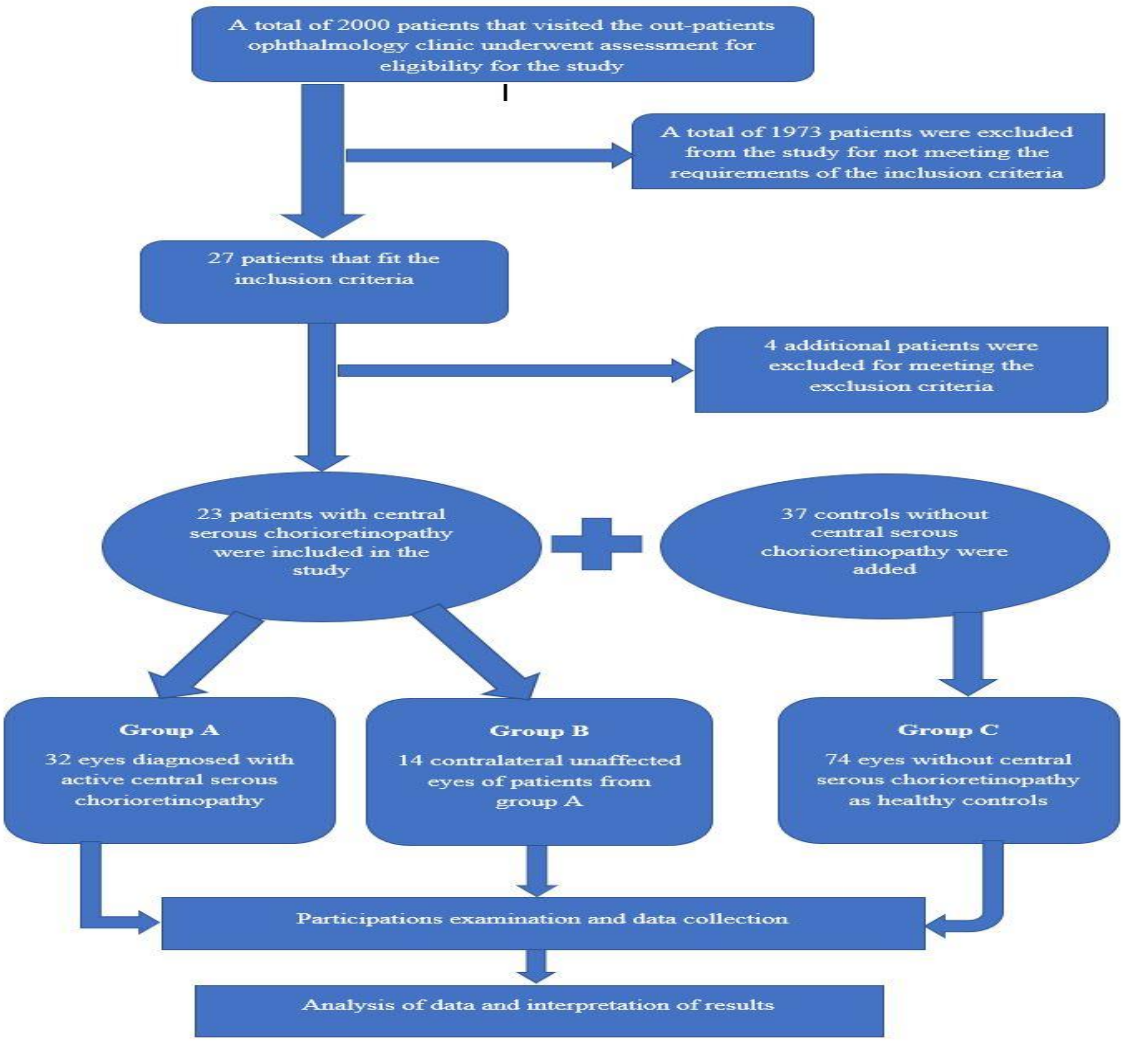

Figure 2: flowchart of the process of data collection

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RESULTS

In Table 2, the mean age of the patients was 45.3±9.4 years, while the controls have an average age of 43.8±13.6 years; these differences are not statistically significant. The Body Mass Index (BMI) differences were not significant between the two groups, with patients averaging 27.2 kg/m² and controls averaging 28.3 kg/m². Spherical equivalent, was similarly close between the two groups (0.78 for patients and 0.81 for controls) and shows no significant difference.

sex distribution across patients and controls is also balanced and shows no significant statistical difference, with 15 males and 8 females in the patient group, and 25 males and 12 females in the control group.

Table 2: *demographic and clinical variables of the studied sample.*

Variable	***Patients (n=23)***	***Controls (n=37)***	***P value***
	Mean ± SD	***Mean ± SD***	
Age	45.3 ± 9.4	43.8 ± 13.6	>0.05 Not sig.
BMI (kg/m^2)	27.2 ± 5.1	28.3 ± 4.7	>0.05* Not sig.
Spherical equivalent	0.78 ± 0.3	0.81 ± 0.2	>0.05 Not sig.
Gender (M/F)	15//8	25//12	>0.05 Not sig.

Table 3 shows the sectoral choroidal thickness measurements across three different groups labeled A, B, and C.

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Group A, consisting of 28 eyes, shows the highest choroidal thickness measurements across all parameters when compared to the other two groups. For example, the subfoveal choroidal thickness (SFCT) is highest in Group A at 375.8 µm, followed by Group B at 337.1 µm, and Group C at 287.8 µm, with the differences being statistically significant. Similar patterns are observed for other measured parameters like superior inner macula (SIM) and i inferior inner macula (IIM). Group C consistently shows the lowest measurements, indicating thinner choroidal sectors compared to Groups A and B. Statistical analysis confirms these observations are significant, with p-values ranging from 0.003 to less than 0.001. indicating high statistical significant difference.

Table 3: *sectoral choroidal thickness measurements and association among the study sample groups*

Parameters	*Group A (28 eyes)*	*Group B (14 eyes)*	*Group C (74 eyes)*	*P values*	
	Mean ± SD	*Mean ± SD*	*Mean ± SD*	***A vs C***	***B vs C***
SFCT	375.8 ± 74.5	337.1 ± 77.2	287.8 ± 39.3	<0.001	0.003
SIM	373.2 ± 71	332.7 ± 68.7	294.3 ± 40.4	<0.001	0.002
IIM	370.3 ± 67.8	329.57 ± 78.1	287.2 ± 43.4	<0.001	<0.001
NIM	365 ± 79.4	329.8 ± 77.6	279.1 ± 42.5	<0.001	0.005
TIM	359.6 ± 87.9	326.7 ± 80.9	277.4 ± 40.4	<0.001	0.012
SOM	357.3 ± 70.3	334.4 ± 59.2	288.8 ± 43.1	<0.001	0.027
IOM	349.7 ± 67.1	312.9 ± 66.3	274.3 ± 44.8	<0.001	0.016
NOM	322.8 ± 72.6	307.5 ± 85.9	248 ± 46.9	<0.001	0.031
TOM	332.1 ± 86.9	286.5 ± 81.1	244.6 ± 48.2	<0.001	<0.001

DISCUSSION

OCT allows for non-invasive, high-resolution imaging of the retina and choroid, enabling detailed assessment of morphological changes associated with CSCR. Enhanced depth imaging OCT (EDI-OCT), in particular, has been instrumental in measuring choroidal

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thickness, which is a key parameter in CSCR studies (Zhang, et al., 2023, Kiilgaard, et al., 2024)

Group A exhibited the highest choroidal thickness measurements in all sectors. For instance, the subfoveal choroidal thickness (SFCT) averaged 375.8 ± 74.5 μm in Group A, followed by 337.1 ± 77.2 μm in Group B, and 287.8 ± 39.3 μm in Group C. The differences between the groups were significant, with p-values ranging from 0.003 to less than 0.001, indicating that the variations in choroidal thickness are not due to chance. Similar patterns were observed for other measured parameters like the superior inner macula (SIM) and inferior inner macula (IIM), where Group A consistently showed higher measurements compared to Groups B and C.

In comparison to similar studies, **Kim et al.** (2011) investigated choroidal thickness in patients with unilateral CSCR using enhanced depth imaging optical coherence tomography (EDI-OCT). Their research included 28 eyes from patients with unilateral CSCR and 28 eyes from healthy controls. Their study showed a significant increase in subfoveal choroidal thickness (SFCT) in the affected eyes, with a mean SFCT of 407.1 μm, compared to 353.5 μm in the unaffected fellow eyes and 308.3 μm in healthy controls. They concluded that choroidal thickness was elevated in both affected and unaffected eyes of patients with unilateral CSC, suggesting that CSC may inherently be a bilateral condition.

Their results are consistent with our findings and Al-Rubiay, & Mohammad, (2023) where Group A (affected eyes) showed the highest choroidal thickness, followed by Group B (unaffected fellow eyes), and then Group C (healthy controls).

The significantly greater choroidal thickness in eyes with CSC, both subfoveal and at points of fluorescein leakage, Jirarattanasopa, et al., (2012) suggests that choroidal dysfunction, particularly choroidal congestion or hyperpermeability, that have a major role in the etiology of CSC. The thickened choroid could be indicative of increased vascular permeability or fluid retention within the choroidal vasculature.

Regarding the unaffected fellow eyes (Group B), our study found that these eyes also had increased choroidal thickness compared to healthy controls, although less than the affected eyes.

Similarly, Maruko et al., (2011). investigated choroidal thickness in patients with CSCR. Their study included 66 eyes with unilateral CSCR and compared them to the healthy eyes.

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They reported that the mean SFCT in affected eyes was significantly greater (mean of 414 μm) than in the control eyes (mean of 350 μm). Although the absolute values are higher than those in our study, the trend of increased choroidal thickness in CSCR patients aligns with our findings.

In a study by Kuroda et al., (2013) involving 35 eyes from 27 patients CSC and a comparison group of 35 healthy controls, findings revealed a markedly increased subfoveal choroidal thickness in CSC-affected eyes compared to controls ($P < 0.01$). Furthermore, choroidal thickness was notably greater at both the fovea and fluorescein leakage sites ($P < 0.01$ for each) in CSC eyes than in corresponding areas of the unaffected eyes of patients with unilateral disease. The study also indicated a significantly higher incidence of choroidal large vessel dilatation in CSC-affected eyes ($P < 0.01$).

The fact that eyes with CSC showed significantly greater choroidal thickness compared to fellow eyes in unilateral cases indicates that even though CSC may manifest in only one eye, the underlying choroidal changes might be present bilaterally. This suggests that CSC is likely a systemic disorder that affects both eyes, even if symptoms are confined to one.

Furthermore, even in patients with acute ICSCR, **Dang et al.** (2014) **concluded** that the subfoveal choroid thickness measurements were higher in patients with acute ICSCR compared to the general population, with symptomatic eyes showing significantly greater thickness than the contralateral unaffected eyes. They also found that photodynamic therapy using a reduced dose of verteporfin, at one-third of the standard amount, could effectively slow increased choroidal vascular hyperpermeability and reduce choroidal thickness the affected patients.

Optical coherence tomography (OCT), particularly SS-OCT, has become indispensable in diagnosing and managing Central Serous Chorioretinopathy (CSCR). The technology's ability to provide high-resolution images of the choroid and retina facilitates detailed assessments of morphological changes associated with CSCR. This study's results corroborate earlier findings from similar research, indicating consistently increased choroidal thickness in CSC-affected eyes, which may suggest underlying systemic issues affecting the choroidal vasculature bilaterally.

Comparison with other studies, like those conducted by **Kim et al.,** (2011) and Maruko et al., (2011). supports the notion that CSC may inherently involve both eyes, even if only one exhibits symptoms. The implication of these findings for clinical practice is profound; it

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suggests that assessments should not be confined to symptomatic eyes but extended to both, enhancing early detection and intervention opportunities.

Photodynamic therapy, adjusted for reduced dosing, has shown promise in managing acute CSC cases by reducing choroidal vascular hyperpermeability and thickness, further underscoring the potential of targeted interventions based on choroidal measurements provided by SS-OCT.

Overall, the integration of SS-OCT into routine ophthalmic evaluations for patients suspected of or diagnosed with CSC offers a significant advancement in both diagnostic and therapeutic strategies, potentially improving patient outcomes through more precise and targeted approaches.

CONCLUSION

The findings conclude that CSC can affects both eyes, even when only one eye shows symptoms, due to increased choroidal thickness and choroidal vessel abnormalities, indicating that the condition likely has a systemic or bilateral nature. Clinically, it is recommended to use OCT to assess choroidal thickness for diagnosis and monitoring, to regularly monitor both eyes even in unilateral cases.

Further research to investigate the mechanisms underlying choroidal thickening in CSC. Studies exploring the molecular and vascular factors contributing to choroidal hyperpermeability could provide insights into targeted therapies. Moreover, integrating SS-OCT with other imaging modalities like OCT angiography may enhance our understanding of choroidal vascular changes in CSC.

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