OCT Angiography – A Perspective Based on 3 Years of Clinical Application

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Abstract

Optical Coherence Tomography Angiography is a new technique for non-invasive, dyeless angiography. It gives flow information of retinal and choroidal vasculature. It’s utility in diagnosing and monitoring various retino-choroidal vascular pathologies especially CNV (choroidal neovascular membranes) has been well established in a number of studies. A few clinical cases are discussed herein which highlight different aspects of OCT-A guided clinical management. It is of importance to understand the imaging characteristics and artifacts on OCT-A before adopting it as the primary angiographic modality. As always clinical correlation with history and other imaging modalities like OCT must be done before deciding ‘which vessels to treat’.

Keywords: OCT angiography, OCT, Choroidal neovascularisation, Fluorescein angiography, Indocyanine green angiography

OCT Angiography (OCT-A) is a revolutionary, relatively new technology that is fast changing the way we diagnose and follow up cases that usually necessitate invasive angiography. A technique for ‘dyeless angiography’, OCT angiography is based is on the principle that in a stationary eye the only movement is due to the flow of blood cells within vessels. OCT angiography detects this movement by capturing rapid, successive scans of the same location. These scans are then compared using various decorrelation algorithms and an angiogram is generated based on these flow signals. Areas of very rapid and very slow flow may not be detected depending on the preset cutoff values. Not only does it avert the risks and side effects of injectable dyes, it also provides us information about blood flow in different layers of the retina as well as the choriocapillaris and choroidal vessels (Figure 1).

From an experimental tool, OCT angiography has rapidly evolved to a primary diagnostic modality. We find OCT...
angiography to be useful when managing several retinal pathologies, the foremost being choroidal neovascular membranes. For some etiologies, like idiopathic choroidal neovascular membranes, we have found the pick up rate of OCT-A 100%\(^3\) when compared to FFA (fundus fluorescein angiography) and ICGA (indocyanine green angiography). In such cases we find that we are fast switching to using only OCT-A as the primary diagnostic technique, thus obviating the need for invasive investigations.

However, caution needs to be exercised while interpreting an OCT angiogram. Automated segmentation to detect flow in different layers may not be reliable when the normal contours of the retina are disturbed as may be the case in the presence of significant subretinal fluid or a large pigment epithelial detachment. Additionally, visualization of the retinal vasculature may be significantly hampered in the afore-mentioned situations. Projection artifacts\(^4\) may arise where reflection of the optical signals of the larger blood vessels (in superficial retina) from the pigment epithelium creates a ghost image of the superficial vessels even in images segmented at the level of deeper retina. A sound knowledge of these artifacts and several others is essential to avoid any misinterpretation.

A few cases are discussed to highlight the utility of OCTA.

**Case Series 1 – ‘Simplifying Diagnosis’**

A 24 year old female presented to us with complaints of a paracentral scotoma like sensation associated with metamorphopsia in the left eye for the past two weeks. On examination, unaided visual acuity in both eyes was 6/6, however fundus examination of the left eye revealed a hypopigmented spot close to the macula (Figure 2). OCT-A (DRI OCT Triton, Topcon, Japan) of the lesion revealed a well-defined vascular network in the deep retina which was diagnosed as idiopathic CNVM. The membrane was clearly visible on OCT-A, obviating the need to perform a dye based angiography. Patient was prescribed a single dose of intra-vitreal anti-VEGF. Follow up OCTA after 4 weeks revealed marked resolution (network of individual vessels not identifiable with >50% reduction in size of visible membrane; grading of resolution proposed by authors).\(^5\) Patient maintained visual acuity with resolution of subjective symptoms.

Another case is that of a known glaucoma patient with a stable course in terms of IOP control and visual fields presenting with recent diminution of vision in both eyes. A clinical examination revealed the presence of parafoveal telangiectasia (PFT) with a cream coloured membrane suggestive of CNV in both eyes (Figure 3). OCT Angiography confirmed the parafoveal telangiectasia in the superficial and deep retinal vascular plexus and also revealed the presence of a well-defined CNV in both eyes. Thus a single investigation in cases of PFT helps in distinguishing vascular pathology at various levels of the retina itself. Patient was advised an intra-vitreal anti-VEGF in both eyes (right followed by the left). OCT angiography revealed marked resolution in both eyes after a 4 week follow up.

**Case Series 2 – ‘When to Inject?’**

In some cases OCT angiography may take a leap ahead of traditional angiography techniques and detect pre-clinical diseases. While this may encourage us to maintain a closer follow-up, it certainly creates a clinical dilemma in some situations. At present it is not very clear whether we should inject intra-vitreal anti-VEGF agents for every sub-clinical membrane picked up on OCT-A.

In a previous case studied and reported by the authors (currently under review), a young male with Best disease presented with diminution of vision in the left eye which showed a well-defined vascular network on OCT-A in the same eye and FFA findings corroborating the diagnosis of a CNV. However the history revealed stable vision in this eye since the past three months with no metamorphopsia, thus we decided to maintain the patient on close follow up. At two weeks, the membrane and vision in the left was stable. However, remarkably, there was now a well-defined branching vascular network visible on OCT-A in the right eye which was not there in the scans done 2 weeks back. There was no definite clinical evidence of CNV in the right eye and no drop in visual acuity. This was a novel situation and a literature search did not help our indecision. The patient was advised to review after further two weeks. However the patient reported back within a week due to sudden diminution of vision in the right eye. On evaluation

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**Figure 2:** Fundus photograph at presentation (A) showing a hypopigmented lesion infero-temporal to fovea. SS-OCT (B) showing a hyper-reflective lesion but no subretinal or intra-retinal fluid. OCT-A at presentation (C) reveals a vascular network in the outer retina which decreased in size post anti-VEGF injection (D). Insets in figures (C) and (D) show the level of segmentation of OCT-A. The B-mode OCT in the insets also shows an area of abnormal flow in outer retina corresponding to the presence of a CNV.
of the fundus we concluded that the CNV previously noted had bled. OCT angiography showed that the branching vascular network had increased in size in the right eye while the left eye still maintained stability. Here we see a patient with bilateral disease with similar imaging characteristics in both eyes. Where one eye showed increased clinical activity and bled within weeks of appearance the other eye maintained quiescence in the entire duration of follow up.

We infer from this case that a documented new CNV on OCT-A which was not there earlier should not be neglected. On the other hand a neovascular membrane in a stable patient with no visual symptoms or metamorphopsia and absence of other signs of activity on OCT and fundus imaging may be followed up closely.

In another case, a 42 year old woman presented to us with sudden diminution of vision in the right eye. Visual acuity was recorded as finger counting close to face and the fundus showed a massive sub-retinal bleed in the right eye (Figure 4). At this first visit OCT-A could not be captured owing to poor image quality due to the bleed. The patient underwent intra-vitreal injection of SF6, Avastin and tPA in the right eye followed by prone positioning. Visual acuity two days after the injection improved to 6/24. The OCT-A at follow up visits revealed a branching network of vessels in the eye but no associated subretinal fluid. The patient was advised a repeat intra-vitreal injection of anti-VEGF when the vessels were first identified and visual acuity further improved to 6/12p. However, the vascular network persisted on OCT-A despite the injection and evolved into a dead tree pattern with no associated fluid on OCT. Due to the absence of fluid and stability of the dead tree network we decided not to intervene further. At 1 year follow up the patient maintained visual acuity despite persistence of the vascular network and has not re-bleed. Thus a dead tree pattern – i.e.

Figure 3: Fundus photograph at presentation (A) showing loss of transparency at the fovea with associated pigmentary changes, right angled branching of vessels towards the macula, pigment clumps and a cream coloured membrane temporal to fovea associated with focal haemorrhage. SSOCT at the same visit (B) showing intraretinal cavitation consistent with the diagnosis of parafouveal telengectasia and an associated area of hyperreflectivity suggestive of type 2 CNV. Fluorescein angiography demonstrating diffuse perifoveal staining (seen in PFT) with temporal leakage increasing in late phase suggestive of a CNVM. OCT-A at superficial retinal (D) and deep retina (E) demonstrating parafouveal telengectatic vessels with the outer retina showing a well defined, compact, highly anastomosing network of vessels diagnosed as CNV.

Figure 4: Fundus photograph (A) and SSOCT (B) at presentation showing a large subretinal bleed. Visual acuity at presentation was counting fingers. 7 weeks after administration of intra-vitreal anti-VEGF, tPA and SF6 combined with prone positioning improved visual acuity to 6/24p, OCT angiography revealed a fine irregular branching vascular network at the fovea (C) and patient was advised repeat anti-VEGF. 3 months after injection of anti-VEGF the visual acuity had improved to 6/12 but the lesion still persisted on OCT-A (D). However, due to the lack of fluid on OCT, we decided to observe the patient.
more well defined vessels which are sparse (not a very dense network) with less anastamosing channels in a case treated with anti-VEGF agents or underlying a disciform scar may not be an indication for repeating anti-VEGF therapy. Such situations are one and plenty in the era of OCT Angiography furthering the debate on ‘When to inject?’

Case Series 3 – ‘Diabetic Retinopathy’

OCT-A holds promise in imaging the diabetic fundus. However, significant advancements are still needed before OCT-A can supersede or even match the utility of fluorescein angiography (FFA). The advantage of OCT-A over FFA is that it differentially shows the vascular alterations in each retinal layer. But, the single most important disadvantage of OCT-A which precludes its widespread use is limitation of its field to a maximum of 12mm. Imaging of the peripheral retina is crucial in diabetic retinopathy and presence of peripheral neovascularization and ischaemic areas has significant implications for the clinical and therapeutic course. The 12 mm OCT-A scan available on DRI OCT Triton (Topcon, Japan) visualizes the macula and disc and disc in a single scan. Significant information can be obtained on the foveal avascular zone, microaneuysms, capillary non-perfusion areas and neovascularization (Figure 5).

Since OCT angiography detects flow only above a preset cutoff value, microaneuysms with slow flow may not be captured. Due to the same reasons, a diffuse leaking capillary bed causing macular edema will not be visualized as opposed to its easy identification on fluorescein angiography. Limitations of field may be overcome by creating a montage or composite of several overlapping 12 mm OCT-A scans. Currently, however, there is no automated software available for doing so. Creation of a manual montage is bound to be a tedious process with only limited benefits. Developments in OCT-Angiography over the past few years has been rapid. In the coming times if wide field OCT-Angiography becomes technologically feasible and software is developed to vary cut off values of flow detection without compromising image quality, need for fluorescein angiography in diabetic retinopathy may become a thing of the past.

Case Series 4 – ‘Assessment of Choroidal Flow - The Dark Areas’

OCT A though a useful noninvasive technology is still evolving in its primitive stages as certain puzzles are yet to be solved. The cause of hypointense/dark areas on OCT-A remains controversial and may be attributed to various causes like shadowing due to blood, fluid or exudates, actual lack of flow or the inability of the OCT-A to pick up a flow rate below the preset decorrelation cutoff. Considering a sample case of choroiditis. The patient concerned is a 45 year old female who presented with sudden onset painless progressive loss of vision. The OCT-A 9 mm scans demonstrated numerous dark spots having irregular margins predominantly scattered over the posterior pole (Figure 6). Following oral steroid therapy for ten days, the number and visibility of the spots decreased rapidly. The cause of these hypointense areas could be any of the aforementioned reasons. Certain authors attribute these focal regions to choriocapillary closure (lack of flow) due to inflammation. But these dark areas disappeared over ten days and it is hard to explain the regeneration or opening up of choriocapillaris so quickly. Another possibility may be the shadowing effect of the overlying fluid/exudates. However, OCT over the lesion failed to localize any neurosensory

Figure 5: (A) 12 mm OCT-A scan demonstrating capillary non-perfusion areas (red asterisks), neovascularization (red solid arrows), microaneuysms (red arrowhead) and an irregular foveal avascular zone. (B) and (C) OCT-A scans of the disc showing neovascularization of the disc.

Figure 6: (A) Late phase fluorescein angiography image (left) of a case of choroiditis showing focal areas of hyperfluorescence corresponding to the active choroiditis lesions over a diffusely hyperfluorescent background. Corresponding Indocyanine green angiography (right) shows the focal hypofluorescent areas corresponding to choroiditis lesions. (B) Corresponding OCT-A image of the posterior pole segmented at the level of choriocapillaris showing dark areas similar to those seen on ICG. (C) Repeat OCT-A done following 10 day therapy with oral steroids shows a marked reduction in these dark areas.
detachment or exudates. We feel that the thin layer of inflammatory cells/exudates at the choriocapillary level might have provided the necessary shadowing effect. Oral steroids caused recovery and hastened the disappearance of these cells/exudates explaining the phenomenon. The hypo areas may also just be slowing of flow which is not detectable by OCTA. Such varied interpretations and inferences of OCTA still require confirmation by histopathology.

In conclusion, we would like to say that although impressive at the first glance, OCT angiography is still an evolving technology. Sound clinical judgement, clinical correlation and caution must be exercised while interpreting OCT angiograms. The retinal physician must have a sound knowledge of all artifacts and should ensure proper image acquisition when using OCT-A as the primary tool to guide patient management. Further studies and clinical experience will help us in tailoring OCT-A based treatment protocols for various retinal pathologies, thus facilitating the transition into an era of comprehensive non-invasive retinal imaging.

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