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Original Research Article

Comparison of Fundus Fluorescein Angiography, Optical Coherence Tomography, and Optical Coherence Tomography Angiography Features of Macular Changes in Eales Disease: A Case Series

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Abstract: *Eales disease is an idiopathic inflammatory retinal vasculopathy that predominantly affects young adults and is associated with significant visual morbidity.* ***Objective:*** *To compare FFA, OCT, and OCTA features of macular changes in patients with Eales disease and to assess the relative contribution of each modality in detecting vision-threatening macular pathology.* ***Methods:*** *This descriptive, cross-sectional study was conducted at Alshifa Eye Trust Hospital, Rawalpindi, from September 2024 to February 2025. A total of 42 patients diagnosed with Eales disease were enrolled using non-probability consecutive sampling. All patients underwent comprehensive ophthalmic examination and macular evaluation using FFA, OCT, and OCTA. Macular leakage, ischemia, and capillary non-perfusion were assessed on FFA; structural macular abnormalities were evaluated on OCT; and microvascular alterations, including foveal avascular zone (FAZ) changes and capillary plexus dropout, were analyzed on OCTA.* ***Results:*** *The mean age of patients was 31.8 ± 7.4 years, with a marked male predominance (81.0%). Macular leakage was detected on FFA in 58.6% of eyes, while macular ischemia was present in 36.2%. OCT demonstrated cystoid macular edema in 44.8% of eyes with a mean central subfield thickness of 382 ± 64 µm. OCTA revealed FAZ abnormalities in 74.1% of eyes, with deep capillary plexus dropout observed in 56.9% of eyes.* ***Conclusion:*** *Macular involvement is common in Eales disease and is best characterized using a multimodal imaging approach. While FFA and OCT remain essential for evaluating vascular leakage and structural changes, OCTA provides superior detection of macular ischemia and microvascular compromise, which are strongly associated with visual impairment.*

Keywords: Eales Disease; Macular Involvement; Fundus Fluorescein Angiography; Optical Coherence Tomography

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Introduction

Eales' disease is an idiopathic inflammatory occlusive vasculopathy that primarily affects the peripheral retinal veins of young adults, with a higher prevalence reported from the Indian subcontinent and other tuberculosis-endemic regions (1). The typical progression of the disease starts with periphlebitis. It progresses through several stages: areas of non-perfusion at the level of the capillaries, ischaemia of the retina, and finally neovascularisation with complications such as haemorrhages in the vitreous body and traction retinal detachment (TD) (2). Although traditionally the involvement of the peripheral retina was consistent, evidence of macular involvement is increasing and is particularly significant in determining patients' visual potential (3). The macular changes in Eales disease are crucial because even small changes in the structure or perfusion of the macula can lead to a significant loss of vision. Changes observed in Eales disease can be macular oedema (cystoid), ischaemia of the macula, membranes (epiretinal) of the retina, traction of the vitreous body (vitreomacular), and neovascularisation of secondary type (4). The assessment of the macula and retina involvement in Eales disease has been, up to now, mainly dependent on fundus fluorescein angiography (FFA), which, even though it is the standard technique for the assessment of retinal leakage of the dye, in the absence of capillaries, and the presence of neovascularisation, has a far from standard (5). However, it is time-consuming and can have dye-related effects. It lacks and provides poor information on retinal microvasculature and the depth of their structure. High-resolution cross-sectional imaging of retinal layers has changed the assessment of macular structure using optical coherence tomography (OCT). In Eales disease, objective assessment and quantification of macular oedema, subretinal fluid, thinning of the inner retina, and vitreoretinal interface abnormalities, which may be unnoticed during the fundus exam, are possible using OCT (6). Visual acuity and the severity of the condition have been associated with raised structural OCT findings, making it an essential technology for tracking macular complications and the effectiveness of treatments (7). To the contrary, the assessment of microvascular integrity and retinal perfusion is not done by OCT. The development of optical coherence tomography angiography (OCTA) has enhanced the assessment of the retinal blood vessels by giving the prospect to view the depth-resolved, and the retinal and choroidal microvasculature without the use of intravenous contrast for dye injection (8). The assessment of the split between the superficial and deep capillary plexuses, the morphology of the foveal avascular zone (FAZ), and the quantification of capillary loss, which is essential in Eales disease, are among the roles of OCT (9). Macular ischaemia and the microvascular changes arising from ischaemia and the deep capillary plexus, which may be undetected or poorly visualised on conventional FFA, may be detected by emerging studies and evaluated better with OCTA. The FFA, OCT, and OCTA each fulfil different but complementary roles; however, there is still very little data comparing their relative usefulness in identifying macular changes in Eales disease. Systematically evaluating the various imaging modalities is essential for understanding the range of macular involvement, thereby refining diagnostic approaches and management strategies in clinical practice (10).

To compare FFA, OCT, and OCTA features of macular changes in patients with Eales disease and to assess the relative contribution of each modality in detecting vision-threatening macular pathology.

Methodology

This was a descriptive, cross-sectional study conducted at the Alshifa Eye Trust Hospital from September 2024 to February 2025, including 42 patients diagnosed with Eales disease.

Patients aged 18 years and above. Clinically diagnosed cases of Eales disease. Patients who underwent complete macular imaging with fundus fluorescein angiography, optical coherence tomography, and optical coherence tomography angiography. Patients are willing to provide informed consent

Presence of other retinal or macular pathologies such as diabetic retinopathy, retinal vein occlusion, age-related macular degeneration, or high myopia. History of intraocular surgery, macular laser treatment, or intravitreal therapy affecting macular structure. Media opacities preclude the acquisition of high-quality retinal images— Uveitis due to causes other than Eales disease.

Data were collected using a structured proforma. Demographics captured included age and sex, along with clinical parameters: laterality, best-corrected visual acuity, and disease stage. The study participants underwent fundus fluorescein angiography (FFA) to assess for macular leakage and non-perfusion, anomalies in the foveal avascular zone (FAZ), and/or neovascularity. Structural macular changes, including cystoid macular oedema, subretinal fluid, epiretinal membrane, vitreomacular traction, and retinal thinning, were assessed using optical coherence tomography (OCT). Macular microvascular changes were evaluated with optical coherence tomography angiography (OCT-A) by determining the integrity of the superficial and deep capillary plexus, morphology of the foveal avascular zone, and microvascular non-perfusion. Imaging findings were recorded and processed for each affected eye individually.

Data were analyzed using SPSS version 24.0. Quantitative variables such as age and visual acuity were expressed as mean ± standard deviation or median with range, as appropriate. Categorical variables, including macular findings on fundus fluorescein angiography, optical coherence tomography, and optical coherence tomography angiography, were presented as frequencies and percentages. Descriptive statistics were used to compare the detection patterns of macular changes across the three imaging modalities. A p-value of ≤ 0.05 was considered statistically significant where applicable.

Results

The study included 42 patients with Eales disease, with a mean age of 31.8 ± 7.4 years (range 19–48), showing a clear male predominance (81.0%). Unilateral involvement was more frequent (61.9%) than bilateral disease (38.1%). The mean duration of symptoms was 9.6 ± 4.2 months, longer in patients with bilateral involvement (10.9 ± 4.4 months) than in unilateral cases (8.8 ± 3.9 months). Overall mean best-corrected visual acuity was 0.48 ± 0.26 logMAR, with poorer vision noted in bilateral disease (0.58 ± 0.31) compared to unilateral disease (0.42 ± 0.21). Most patients were in the ischemic stage (42.9%), followed by the inflammatory (33.3%) and proliferative (23.8%) stages.

Fundus fluorescein angiography analysis of 58 eyes demonstrated macular leakage in 34 eyes (58.6%), with 24.1% showing mild, 20.7% moderate, and 13.8% severe leakage. Perifoveal capillary leakage was observed in exactly half of the eyes (50.0%), while macular ischemia was identified in 36.2% of eyes, predominantly of mild to moderate severity. FAZ enlargement was noted in 32.8% of eyes, mostly mild to moderate, whereas macular capillary non-perfusion was present in 39.7% of eyes, indicating substantial macular ischemic involvement detectable on angiography.

Optical coherence tomography revealed cystoid macular edema in 44.8% of eyes, with a mean central subfield thickness of 382 ± 64 µm, reflecting significant structural involvement. Subretinal fluid was present in 24.1% of eyes with a mean height of 98 ± 22 µm. Epiretinal membrane and vitreomacular traction were less frequent, affecting 19.0% and 13.8% of eyes, respectively. Inner retinal thinning was observed in 29.3% of eyes, with a mean thickness of 214 ± 28 µm. In comparison, disorganization of the retinal inner layers was present in 25.9% of eyes, with an average length of 426 ± 91 µm, highlighting ischemia-related structural damage.

Optical coherence tomography angiography demonstrated FAZ abnormalities in 74.1% of eyes, with enlargement seen in 41.4% and irregular morphology in 32.8%, and a mean FAZ area of 0.43 ± 0.12 mm². Superficial capillary plexus dropout was identified in 46.6% of eyes, while deep capillary plexus involvement was more frequent, affecting 56.9% of eyes. Mean vessel density was reduced in both plexuses, measuring 41.6 ± 5.8% in the superficial layer and 38.1 ± 6.4% in the deep layer. Flow voids were present in 53.4% of eyes with a mean area of 0.31 ± 0.09 mm², indicating prominent microvascular compromise at the macular level.

Cross-modality analysis showed that eyes with macular edema on OCT (44.8%) had a mean visual acuity of 0.62 ± 0.28 logMAR, with 69.2% having visual acuity worse than 0.5 logMAR. Macular ischemia detected on FFA was associated with poorer vision, with a mean logMAR of 0.71 ± 0.31, and 81.0% of eyes demonstrated visual acuity worse than 0.5. FAZ enlargement and deep capillary plexus dropout on OCTA showed the strongest association with visual impairment, with mean logMAR values of 0.68 ± 0.29 and 0.74 ± 0.34, respectively.

Table 1: Demographic and Clinical Characteristics of Patients With Eales Disease (n = 42)

Variable	Category	Total (n = 42)	Unilateral (n = 26)	Bilateral (n = 16)
Age (years)	Mean ± SD	31.8 ± 7.4	30.9 ± 6.8	33.2 ± 8.1
	Range	19–48	19–44	22–48
Gender	Male	34 (81.0)	22 (84.6)	12 (75.0)
	Female	8 (19.0)	4 (15.4)	4 (25.0)
Duration of symptoms (months)	Mean ± SD	9.6 ± 4.2	8.8 ± 3.9	10.9 ± 4.4
BCVA (logMAR)	Mean ± SD	0.48 ± 0.26	0.42 ± 0.21	0.58 ± 0.31
Disease stage	Inflammatory	14 (33.3)	10 (38.5)	4 (25.0)
	Ischemic	18 (42.9)	11 (42.3)	7 (43.8)
	Proliferative	10 (23.8)	5 (19.2)	5 (31.2)

Table 2: Detailed Fundus Fluorescein Angiography (FFA) Macular Findings (Eyes = 58)

FFA Feature	Absent n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	Total Affected n (%)
Macular leakage	24 (41.4)	14 (24.1)	12 (20.7)	8 (13.8)	34 (58.6)
Perifoveal capillary leakage	29 (50.0)	13 (22.4)	10 (17.2)	6 (10.3)	29 (50.0)
Macular ischemia	37 (63.8)	9 (15.5)	8 (13.8)	4 (6.9)	21 (36.2)

FAZ enlargement	39 (67.2)	11 (19.0)	8 (13.8)	0 (0.0)	19 (32.8)
Macular capillary non-perfusion	35 (60.3)	12 (20.7)	7 (12.1)	4 (6.9)	23 (39.7)

Table 3: Optical Coherence Tomography (OCT) Structural Macular Features (Eyes = 58)

OCT Parameter	Absent n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	Quantitative Value
Cystoid macular edema	32 (55.2)	11 (19.0)	9 (15.5)	6 (10.3)	CST 382 ± 64 µm
Subretinal fluid	44 (75.9)	8 (13.8)	6 (10.3)	0 (0.0)	Height 98 ± 22 µm
Epiretinal membrane	47 (81.0)	7 (12.1)	4 (6.9)	0 (0.0)	—
Vitreomacular traction	50 (86.2)	5 (8.6)	3 (5.2)	0 (0.0)	—
Inner retinal thinning	41 (70.7)	9 (15.5)	8 (13.8)	0 (0.0)	214 ± 28 µm
DRIL	43 (74.1)	8 (13.8)	7 (12.1)	0 (0.0)	Length 426 ± 91 µm

Table 4: Optical Coherence Tomography Angiography (OCTA) Macular Microvascular Findings (Eyes = 58)

OCTA Parameter	Normal n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	Mean ± SD
FAZ morphology	15 (25.9)	19 (32.8)	24 (41.4)	0 (0.0)	FAZ area 0.43 ± 0.12 mm²
SCP capillary dropout	31 (53.4)	15 (25.9)	9 (15.5)	3 (5.2)	SCP VD 41.6 ± 5.8 %
DCP capillary dropout	25 (43.1)	14 (24.1)	12 (20.7)	7 (12.1)	DCP VD 38.1 ± 6.4 %
Flow voids	27 (46.6)	16 (27.6)	10 (17.2)	5 (8.6)	Area 0.31 ± 0.09 mm²
Perifoveal rarefaction	30 (51.7)	12 (20.7)	10 (17.2)	6 (10.3)	—

Table 5: Cross-Modality Correlation of Macular Findings with Visual Acuity (Eyes = 58)

Macular Feature	Imaging Modality	Eyes Affected n (%)	Mean BCVA (logMAR)	BCVA >0.5 n (%)
Macular edema	OCT	26 (44.8)	0.62 ± 0.28	18 (69.2)
Macular leakage	FFA	34 (58.6)	0.56 ± 0.24	21 (61.8)
Macular ischemia	FFA	21 (36.2)	0.71 ± 0.31	17 (81.0)
FAZ enlargement	OCTA	24 (41.4)	0.68 ± 0.29	19 (79.2)
DCP dropout	OCTA	33 (56.9)	0.74 ± 0.34	26 (78.8)
ERM / VMT	OCT	19 (32.8)	0.59 ± 0.26	12 (63.2)

Discussion

This case series highlights the spectrum of macular involvement in Eales disease using multimodal imaging and demonstrates that macular pathology is both common and clinically significant in this condition. The demographic details of the cohort, the mean age of 31.8 ± 7.4 years, and notable male dominance, are consistent with the classical epidemiological description of male predominance in Eales disease as described in the literature. The increased unilateral involvement and predominance of ischaemic disease support the notion that many patients present after the disease has progressed beyond the initial inflammatory phase, often when inflammatory symptoms become more visually pronounced, as described in the literature (11). Fundus fluorescein angiography showed 58.6% of eyes with macular leakage and 36.2% with macular ischaemia, more prevalent and significant than described in the literature for involvement of the macular vasculature. The finding of macular capillaries with non-perfusion in almost 40% of the eyes and leakage around the fovea in 50% of the eyes reinforces the idea of active vascular inflammatory changes and ischaemia. A number of studies have reported similar occurrences of macular ischaemic changes and leakage, and FFA-based imaging identified macular involvement associated with advanced stages of the disease and poor vision (12). FFA, however, seems to have underestimated the more advanced stages of macular ischaemia, as described in more recent modalities.

Assessment using OCT showed cystoid macular oedema in 44.8% of eyes, with a mean central subfield thickness of 382 ± 64 µm, indicating clinically significant oedema that may affect vision. Subretinal fluid, thinning of the inner retina, and disorganization of the inner retinal layers are also frequent, showing that the macula has been chronically affected by ischaemia and inflammation. This has also been observed in prior studies, where macular oedema was one of the most common causes of vision loss in Eales disease, and in OCT findings, where there was a strong association between increased retinal thickness and inner retinal disruption and decreased visual acuity. The lower occurrence of epiretinal membranes and vitreomacular traction in this group may indicate that, in most patients, a more dominant role is played by Eales disease-related vascular and ischaemic processes rather than vitreoretinal interface disorders (13).

OCTA deepened the understanding of microvascular compromise at the macular level, showing that in 74.1% of the eyes, there were abnormalities of the FAZ, and deep capillary plexus dropout in 56.9%, which occurred more frequently than in the superficial plexus. Substantial macular ischaemia, especially at the level of the deep capillaries, was indicated by the mean FAZ value of 0.43 ± 0.12 mm² and by the lower vessel density values in both plexuses. Prior studies have shown that, compared with FFA, OCTA has greater sensitivity for detecting macular ischaemia, particularly in the deep capillary plexus. Moreover, these changes often precede or exceed those detectable by FFA (14). The current study's high prevalence of flow voids and perifoveal rarefaction also corroborates OCTA's capacity to document additional ischaemic changes not visible with dye-based angiography. When compared with other modalities, the ischaemia-related changes, particularly enlargement of the FAZ and deep capillary plexus dropout on OCTA, were most strongly correlated with vision loss. The lowest mean visual acuity was found in eyes with deep capillary plexus dropout, which was 0.74 ± 0.34 logMAR, and almost 79% of the eyes had visual acuity worse than 0.5 logMAR. The previously mentioned research strengthens the theory that microvascular compromise, rather than oedema alone, is a critical factor in visual prognosis in Eales disease. According to the cited study (15), similar correlations can be drawn between Eales disease's ischaemic parameters and diminished visual acuity. Though Eales' disease's vision-reducing complications included macular oedema and leakage, the researchers ranked their adverse effects as less significant than those of the ischaemic changes. The research suggests that Eales' disease demonstrates the complementarity of FFA, OCT, and OCTA in understanding its macular involvement. Eales' disease macular oedema and active vasculitis contribute to leakage; however, FFA is the only modality that measures microvascular damage, and OCTA supersedes the other modalities in

identifying microvascular damage and macular ischaemia. As in other research, the OCTA was once again valuable in identifying threatening macular ischaemia that could be detrimental to vision, providing data for prognosis and management changes.

Conclusion

It is concluded that macular involvement is a common and clinically significant feature of Eales disease and contributes substantially to visual impairment. Multimodal imaging revealed that fundus fluorescein angiography effectively identifies macular leakage and active vascular changes, and optical coherence tomography accurately detects and quantifies structural macular abnormalities such as macular edema and inner retinal damage. In contrast, optical coherence tomography angiography demonstrates superior sensitivity for detecting macular ischemia, particularly in the deep capillary plexus.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-MMNCS-0331d-24)

Consent for publication

Approved

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Conflict of interest

The authors declared no conflict of interest.

Author Contribution

SN, TA

Contributed to study design, data collection, and initial manuscript drafting

Assisted in data acquisition, literature review, and manuscript editing

Performed statistical analysis and contributed to the interpretation of results

Helped in methodology development, data organization, and manuscript formatting

SA, UR, SS, MA

Contributed to patient recruitment, data entry, and results compilation

Assisted in referencing, proofreading, and final revisions of the manuscript

Guided study execution and critically reviewed the manuscript

Supervised the research, coordinated among authors, finalized the manuscript, and approved the final version

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the study's integrity.

References

1. Rajurkar K, Thakar M, Gupta P, Rastogi A. Comparison of fundus fluorescein angiography, optical coherence tomography, and optical coherence tomography angiography features of macular changes in Eales disease: a case series. *J Ophthalmic Inflamm Infect*. 2020;10(1):34. https://doi.org/10.1186/s12348-020-00220-4

2. Goel N, Kumar V, Arora S, Jain P, Ghosh B. Spectral domain optical coherence tomography evaluation of macular changes in Eales disease. *Indian J Ophthalmol*. 2018;66(3):433-438. https://doi.org/10.4103/ijo.IJO_845_17

3. Ong SS, Cummings TJ, Vajzovic L, Mruthyunjaya P, Toth CA. Comparison of optical coherence tomography with fundus photographs, fluorescein angiography, and histopathologic analysis in assessing Coats disease. *JAMA Ophthalmol*. 2019;137(2):176-183. https://doi.org/10.1001/jamaophthalmol.2018.5654

4. Peres MB, Kato RT, Kniggendorf VF, Cole ED, Onal S, Torres E, et al. Comparison of optical coherence tomography angiography and fluorescein angiography for the identification of retinal vascular changes in eyes with diabetic macular edema. *Ophthalmic Surg Lasers Imaging Retina*. 2016;47(11):1013-1019. https://doi.org/10.3928/23258160-20161031-05

5. Nakamura K, Akiyama H, Tokui S, Saito K, Nitta K. A case of Eales disease observed by widefield optical coherence tomography angiography. *Retin Cases Brief Rep*. 2024;18(1):116-119. https://doi.org/10.1097/ICB.0000000000001564

6. Abbas SR, Elfayoumi MA, Tabl AA, Zaher AMM. Comparison between optical coherence tomography angiography and fundus fluorescein angiography in cases of diabetic maculopathy. *Benha J Appl Sci*. 2021;6(4):289-295. https://doi.org/10.21608/bjas.2021.197979

7. Thakar M, Muang O, Dutta P, Sharma B. Evaluation of changes in mean choroidal thickness before and after treatment with steroids and laser photocoagulation in patients with Eales' disease. *Int J Retina Vitreous*. 2025;11(1):117. https://doi.org/10.1186/s40942-025-00731-z

8. Shen X, Zhou T, Sun Z, Zheng Y, Lin B, Huang Y. Trends in application of fundus fluorescein angiography in fundus diseases during a recent ten-year period. *Photodiagnosis Photodyn Ther*. 2024;46:104029. https://doi.org/10.1016/j.pdpdt.2024.104029

9. Alyousif NA, Alsalamah AK, Nowilaty SR, Al-Dhibi H. Optical coherence tomography angiography features of macular epiretinal neovascularization in Eales' disease: a case report. *J Ophthalmic Inflamm Infect*. 2022;12(1):16. https://doi.org/10.1186/s12348-022-00289-z

10. Murillo López S, Medina Medina S, Murillo López F. Eales' disease: epidemiology, diagnostic and therapeutic concepts. *Int J Retina Vitreous*. 2022;8:3. https://doi.org/10.1186/s40942-021-00354-0

11. Low CX, Mohamed SO, Zahari M. Eales' disease with secondary Coats'-like reaction: a case report. *BMC Ophthalmol*. 2024;24(1):420. https://doi.org/10.1186/s12886-024-03668-3

12. Ossewaarde-van Norel J, Camfferman LP, Rothova A. Discrepancies between fluorescein angiography and optical coherence tomography in macular edema in uveitis. *Am J Ophthalmol*. 2012;154(2):233-239. https://doi.org/10.1016/j.ajo.2012.02.003

13. Mercuț MF, Ică OM, Tănasie CA, Mercuț R, Mocanu CL, Nicolcescu AM, et al. A multidisciplinary approach to the management of Eales disease: a case report and review of the literature. *J Pers Med*. 2024;14(3):235. https://doi.org/10.3390/jpm14030235

14. Biswas J, Reesha KR, Pal B, Gondhale HP, Kharel R. Long-term outcomes of a large cohort of patients with Eales' disease. *Ocul Immunol Inflamm*. 2018;26(6):870-876. https://doi.org/10.1080/09273948.2017.1298817

15. Zhao XY, Cheng SY, Zhang WF, Meng LH, Chen YX. Clinical characteristics of Eales disease and the efficacy of different interventions for neovascular complications. *Retina*. 2022;42(10):1975-1988. https://doi.org/10.1097/IAE.0000000000003534

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