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ORIGINAL ARTICLE

Assessment of Choroidal Neovascular Membrane by Optical Coherence Tomography Angiography

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Abstract

Background: **As an alternative to invasive fundus fluorescein angiography (FFA), Optical coherence tomography angiography (OCT-A) can be used to scan chorio-retinal vasculature.**

Aim: **Research OCT-A for sings of choroidal neovascularization (CNV) and its unique structure. To detect any current CNV activity, OCT-A can be used. Determine the sensitivity of OCT-A for detecting CNV activity and compare it with FFA and spectral-domain optical coherence tomography (SD-OCT).**

Patients and methods: **Thirty eyes with various sources of CNV diagnosis were enrolled in this prospective study to compare OCT-A, SD-OCT and FFA. The study was conducted at Al-Azhar University Hospitals and Tanta Ophthalmology Hospital Egypt.**

Results: **Clinically, OCT-A shows the active state was linked to the presence of characteristics such as a sea-fan or medusa-shaped lesion, extensive branching, and numerous microscopic capillaries, anastomoses or loops and perilesional dark halo in comparison with FFA and SD-OCT, OCT-A provides a reliable tool for detecting CNV.**

Conclusion: **Because of its excellent sensitivity and specificity, OCT-A is a useful technique for diagnosing CNV in individuals with neovascular age-related macular degeneration (nARMD) who have not yet begun treatment. OCT-A could become an alternative to FFA in routine clinical practice.**

Keywords: Choroidal neovascularization, Optical coherence tomography angiography, Fundus fluorescein angiography

1. Introduction

Choroidal neovascularization (CNV) is the development of new blood vessels in the choroid that break in the Bruch's membrane and into the subretinal pigment epithelium (sub-RPE) or subretinal space.[1]

CNV is a common cause of central vision. If scarring and macular atrophy are not addressed, they might cause irreversible vision loss. We need to diagnose it accurately, localize it, and assess its activity level before beginning treatment.[2]

The gold standard for viewing the retinal vasculature has been the invasive technique of fundus fluorescein angiography (FFA). The neovascular network's complexity is revealed by leaking dye.[3]

There are risks involved in the FFA procedure. One to three percent of people experience nausea and vomiting. In 0.008%. Of cases, serious adverse events such as myocardial infarction, anaphylaxis, and even death have been reported. Due to the drug's quick clearance by the kidneys (within 24 h) and the concomitant color change in urine, patients with renal insufficiency are at increased risk for nephrotoxicity after FFA. The microcirculation of the retina and choroid can now be assessed in a painless, noninvasive way with optical coherence tomography angiography (OCT-A). The primary advantages of this method over the more traditional ones are its simplicity, rapidity, and accuracy in representing the retina and choroidal vasculature.[4]

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OCT-A detects blood flow within the vascular structures of the eye by detecting motion contrast among rapidly repeated B-scans to detect erythrocyte movement. The present gold standard, dye testing may be will shortly be replaced by this new technology.[5]

The goal of this study was to investigate the activity of CNV by OCT-A and characterize its structural features and progression. Compare the efficacy of OCTA in detecting to that of other approaches such as with FFA and spectral domain-OCT (SD-OCT).

2. Patients and methods

Thirty eyes of patients suffering from CNV of varying etiologies who visited the outpatient retina clinics at Al-Azhar University Hospital (Cairo, Egypt) and Tanta Ophthalmology Hospital (Gharbia, Egypt) were included in this cross-sectional, nonrandomized, noninterventional study. All participants were given a thorough description of the investigation's aims and methods before they were enrolled. All individuals who participated in the research voluntarily provided written informed consent confirming their agreement to take part.

Inclusion criteria: individuals above the age of 18, those with CNV owing to myopia, ARMD, or other causes, and who have had anti-vascular endothelial growth factor (anti-vascular endothelial growth factor (VEGF)) medication.

Exclusion criteria: patients with diabetic macular edema, macular scar, and macular hole. Diseases and injuries of the optic nerve as optic neuritis, optic atrophy, and glaucoma.

3. Methods

The patients were subjected to: Subjects' best-corrected vision was recorded on LogMAR chart, their anterior segment was examined by using a slit lamp, and their fundi were examined using a slit lamp and a Volk 90D and/or 78D lenses.

Imaging: FFA with a Fluorescein angiography equipment (Topcon Corp, Japan), OCT (Optovue Avanti Corp, United States) on the macula, via a B scan, and OCT-A (Optovue Avanti Corp, United States). Mydriatic eye drops (tropicamide 1%) were administered to dilate the pupils before OCT and OCT-A images could be taken. Scanning zones for OCTA imaging were 6 × 6 mm, with the focal point being the fovea.

Four distinct areas of the retina and choroid were identified with the macula. The superficial capillary plexus (SCP): is located in the innermost layer of the eye between the internal limiting membrane (ILM) and the inner plexiform layer (IPL). The outer nuclear layer (ONL) and the IPL make up the avascular outer retina, which is part of the deep capillary plexus (DCP). 20 mm thick slab of choriocapillaris beginning 10 mm below retinal pigment epithelium (RPE) and Bruch's membrane.

OCT shows disruption in the RPE layer with subretinal fluid, and foveal thickness and will detect the activity of CNV. FFA provides a map of retinal vascular structure and function by highlighting leakage from retinal vessels, hyper fluorescence patch increases in intensity and size, hyper fluorescence drusen, and detect the activity of CNV. OCTA was analyzed by classifying a number of anatomical features thought to be linked to neovascular activity.

3.1. Statistical analysis

Data that was entered into the computer was analyzed using SPSS version 20.0, which was developed by IBM Corp. New York. In addition to the qualitative information for both numerical and percentage breakdowns. Shapiro-Wilk test was used a number of mathematical measures, such as the lowest and highest values, the mean, the standard deviation, the media, along with interquartile range (IQR), were utilized using χ^2test, post-Hoc test, and *t*-test.

4. Results

Table 1.

The present research conducted on 30 eyes of 27 patients who were diagnosed with CNV of different etiologies. From them, 11 (40.7%) cases were males and 16 (59.3%) cases were women with mean age of

Table 1. Distribution age, sex, medical history and side of affection.

	Demographic Data		No. (%)
Cases ($n = 27$)	Age (y)		
	Minimum–maximum		32.0–75.0
	Mean ± SD.		55.96 ± 11.30
	Median (IQR)		60.0 (52.50–63.50)
	Sex	Male	11 (40.7)
		Female	16 (59.3)
	Medical Hx	NAD	14 (51.9%)
		HTN	12 (44.4%)
		Renal Failure on Dialysis	1 (3.7%)
Eyes ($n = 30$)	Right		16 (53.3%)
	Left		14 (46.7%)

IQR, Inter quartile range; SD, Standard deviation.

Table 2. Descriptive analysis of the studied cases according to BCVA (n = 30).

	Minimum–maximum	Mean ± SD.	Median (IQR)
BCVA (Log MAR)	0.20–1.60	0.78 ± 0.34	1.0 (0.50–1.0)

BCVA, best corrected visual acuity; IQR, Inter quartile range; SD, Standard deviation.

Table 3. Descriptive analysis of the studied cases according to optical coherence tomography angiography (n = 30).

Optical coherence tomography angiography	No. (%)
Superficial and deep capillary layers	
Affection of capillary perfusion mostly FAZ	30 (100.0)
Outer retina and choriocapillaris layers	
Absence of vascular branching lesion or anastomoses	10 (33.3)
Vascular branching neovascular membrane	13 (43.3)
Dense glomerular neovascular membrane	7 (23.3)
Active or not	
Inactive	10 (33.3)
Myopic CNV	3 (10.0)
ARMD CNV	7 (23.3)
Active	20 (66.7)
Myopic CNV	6 (20.0)
ARMD CNV	14 (46.7)

Table 4. Comparison of optical coherence tomography angiography features according to activity status.

	Inactive N = 10		Active N = 20		P
Well-defined medusa or a sea-fan-shaped lesion	0	0.0%	15	75.0%	<0.001
Branching and numerous tiny capillaries	0	0.0%	20	100.0%	<0.001
Anastomoses or loops	0	0.0%	19	95.0%	<0.001
Perilesional dark halo	0	0.0%	14	70.0%	<0.001

(55.96 ± 11.30) ranging from 32 to 75 years, regarding medical history of the cases, 14 (51.9%) cases with no abnormality detected and 12 (44.4%) cases with hypertension, and one case with renal failure on dialysis (3.7%). The affected eyes were 16 (53.3%) right eyes and 14 (46.7%) left eyes Table 2.

The Mean ± SD best corrected visual acuity (BCVA) of the studied cases was 0.78 ± 0.34. Ranging from 0.20 to 1.60 with median IQR BCVA was 1.0 (0.50–1.0) Table 3.

This table showed that 30 (100%) cases revealed affection of capillary perfusion mostly foveal avascular zone (FAZ). Of their superficial and deep capillary layers regarding outer retina and choriocapillaris layers, 10 (33.3%) cases had absence of vascular branching lesion or anastomosis. 13 (43.6%) cases had vascular branching neovascular membrane. 7 (23.3%) cases had dense glomerular neovascular membrane. 10 (33.3%) case with inactive (3 cases were myopic CNV 10.0%) and (7 cases were ARMD CNV 23.3%). 20 (66.7%) cases with active (6 cases were myopic CNV 20.0%) and 14 cases were ARMD CNV 46.7%) Table 4.

The presence of a black halo around the lesion and the presence of branching and numerous small capillaries, anastomoses, or loops were significant predictors of clinical activity Table 5.

This table showed that 75% in Well-defined medusa or a sea-fan-shaped lesion, 100% in branching and numerous tiny capillaries, 95% in anastomoses or loops, and 70% in perilesional dark halo. Also, OCT-A specificity in diagnoses of CNV activity is 100% and has high Accuracy rate in in diagnoses of CNV activity 83.33% in Well-defined

Table 5. Agreement (sensitivity, specificity and accuracy) for optical coherence tomography angiography.

Optical coherence tomography angiography	Activity According to Clinical Presentation and Fundus fluorescein angiography and Optical coherence tomography		Sensitivity	Specificity	PPV	NPV	Accuracy
	Inactive (n = 10) No. (%)	Active (n = 20) No. (%)					
Perilesional dark halo							
Absent	10 (100.0)	6 (30.0)	70.0	100.0	100.0	62.50	80.0
Present	0	14 (70.0)					
χ^2 (p)	13.125[a]([FE]P<0.001[a])						
Anastomoses or loops							
Absent	10 (100.0)	1 (5.0)	95.0	100.0	100.0	90.91	96.67
Present	0	19 (95.0)					
χ^2 (p)	25.909*([FE]P<0.001*)						
Branching and numerous tiny capillaries							
Absent	10 (100.0)	0	100.0	100.0	100.0	100.0	100.0
Present	0	20 (100.0)					
χ^2 (p)	30.0[a]([FE]P<0.001[a])						
Well-defined medusa or a sea-fan-shaped lesion							
Absent	10 (100.0)	5 (25.0)	75.0	100.0	100.0	66.67	83.33
Present	0	15 (75.0)					
χ^2 (p)	15.0[a](<0.001[a])						

χ^2: Chi square test FE: Fisher Exact.
P: P value for association between different categories.
[a] Statistically significant at P less than or equal to 0.05.

medusa or a sea-fan-shaped lesion, 100% in branching and numerous tiny capillaries, 96.67% in anastomoses or loops, and 80% in perilesional dark halo.

4.1. Case presentation

Case number (1), female patient 66 years old. She complained drop of vision of Right eye.VA was 1.00 Log MAR Figs. 1–3.

5. Discussion

Thirty eyes with CNV diagnoses from various sources were included in this prospective study using OCT-A, SD-OCT, and FFA. To compare between them in CNV diagnosis. Both the superficial and deep capillary layers of all patients' eyes showed morphological abnormalities on OCT-A, with FAZ being the most prominent.

Well-defined medusa or sea-fan shaped lesions with branching and a large number of numerous tiny capillaries, anastomoses, or loops were shown to have a significant correlation with a perilesional black halo, as shown by both OCT and FFA.

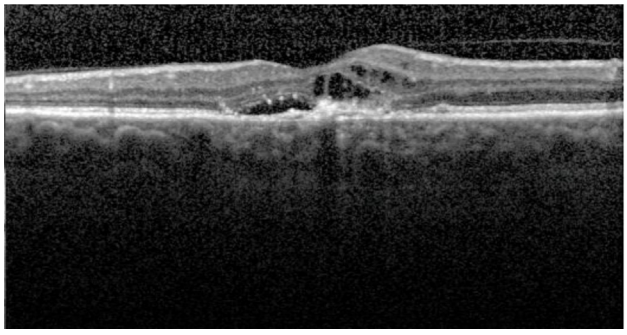

Fig. 2. Optical coherence tomography vertical line scan of the macula showing subfoveal hyper reflective material associated with overlying cystoid macular edema and subretinal fluid collection. Suggestive for active age-related macular degeneration.

A prospective research including 80 eyes with CNV was conducted by Coscas and colleagues To categorize the lesion into active and resting patterns, they used OCTA images of the vascular system. Arborization inside a CNV, as depicted by these researchers, is indicative of a dynamic lesion; the phrases 'lacy wheel' and 'sea fan' were coined to convey this idea. Big, mature vasculature, however, is a telltale sign of a dormant lesion, hence the name 'dead tree' was coined to characterize it.[6]

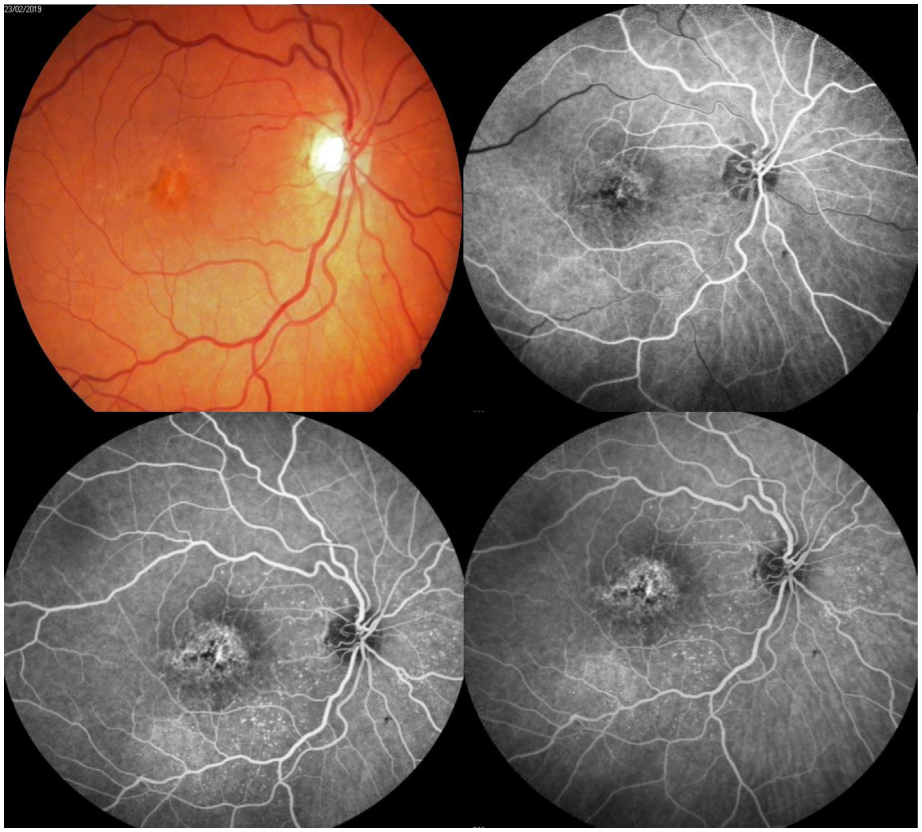

Fig. 1. Fundus photography shows macular lesion. Fundus fluorescein angiography Shows subfoveal small hyper fluorescent lesion (early filling) and increasing hyper fluorescence along phases of angiogram associated with late leakage. Suggestive for active age-related macular degeneration.

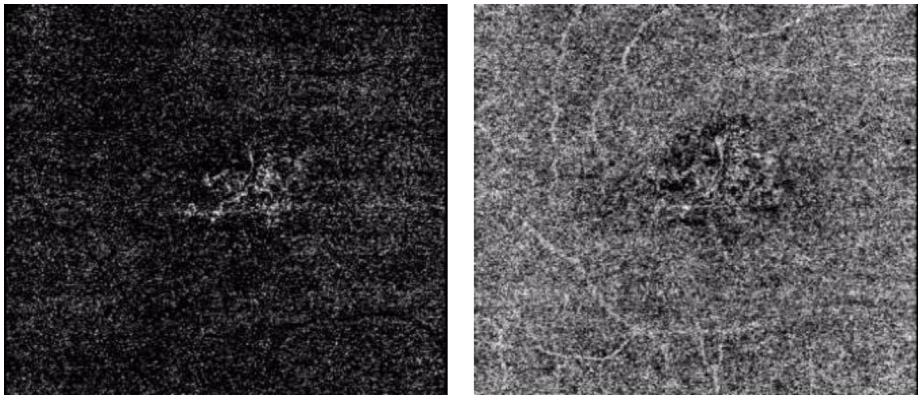

Fig. 3. Optical coherence tomography angiography (6 ×▒ mm) showing sharply defined, dense interlacing neovascular network in both deep retina and choriocapillaris, correspond to active age-related macular degeneration.

El Ameen and colleagues examined a hypothetical sample of 14 eyes with type II CNV using OCTA images to identify distinguishing morphological features. Like to our results, vascular network was characterized by a lesion in the shape of a medusa or glomerulus.[7]

Also, sea fan and medusa patterns were employed by Kuehlewein and colleagues to describe inactive lesions in a prospective cohort of 33 eyes with type I CNV in ARMD. These patterns are characterized by the presence of high caliber adult feeder vasculature and its branches. These finding also, like our finding in patients with AMD, CNV.[8]

Thirty participants were analyzed for FFA 13 eyes (43.3% of the total) showed positive results. Nine (30%) eyes showed an enlarged, brighter subfoveal hyper fluorescence area. Three (16.7%) eyes showed drusen with perifoveal hyper fluorescence. Three (16.7%) eyes did not receive FFA, and the juxtafoveal hyper fluorescence patch grew in size and intensity. Given that FFA in type one CNV had unclear borders and hyper fluorescence often appeared in the later minutes of the angiography.

Of the cases examined by OCT, 11 (36.7% of the total) showed irregularities that were consistent with subfoveal active ARMD CNV, 10 (33%) showed drusen, 5 (16.7% of the total) showed irregularities that were consistent with subfoveal active myopia, and 4 (13.6%) showed irregularities that were consistent with juxtafoveal active ARMD CNV. FFA confirms the presence of 16 active instances, whereas OCTA and OCT produce consistent results showing 20 active cases.

In a study including 44 eyes diagnosed with AMD, Abdel Aziz *et al*. observed that OCT-A had good specificity and sensitivity in detecting vascular lesions in cases of neovascular ARMD. Twenty-four (54.50%) eyes were classified as having dry ARMD due to the absence of exudative changes, while 20 (45.50%) eyes were classified as having neovascular ARMD due to the presence of at least one criterion of activity on SD-OCT. Contrary to our findings, drusen were the most frequently observed macular finding on SD-OCT, occurring in 61.4% of the eyes studied. This was followed by Pigment epithelium detachment at 29.5%, Neurosensory detachment at 27.3%, Geographic atrophy at 13.6%, and cystoid macular edema at 6.8%. Contrary to our findings, OCT-A showed that 28 eyes were negative while 16 eyes were positive (pattern I).[9]

In this study, OCT-A was found to have a good degree of accuracy, sensitivity, specificity, and positive predictive value in identifying both dynamic and static subretinal fluid and macular edema. OCT-A was found to have a sensitivity of 50% and a specificity of 91% for detecting CNV associated with nARMD by De Carlo *et al*.[10]

In a retrospective investigation, the sensitivity and specificity of various imaging modalities for detecting CNV were compared using masked graders. Researchers found that although FFA was just 74.5% sensitive and 82.3% specific, OCT-A was 85.6% sensitive and 81.5% specific. The detection rate went up to 92.7% when FFA and SD-OCT were used combined Souedan *et al*.[11]

The current study revealed that, 67% had branching and many tiny capillaries, 63% had anastomoses or loops, and 47% had a perilesional black halo. Clinical activity was strongly linked to medusa- or sea-fan-shaped lesions that were well-defined, had numerous tiny capillaries, anastomoses, or loops, and a perilesional black halo.

These findings show that branching and many tiny capillaries have high accuracy, sensitivity, specificity, and positive predictive value for detecting active CNV.

Ong *et al*. demonstrated that OCTA can identify the main trunk of active CNV, which is comprised of many small capillaries, vascular loops, and anastomoses. However, OCTA revealed that the quiescent CNV lacked microvessels, vascular loops, and anastomoses.[12]

Fossataro *et al*[13] identified OCTA to be a potentially beneficial and essential tool for analyzing dark halo in nAMD due to its ability to visualize the areas of diminished vessel density around MNV more clearly. The black halo around CNV as seen by OCTA shifted after anti-VEGF therapy.[14]

The results presented are consistent with those found by Souied and colleagues medusa-shaped complex or a glomerulus-shaped lesion may indicate the presence of a neovascular membrane between the outer retina and the choriocapillaris layer.[15]

OCTA has some limits to its applicability. One of them is the confined viewing area. Furthermore, projection artifact from superficial vessels is not properly adjusted for when imaging deeper layers El-Nawawy *et al*.[16] The necessity for additional intravitreal injections can be determined with this potent innovative method for assessing CNV existence and activity.[17]

The short sample size, the inability to compare OCT-A and SD-OCT, and the intrinsic artifacts and operator dependency of OCT-A all work against the validity of our results. Larger, more rigorously controlled studies in the future would provide additional support.

5.1. Conclusion

When it came to identifying CNV activity, there was substantial concordance among SD-OCT and OCT-A findings. Shadowing, segmentation artifacts, and insufficient vascular flow were just some of the difficulties that hampered its usefulness. The outcomes of OCT were correctly predicted 100% of the time by OCTA, with a perfect (100%) sensitivity, specificity, and accuracy.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

Conflicts of interest

The authors declared that there were NO conflicts of Interest.

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