Ultra-widefield OCTA in Clinical Practice: Expanding Insights into the Peripheral Retina. A Review

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SUMMARY

Ultra-widefield optical coherence tomography angiography represents the latest technological advance that significantly expands the possibilities of non-invasive imaging, not only of retinal and choroidal microcirculation. Compared to conventional OCTA, it enables visualization of the peripheral retina, providing a more comprehensive view of the distribution of vascular changes across a wide spectrum of diseases. In clinical practice, this technology may reduce the need for invasive examinations, particularly fluorescein angiography, or contribute to more accurate identification of patients in whom such examination remains necessary.

The aim of this paper is to highlight the clinical application of UWF-OCTA in everyday practice and to demonstrate its benefits based on original imaging material. The study presents typical findings in diabetic retinopathy, central serous chorioretinopathy, pediatric retinal vascular diseases, and vitreoretinal pathologies.

Key words: Ultra-widefield OCTA, peripheral retina, diabetic retinopathy, pediatric ophthalmology, peripheral ischemia

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INTRODUCTION

In recent decades, advances in imaging technology rank among the key factors that have fundamentally influenced the diagnosis and management of retinal pathologies. One of the most significant innovations in this field is optical coherence tomography angiography (OCTA), which enables non-invasive imaging of retinal and choroidal microcirculation without the need to administer a contrast substance. Compared to traditional fluorescein angiography it therefore represents a more sparing and repeatable diagnostic tool, which has progressively become established in everyday clinical practice.

The original use of OCTA was predominantly limited to the region of the posterior pole, which to a certain degree restricted its application in diseases affecting the peripheral parts of the retina. However, it is precisely the retinal periphery that plays a fundamental part in the pathophysiology of several vascular, degenerative and inflammatory ocular pathologies. Technological development has therefore naturally been directed towards extending the field of imaging, and this has led to the creation of ultra-widefield OCTA (UWF-OCTA).

UWF-OCTA thus opens up new possibilities for evaluating peripheral perfusion, detecting ischemic changes and identifying neovascularizations. This procedure is important especially in the case of pathologies where peripheral changes precede or determine the progression of the disease, such as diabetic retinopathy, as well as other vascular or hereditary retinal pathologies.

The application of this technology in pediatric ophthalmology represents a specific chapter. Diagnosis of pathologies such as retinopathy of prematurity (ROP), familial exudative vitreoretinopathy (FEVR), and Coats disease, is frequently limited by the invasiveness of the available diagnostic methods and the need to repeat them. The non-invasive character of OCTA, extended by ultra-widefield imaging, therefore represents a potentially significant benefit precisely for these groups of patients.

At present, an integration of angiographic and structural imaging procedures is taking place, which enables a more comprehensive evaluation of pathological changes. A combination of UWF-OCTA with OCT high-resolution scans provides a detailed view of morphological changes of the retina and vitreous, which is applicable to a broad spectrum of clinical findings – from central serous chorioretinopathy, via inflammatory processes, to retinal tears or retinal detachment.

However, despite rapid technological advances, several questions remain unanswered. The interpretation of findings, especially in peripheral regions, may be influenced by the presence of artefacts and technical limitations, and this places greater demands on the experience of the attending physician. At the same time, it is not entirely clear as to the degree to which UWF-OCTA is able to replace or supplement established imaging methods in a variety of clinical situations. The aim of this study is therefore to present an outline of the possibilities for application of UWF-OCTA in modern ophthalmology for both adult and pediatric patients, to highlight its benefits and limitations, and to illustrate its clinical use in selected cases from everyday practice.

Diabetic retinopathy

Diabetic retinopathy (DR) ranks among the most common causes of visual disorders and blindness in working age, and its progression is closely linked with the scope of retinal ischemia. Traditional imaging methods including fluorescence angiography (FA) enable evaluation of perfusion, but their use is limited by their invasiveness, and in the case of standard protocols also by the scope of the visualized field.

UWF-OCTA enables non-invasive imaging of the microvasculature within an extended range of the retina, including peripheral regions, which play a crucial role in the pathophysiology of the disease. Several studies have indicated that the scope of retinal nonperfusion correlates with the risk of progression of DR and the onset of neovascularizations [1,2].

In the stage of non-proliferative DR (NPDR), UWF-OCTA enables identification of the regions of capillary drop-out, irregularities of the capillary network and reduced vascular density, frequently also outside of the central retina. These changes may be more extensive than indicated by the clinical finding in the macular region, which is significant for a more precise stratification of risk (Figure 1) [2,3].

The significance of UWF-OCTA also consists in the possibility of repeated observation of the dynamics of the pathology without placing a burden on the patient, which is an advantage for example when monitoring the effect of treatment. By contrast with FA, however, OCTA does not provide information about dye leakage, and consequently it is necessary to view these methods as complementary, especially in ambiguous cases [4].

Central serous chorioretinopathy

This pathology is among pachychoroid spectrum diseases, and is characterized by serous detachment of the neuroretina as a consequence of dysfunction of choroidal circulation and the retinal pigment epithelium (RPE). A key role in this is played by permeability of the choroidal vessels and altered choroidal blood flow. UWF-OCTA enables an extension of evaluation of choroidal and retinal microcirculation also beyond the macular region, and this information supplements our observations concerning choroidal dysregulation that is typical of pachychoroid spectrum diseases [7].

UWF-OCTA extends the possibilities of evaluating central serous chorioretinopathy (CSCR), in particular with regard to choroidal circulation and the scope of changes or differential diagnosis, especially in the case of suspected secondary choroidal neovascularization, which may

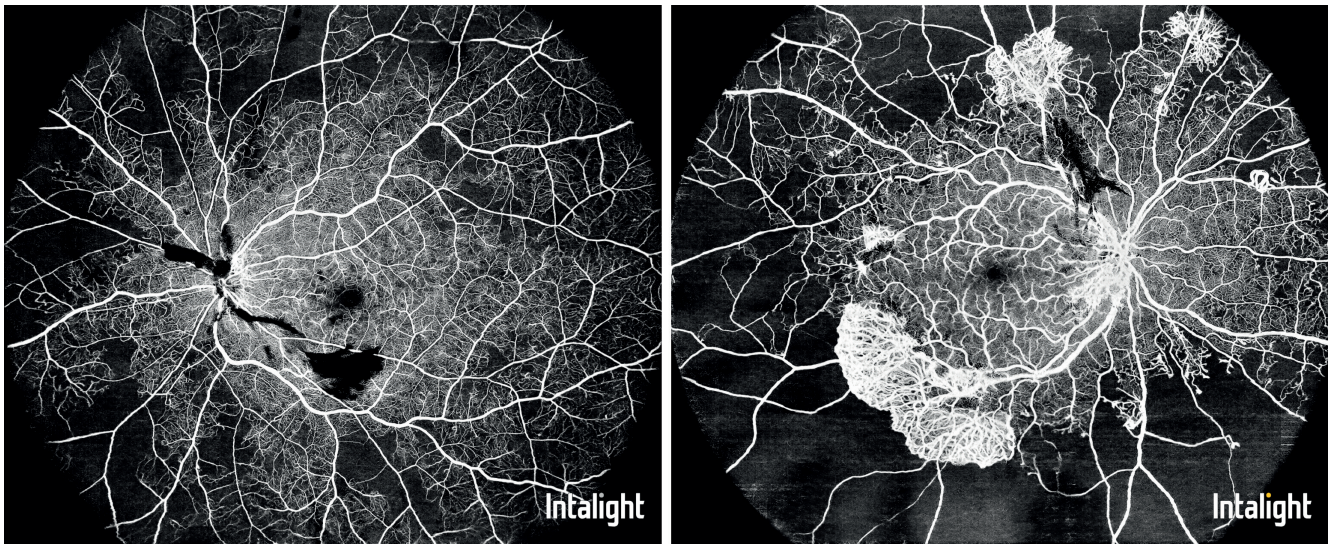

Figure 1. Eyes of patients with proliferative diabetic retinopathy – the UWF-OCTA image shows the extent of both peripheral and central nonperfusion, with signal blockage due to hemorrhage, and numerous neovascularizations

occur in chronic forms of CSCR. New UWF-OCTA instruments offer software implemented tools for quantitative evaluation of vascular changes in the choroid with the aid of modern parameters such as choroidal vascular index (CVI), or choroidal vascular volume (CVV), which are currently considered promising indicators for evaluating the choroidal vasculature [8,9].

Pediatric application

For a long time, the use of OCTA in pediatric ophthalmology was limited especially by the technical demands placed by the examination and the need for cooperation on the part of the pediatric patient. Conventional OCTA systems with a limited visual field provide information primarily about the central retina, which substantially limits their application in the case of pathologies in which crucial changes are visible on the periphery. However, a significant advance has been brought by the development of UWF-OCTA, since it also enables imaging of the far peripheral retina, which is of fundamental importance for the diagnosis and monitoring of a number of pediatric pathologies.

The non-invasive character of the examination represents a significant advantage in comparison with FA, which is associated with the need for intravenous administration of a contrast substance and also with general anesthesia, therefore requiring hospitalization of pediatric patients. The possibility of quick and repeatable examination that places less of a burden on the patient increases the potential of OCTA in the pediatric population, especially in the case of long-term monitoring of the pathology.

In retinopathy of prematurity (ROP), current use in its acute phase is still limited by technical factors. On the other hand, UWF-OCTA can be used on older children after treatment for ROP, where it enables a detailed evaluation of residual vascular changes, the scope of the peripheral avascular zone, and the reorganization of the capillary network. These changes may contribute to a better understanding of the long-term consequences of the pathology, and at the same time enable an evaluation of the effect of the preceding treatment. Within this context, UWF-OCTA may serve as a tool for optimizing future therapeutic strategies (Figure 2).

Familial exudative vitreoretinopathy (FEVR) is a genetically conditioned disease characterized by an abnormal growth of blood vessels in the retina, leading to insufficient vascularization of the retinal periphery and its ischemia [10]. It manifests variable progression, from stable peripheral avascularity to rapid deterioration with neovascularization, traction and retinal detachment, especially in childhood and adolescence. Progression may occur at any time, though most commonly before the age of 20 years; later complications are also possible after a latent period [11,12]. For this reason, long-term observation of patients is of primary importance, especially with the aim of timely detection of progression and indication of treatment (Figure 3).

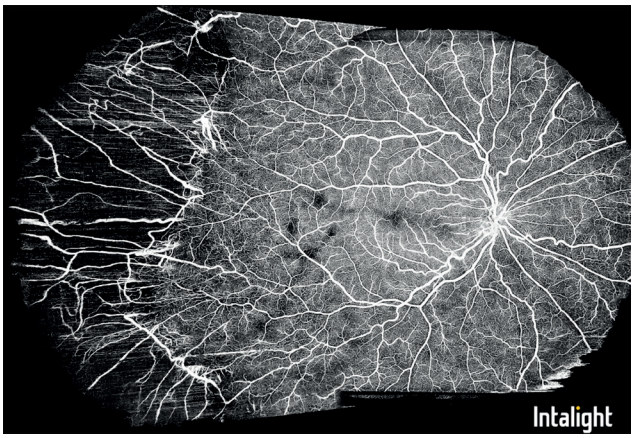

Figure 2. A composite of two UWF-OCTA images reveals old scarring of the peripheral retina with translucent choroidal vessels, treated for retinopathy of prematurity, central localized zones with capillary irregularities, and a small diameter of the foveal avascular zone

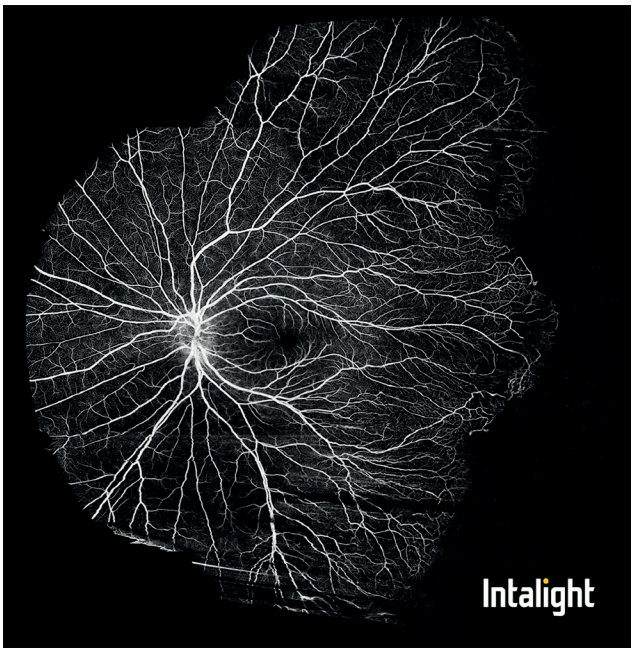

Figure 3. Composite of three images focusing on the inner retinal layers of a patient with familial exudative retinopathy without significant irregularities at the avascular interface

Coats disease is characterized by the presence of telangiectasia, which leads to pronounced hyperpermeability and retinal or subretinal exudation of plasma and lipids [13,14]. UWF-OCTA documents peripheral and central exudates, retinal thickening, or increased vascular flow in the telangiectatic regions in a single scan, also thanks to simultaneous en-face imaging (Figure 4). In some publications, anomalous foveal vascular networks and chorioretinal anastomoses have been described as a reaction to treatment or progression [15]. UWF-OCTA has enabled the description and simple identification of type 3 neovascularization in a subset of patients with macular fibrosis [16].

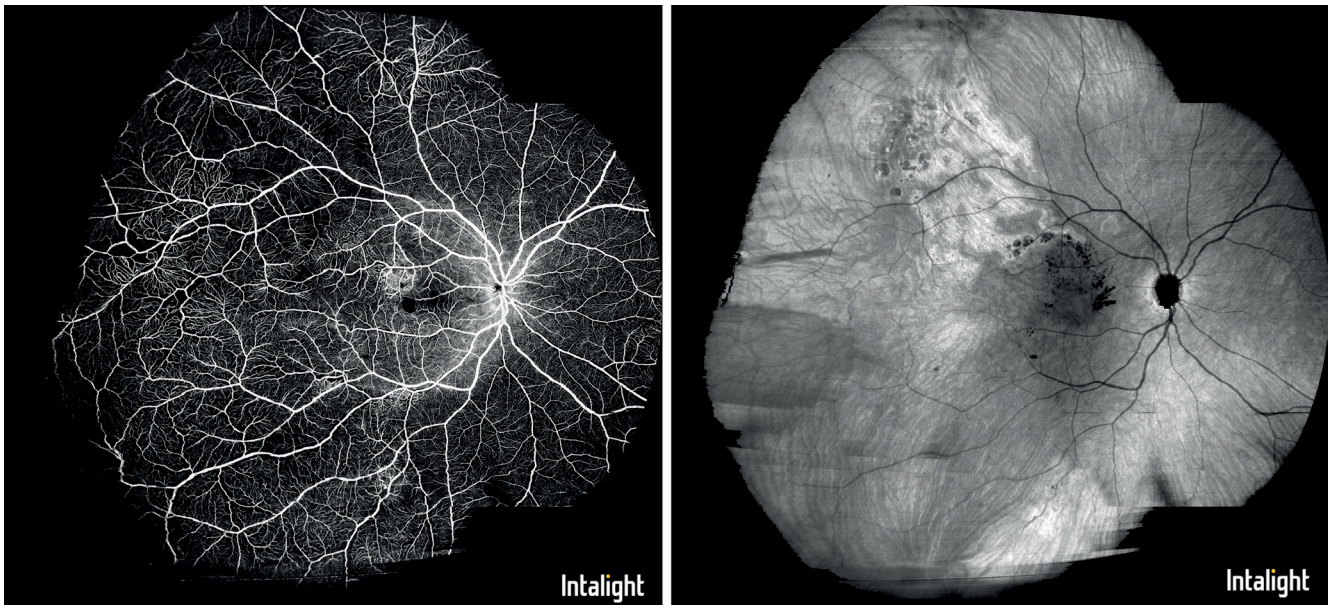

Figure 4. Image montage of a patient with Coats' disease; on OCTA (left), telangiectasias are particularly visible; on the structural en-face image of the outer retinal layers (right), numerous cysts in the macular region and traces of laser treatment are visible temporally above the macula

Peripheral and vitreoretinal findings

UWF-OCTA technologies are not restricted only to evaluating vasculature, but also enable detailed imaging of the peripheral retinal structures and vitreous. In combination with deep structural OCT scans which reach a depth of up to 12 mm, it is possible also to visualize peripheral retinal lesions such as tears, degenerative changes, and incipient retinal detachment, which are virtually inaccessible using standard imaging techniques. At the same time, UWF-OCTA technologies provide information about the condition of the vitreoretinal interface, including the presence of tractions, adhesions, and inflammatory changes in the vitreous, which is important information not only diagnostically, but also in the event of planning surgical procedures (Figure 5). In the case of myopia, especially at higher levels, there is an increased incidence of peripheral degenerations, potentially dangerous tears, or staphylomas, which thanks to the wide scope and markedly deep scanning of UWF-OCTA technologies can now be visualized.

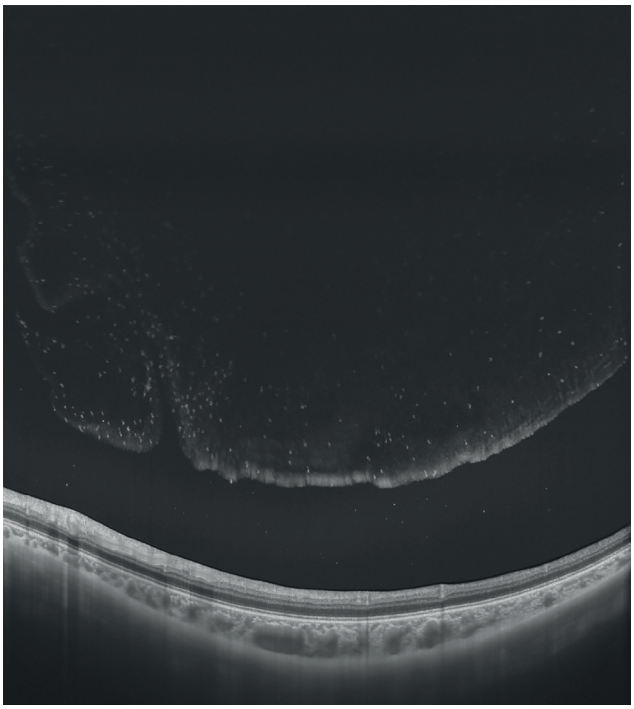

Figure 5. Deep, 12-mm retinal section with highlighted hyperreflectivities in the vitreous cavity of a patient with vitritis

CONCLUSION

In contemporary clinical practice, in which the realization of fluorescein angiography is frequently limited by time or organizational factors, with the consequence that its indication is reduced to essential cases, UWF-OCTA represents a significant benefit. In several situations it enables us to obtain sufficient diagnostic information via a non-invasive method, which may reduce the requirement for performing FA while maintaining the quality of provided care, or contribute to more accurate identification of patients in whom such examination remains necessary.

Ultra-widefield OCTA thus represents a promising tool in modern ophthalmology, which has the potential to significantly influence the approach to the diagnosis and monitoring of pathologies of the retina, vitreous, and choroid, and thereby contribute to a better understanding of their pathophysiology. Despite its indisputable benefit, it remains necessary to view this method within the context of its limitations,

and interpret the findings in combination with other imaging modalities. Further technological development, including improving the quality of imaging the periphery and advanced quantitative analyses may lead to a yet broader application of UWF-OCTA in clinical practice.

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