

Emerging Star in Ophthalmic Imaging Technologies – OCT Angiography

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Optical Coherence Tomography (OCT) angiography has recently been introduced as a novel non-invasive OCT based technique providing three-dimensional high resolution images of vascular and microvascular ocular structures without the need to use intravenous dyes. A relatively narrow angle of view and a lack of information along the timeline are outweighed by the huge advantages of non-invasiveness and three-dimensional information of the depicted areas of interest, as this technique emerges and becomes the new star among ophthalmic imaging techniques.

Keywords

OCT, OCTA, optical coherence tomography, optical coherence tomography angiography, imaging technology, retinal imaging

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Imaging techniques in the diagnostic field of the eye have undergone a tremendous development over the last few decades. Fluorescein angiography (FA) as one of them, has been a key tool in the diagnosis of retinal diseases such as diabetic retinopathy, age-related macular degeneration, artery or vein occlusions, vasculitis and vascular tumours of the retina. Additionally, to FA, choroidal alterations such as vascular occlusions, exudation in uveitic processes or choroidal vascular tumours can be detected with indocyanine angiography (ICGA). Both diagnostic procedures, FA and ICGA, are invasive and can be combined in one sitting. In the last two decades, non-invasive imaging technologies have become increasingly important in the diagnosis of ocular diseases, especially those of the posterior fundus. Among them, the 1991-introduced optical coherence tomography (OCT), holds the pioneer position, enabling non-invasively obtained en-face and cross-sectional scans through the retina or anterior segment with a resolution of up to 6 microns.¹⁻⁵

Based on this technology, the non-invasive OCT angiography (OCTA) has recently been introduced providing high resolution visualisation of vascular structures in three dimensions.^{6,7} From the technical point of view, OCTA can be based on various methods⁸ that, altogether, use motion as a contrast mechanism to visualise the location of moving particles such as blood cells. These can be visualised in retinal or choroidal vessels of the posterior fundus, or, when used for the anterior segment, vessels of the iris. For the first time, this technology non-invasively enables angiographic images of ocular structures without the need to use intravascular fluorescein or indocyanine green as dyes to visualise vascular structures of the eye. The commercially available OCTA devices acquire volume data sets within few seconds and deliver detailed three-dimensional images of the microvasculature of the imaged ocular structures such as retina or choroid.⁹ Thus, microvascular abnormalities of the posterior fundus such as vascular occlusion, microaneurysms, neovascularisations, altered vascular networks or non-perfused areas can successfully and non-invasively be visualised. OCTA has been shown to be feasible in the diagnosis of retinal or choroidal diseases with vascular alterations such as age-related macular degeneration, diabetic retinopathy, arterial or venous vascular occlusion and macular teleangiectasia.¹⁰⁻¹⁶

Additionally, to the advantage of non-invasiveness and high resolution, the depicted vascular alterations can be precisely located within the obtained three-dimensional volume scans which adds information of one dimension (z-axis) compared to invasive two-dimensional FA images. Another aspect of this advantage of three-dimensional volume scans with vascular imaging, is the fact that OCTA is embedded in the standard OCT procedure, making manual overlays between cross sectional OCT scans and – at a different time point obtained – en-face FA images, unnecessary.

Having mentioned those huge advantages, it is fair to say that OCTA also faces noteworthy challenges that should be addressed while this very promising technique will be further developed in the future.

In comparison to FA, OCTA does not provide information over time. This is especially important in the context of the so-called leakage phenomenon of slowly leaking vessels due to various reasons. Leakage becomes visible on FA images after several minutes. OCTA images are obtained within a short time, mainly few seconds, and visualise particles that have to change their location and move with a minimum speed. Therefore, slowly leaking particles cannot be visualised with OCTA. On the other side, due to its high resolution, OCTA may be able to depict alterations of vessel walls indicating leakage, a point of future research.

Another aspect worthy to be mentioned is the relatively narrow angle of view of OCTA images providing information of chosen areas of interest, leaving the necessity to either perform several scans to cover larger areas of interest or clinically pre-screen and then define

areas of interest with the risk of overseeing alterations that are not clinically visible.

Some of the aforementioned challenges are likely to remain due to the post-processing methods of OCTA visualising the moving particles, whereas other issues, such as the angle of view or contrast and resolution will be addressed and improved along with the expected developmental process of this technology.

Given the huge advantages of non-invasively acquired images providing three-dimensional information of vascular and microvascular architecture of the eye, the importance and indication for the use of OCTA will become clearer as more and more studies are being conducted to better evaluate this promising novel imaging technique. □

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