REVIEW ARTICLE

MODERN DIAGNOSTIC POSSIBILITIES FOR THE ASSESSMENT OF POSTERIOR EYE DISEASES WITH ULTRA-WIDEFIELD IMAGING

Paulina SZABELSKA[1], Justyna MĘDRZYCKA[1], Radosław RÓŻYCKI[1], Joanna GOŁĘBIEWSKA[1]

[1] Department of Ophthalmology, Military Institute of Aviation Medicine, Warsaw, Poland

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Author's address: P. Szabelska, Department of Ophthalmology, Military Institute of Aviation Medicine, Krasińskiego 54/56 Street, 01-755 Warsaw, Poland, email: paulina.szabelska@gmail.com

Abstract: Ultra-widefield retinal imaging is a modern method of imaging the posterior segment of the eye that enables scanning of the entire far periphery of retina. Our study presents the diagnostic possibilities of this technique using Optos California to illustrate pathology anywhere in the retina and provide clinical data from the retinal surface through the choroid.

Keywords: ultra-widefield imaging, UWF, Optomap, fluorescein angiography

INTRODUCTION

Fundus Camera Imaging

Color fundus photography uses a fundus camera to capture images of the posterior segment of the eye to document the presence of abnormalities and observe how they change over the time.

Fundus cameras have been available for tens of years. Traditional devices are made up of a low-power microscope with a camera as an attachment [12]. Lotmar reported that use of a traditional fundus camera made it possible to take a single image of 30-45 degrees of the retina and 96 degrees in mosaic visualizing mode [8].

Angiography techniques

Fundus fluorescein angiography (AF) is a procedure for examining blood flow pattern into the retina and choroid. Fluorescein has a low molecular weight and binds to blood albumins in approximately 80%. Depending on the concentration, it stains from yellow to orange-red.

The diluted solutions absorb light with a peak wavelength of 480 nm (blue) and emit it at a peak wavelength of 530 nm (yellow green). By using appropriate filters, it is possible to separate the exciting light from the emitted light, which is the basis of AF.

In AF, excitation light is introduced into the eye; fluorescence from intrinsic fluorophores is detected using a barrier filter which blocks blue light reflected from the eye, allowing only yellow-green emitted light to pass.

Under normal conditions, fluorescein does not pass through the vessel walls in the retina and central nervous system. The blood–retina barrier prevents fluorescein from diffusing into retinal tissue. However, leaks can be shown in areas where new vessels grow, where there is a lack of a blood–ocular barrier or in regions with blood–ocular barrier defects induced by inflammation or ischemia. Fluorescein leaks easily from the choriocapillaris, staining the surrounding tissue (Figure 1) [3,4,10,13,16].

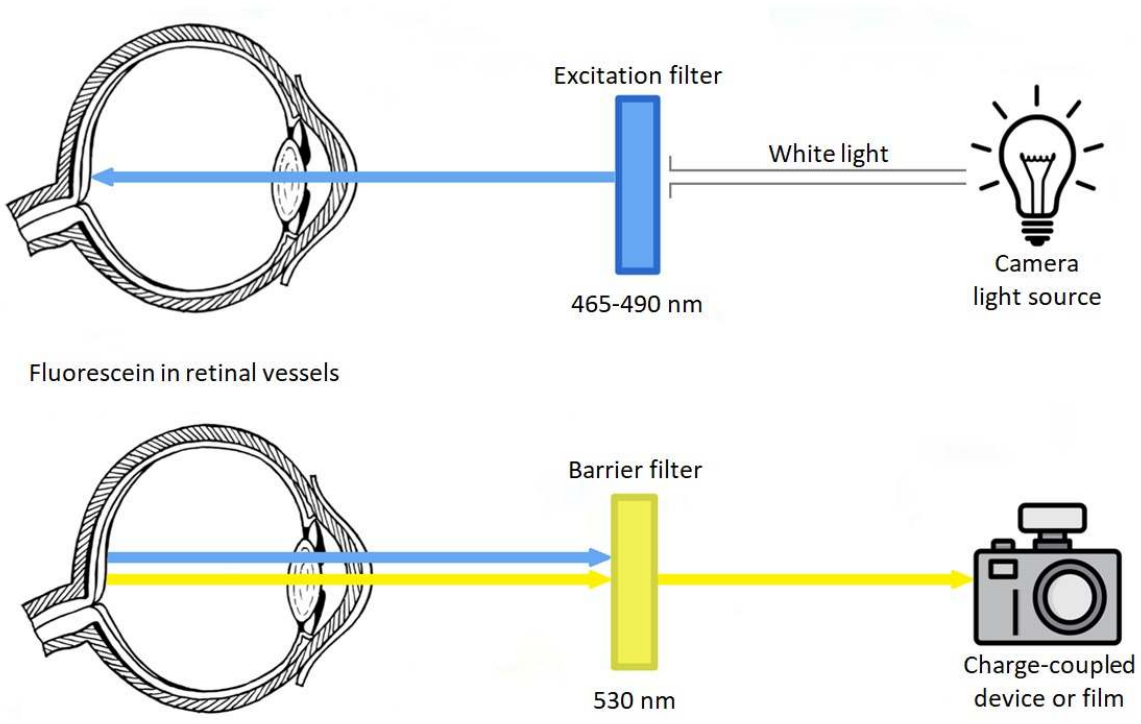

Fig. 1. Principles of AF.

Whilst AF is an excellent method of examining the retinal circulation, it has limited application in assessment of the choroidal vasculature, mainly due to masking by the retinal pigment epithelium (RPE).

Indocyanine green (ICG) is a water-soluble and almost completely protein-bound (98%) after intravenous injection. The intravascular retention of ICG makes it ideal for imaging choroidal vessels. The excitation and emission filters are set at infrared wavelengths and that is why indocyanine green angiography (ICGA) has to be performed using a properly adapted camera (Figure 2). Infrared light is also scattered less than visible light, making ICGA superior to AF in eyes with media opacity. Since the efficacy of ICG fluorescence is low, the practical ICGA method can only be performed with digital sensors [10,13,16]. Technological progress – mainly the introduction of laser techniques – made it possible to visualize the far periphery of the retina also in AF and ICGA [17].

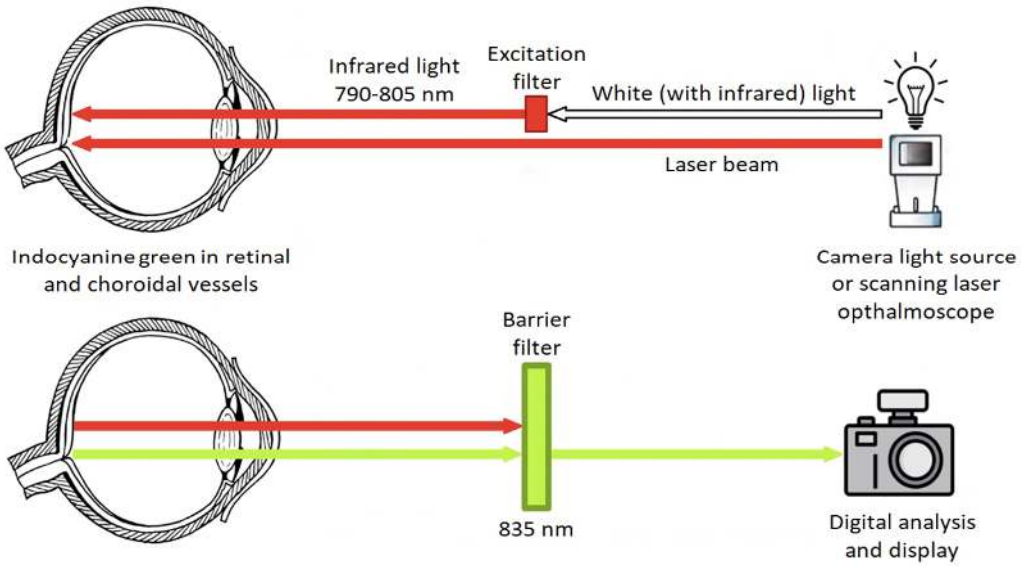

Fig. 2. Principles of ICGA.

METHODS

Our study presents the diagnostic possibilities of Ultra-widefield (UWF) imaging using Optos California to illustrate pathology anywhere in retina in patients referred to Ophthalmology Department of Military Institute of Aviation Medicine in Warsaw, Poland.

Optomap Imaging

Retinal imaging cameras like Optos California use digital image capture, which allows to take a picture and analyze it at the same time. Ultra-widefield fundus imaging is non-invasive and non-contact technique of visualizing the retina based on optical scattering and the pictures can be obtained without mydriasis [9].

A wide-field of view was obtained with a scanning laser ophthalmoscope using an ellipsoidal mirror to obtain images of the retinal periphery. Optomap technology incorporates low-powered laser wavelengths that scan simultaneously. This allows review of the retinal substructures in their individual laser separations:

- green laser (532 nm) scans from the sensory retina to the retinal pigment epithelium (RPE);
- red laser (633 nm) scans from the RPE to the choroid (Figure 3).

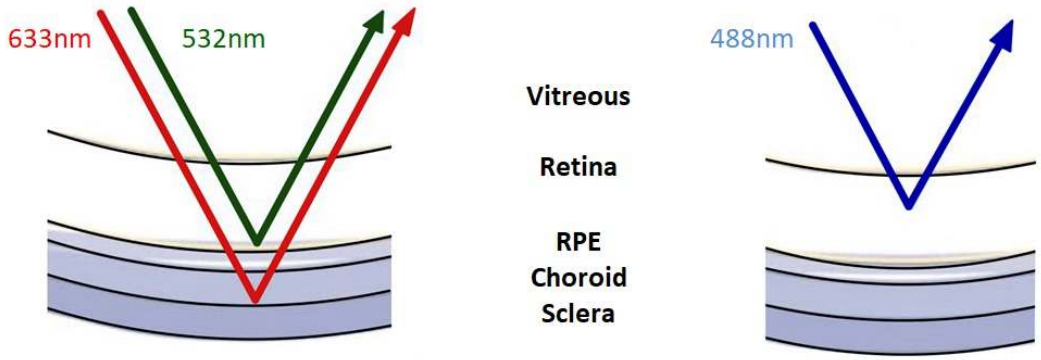

Fig. 3. Red, Green and Blue Scanning Lasers.

The red and green lasers used to capture an Optomap image produce a pseudo-color retinal picture that differs from the "true color" view produced by a traditional fundus camera using a white-light source [6,11,18].

The Optomap UWF imaging method is a unique technology that captures more than 80% of the retinal area in a single picture, while traditional imaging methods typically show 30-45% of retinal area at the same time. California Optos device produces a single 200° image of the retina with unrivaled clarity in less than 1 second and scanning area across the retina and into the far periphery (Figure 4) [10,12].

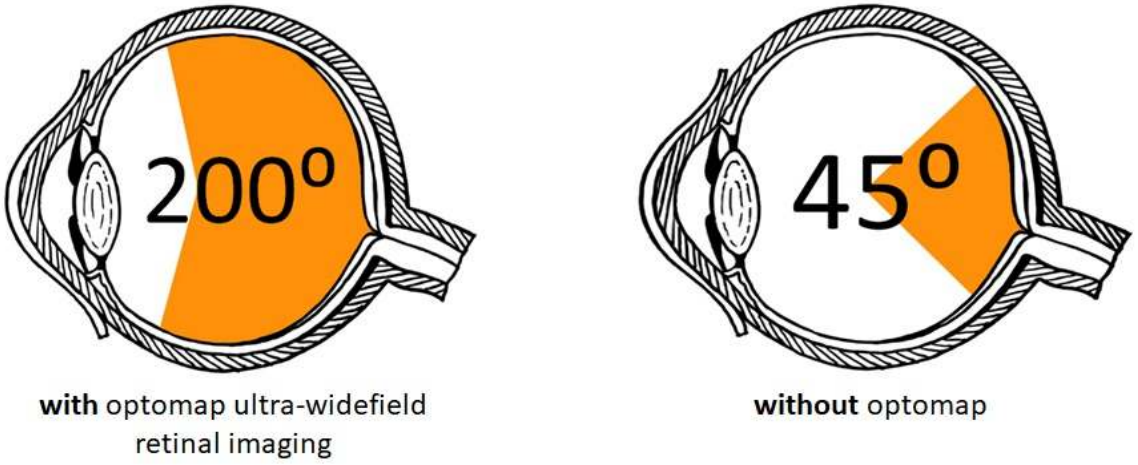

Fig. 4. Retinal imaging with and without an optomap.

Optomap angiography

Ultra-widefield AF (UWF-AF) imaging allows visualization of peripheral ocular lesions that standard AF is unable to detect [19]. In recent years, UWF-AF imaging has been used for clinical examination and can acquire a fundus image covering 200 degrees [5].

The Optos device enables a variety of imaging methods, including autofluorescence and interweaved angiography. It also enables parallel capture of AF and ICGA images without manually switching between imaging modalities [1]. Ultra-wide-angle imaging, including UWF-AF, has already become an indispensable tool in the assessment of peripheral retinal pathology, and may also become the basis for screening and telemedicine. Wide-angle imaging may contribute to the diagnostic and therapeutic management of many retinal vascular disorders by providing additional information to clinicians. Images of the peripheral retina may be taken during routine angiography [17].

RESULTS

UWF imaging is a useful tool for monitoring the development of DR [14]. In DR, lesions can be very distant in the peripheral parts of the retina and may be much easier to document with this method of visualization (Figure 5,6) [15].

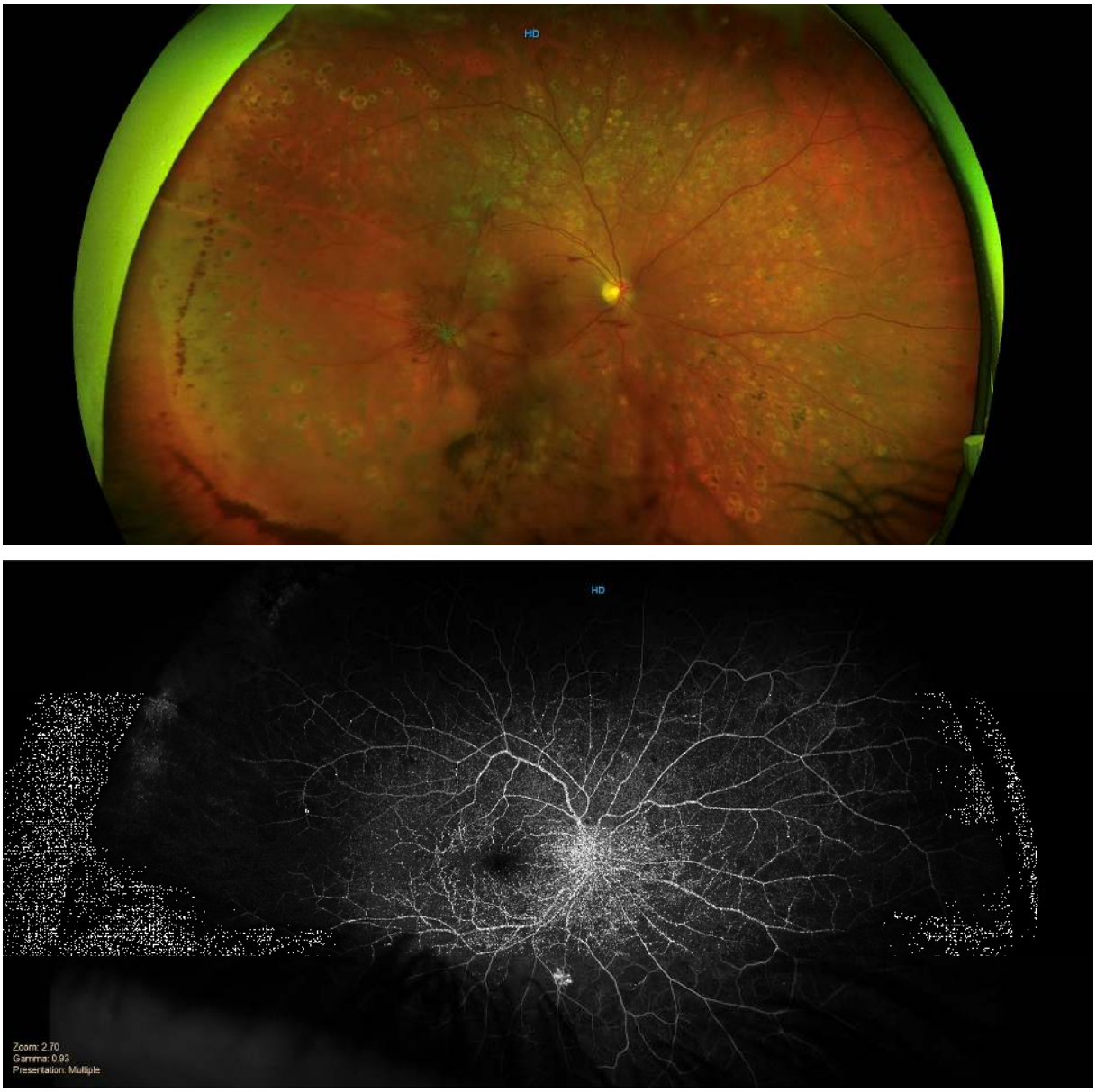

Fig. 5 and 6. Optomap imaging and UWF-AF show extensive areas of retinal ischemia with neovascularization in the lower retina parts.

Some of the uveitis can start in the peripheral parts of the retina. Figures 7 and 8 present a patient with suspected cytomegaloviral retinitis due to acquired immune deficiency syndrome.

The disease usually begins in the peripheral retina and progresses slowly. The right eye presents “flame-like” hemorrhages far in the nasal regions of the retina called “pizza slices”. The left eye presents advanced stage of the disease.

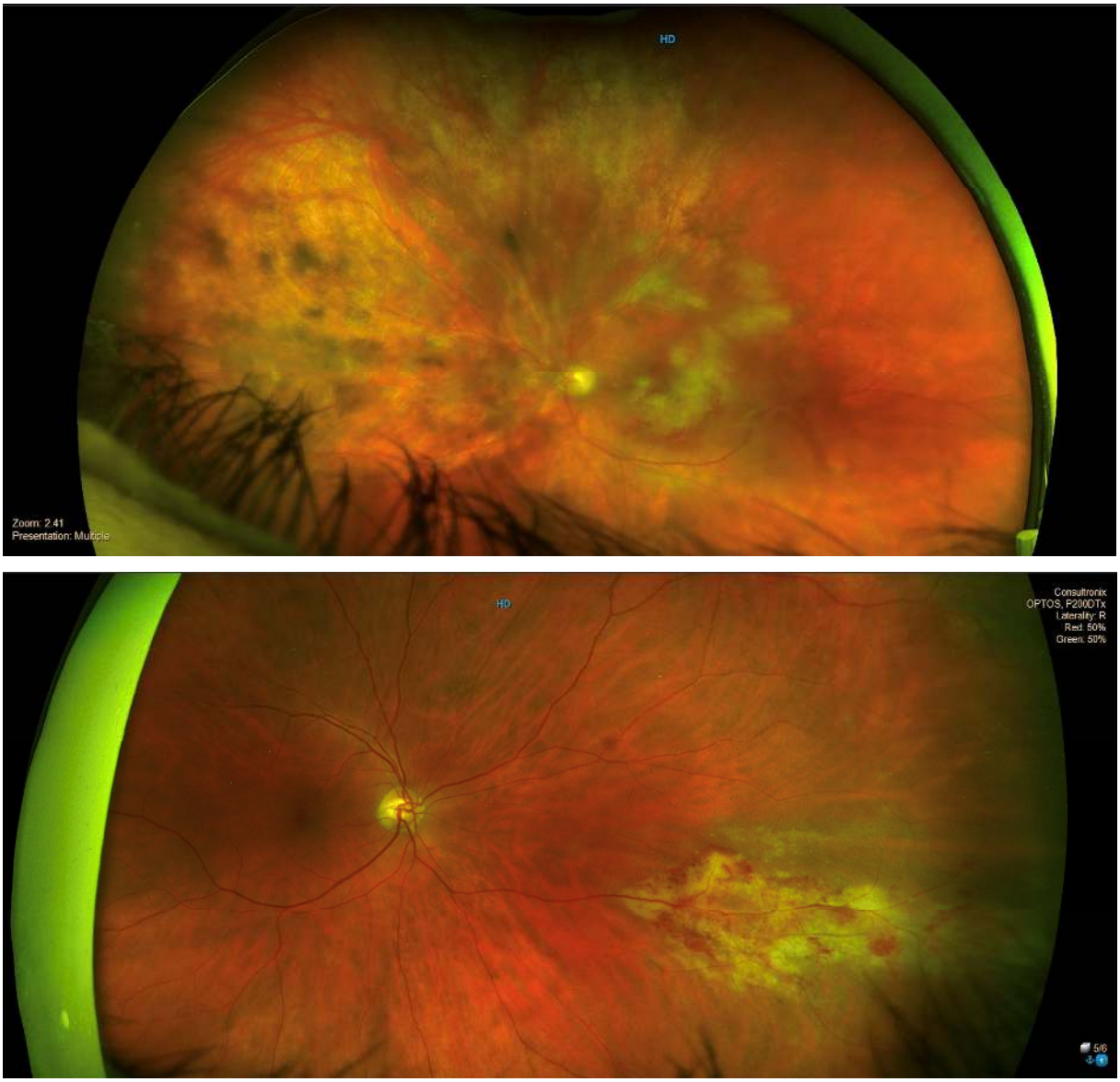

Fig. 7 and 8. UWF imaging - Patient with suspected cytomegaloviral retinitis due to acquired immune deficiency syndrome.

Retinitis pigmentosa (RP), one of photoreceptor dystrophies is a long–term disease that usually develops over several decades. UWF examination reveals the presence of bone spicule-shaped pigment deposits in the mid and far periphery, along with atrophy of the retina. Narrowing of the retinal vessels is observed and the optic disc is moderately pale (Figure 9).

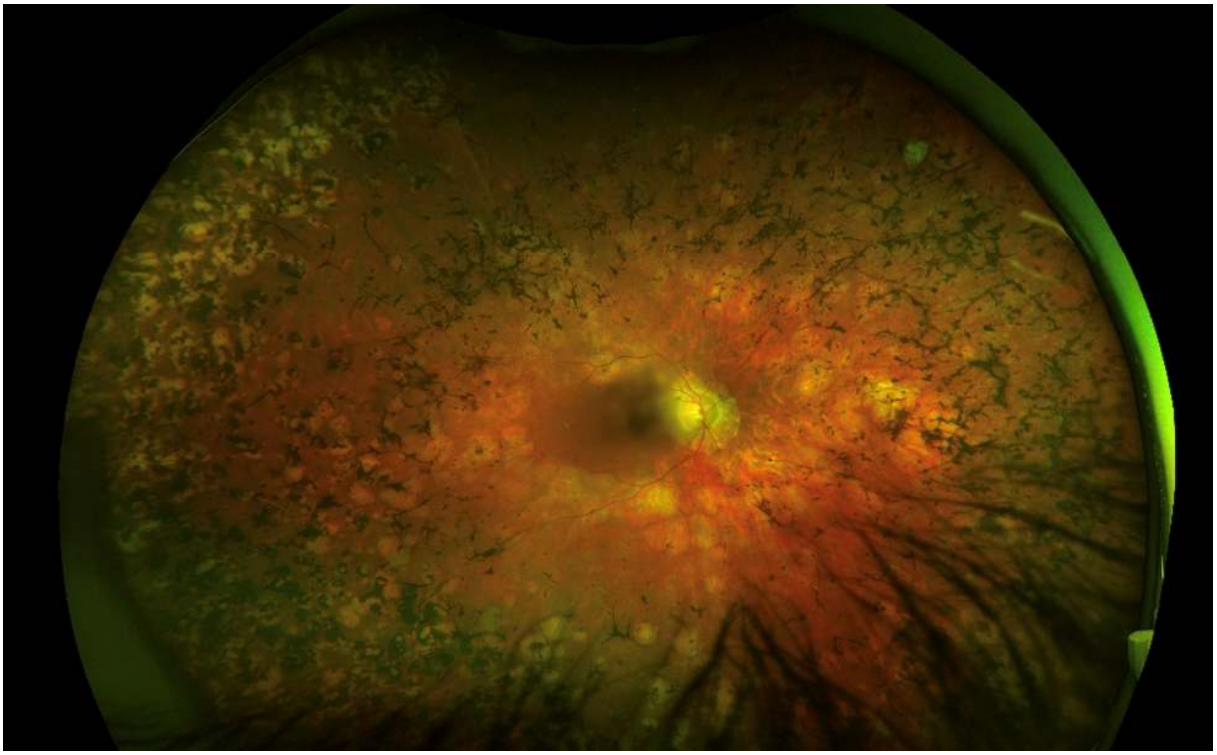

Fig. 9. UWF imaging - Fundus of the patient with retinitis pigmentosa (the end stage of the disease).

DISCUSSION

In order to select the correct type of imaging device, it is important to understand the division of the areas of the retina. Choudhry N. at al. recommended distinguishing the following in the eye fundus: the posterior pole, midperiphery and far periphery. The term "posterior pole" was described as the area of the retina within and slightly beyond the major temporal vascular arcades, captured at an angle of 45-50 degrees [2,8]. This area can be visualized by standard fundus camera imaging without mosaic mode. The term midperiphery may be used to describe the area of the retina extending from the vascular arcades to the posterior edge of the vortex vein ampulla [2]. This retinal region can be viewed with conventional fundus cameras if there is excellent pupil dilation and patient cooperates well when taking images [8]. The term far periphery refers to the region of retina anterior to the vortex vein ampulla. It is possible to visualize it (approx. 110 to 220 degrees zone) using ultra-widefield (UWF) imaging methods [2]. Figure 10. illustrates retinal areas with reference to the Choudhry's publication.

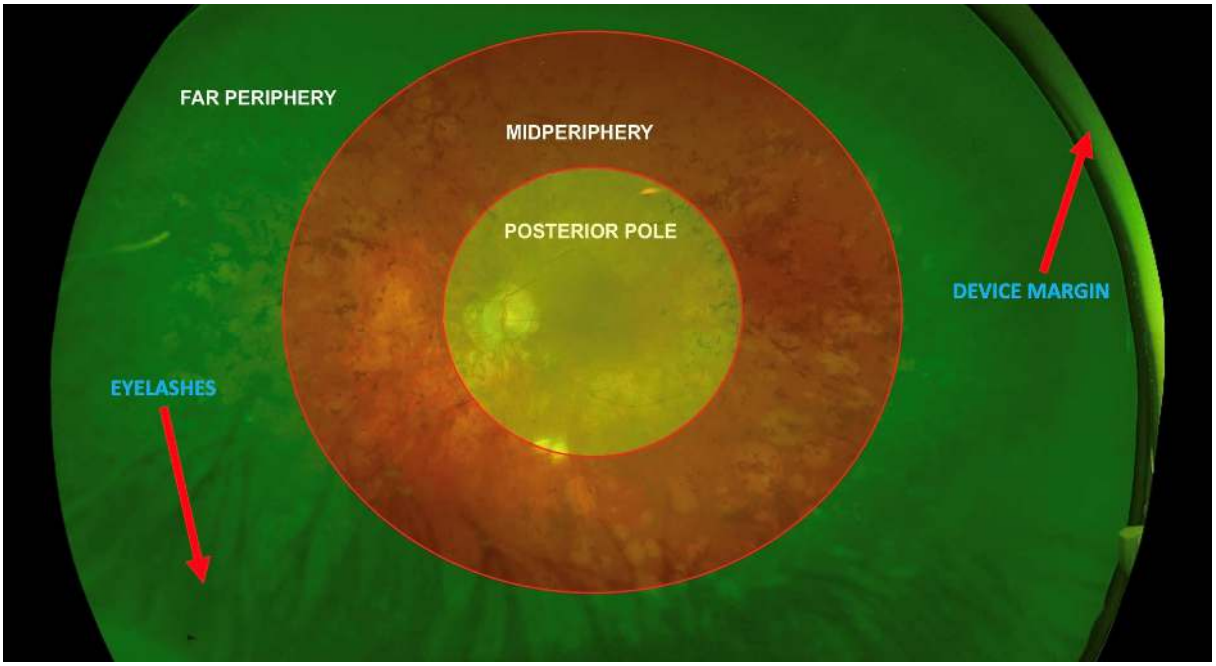

Fig. 10. Fundus of the patient with retinitis pigmentosa with marked retinal areas. Artifacts marked with red arrows.

ULTRA-WIDEFIELD FUNDUS ANGIOGRAPHY AND OPTOMAP IMAGING IN CLINICAL PRACTICE

Available retinal imaging devices allow the assessment of 96 degrees of the fundus, which is no more than 45% of the retinal surface and therefore it is recommended to expand the diagnostics to include UWF [8].

Optos photography and UWF-AF can serve as one of the screening tests for many ocular conditions such as:

- diabetic retinopathy (DR);
- retinal Vein Occlusions (CRVO, BRVO);
- retinal Artery Occlusions (CRAO, BRAO);
- retinitis and chorioretinitis;
- tumors and nevi;
- other retinal pathologies (such as Coats disease, Eales disease, macroaneurysms) [17].

UWF imaging limitations

First of all, one of the disadvantages of the UWF imaging is low availability of the device. It is associated with high costs and therefore not every clinical center can afford it. The learning curve of the clinical specialists taking pictures is also important. There is no data

available on how many photos they need to take to become a professional. What is more, it is difficult to visualize superior and inferior zones because of anatomical limitations. Eyelashes, eye lids and nose are common artefact seen in the photographs (Figure 10) [7].

CONCLUSIONS

UWF fundus imaging allows the assessment of the retina and choroid far beyond the equator of the eye and is helpful in understanding the pathophysiology of vitreoretinal disorders. It is an excellent screening test to quickly assess both the central and peripheral retina in diseases such as diabetic retinopathy, uveitis, retinal vein occlusions and photoreceptor dystrophies. UWF-AF can show leakage, nonperfusion, and ischemia in both the macula as well as in the retinal periphery. UWF imaging is a useful tool for the examination, diagnosis and monitoring of ocular disorders. It can be added to ophthalmologic examination schedule and be helpful in selecting the appropriate therapeutic processes.

AUTHORS' DECLARATION

Study Design: Paulina Szabelska. **Data Collection:** All authors. **Manuscript Preparation:** Paulina Szabelska, Justyna Mędrzycka, Joanna Gołębiewska. The Authors declare that there is no conflict of interest.

REFERENCES

1. Anderson L, Friberg TR, Singh J. Ultraszerokokątne obrazowanie siatkówki i odwarstwienie siatkówki. Nasienie Oftalmol. 2007; 22: 43-47.
2. Choudhry N, Duker JS, Freund KB, Kiss S, Querques G, Rosen R, Sarraf D, Souied EH, Stanga PE, Staurenghi G, Sadda SR. Classification and Guidelines for Widefield Imaging: Recommendations from the International Widefield Imaging Study Group. Ophthalmol Retina. 2019; 3(10): 843-849.
3. Delori FC, Dorey CK, Staurenghi G, Arend O, Goger DG, Weiter JJ. In vivo fluorescence of the ocular fundus exhibits retinal pigment epithelium lipofuscin characteristics. Invest Ophthalmol Vis Sci. 1995; 36: 718-729.
4. Gawęcki M. Angiografia fluoresceinowa i indocyjaninowa: Praktyczny podręcznik. Gdańsk: KMG Dragon's House 2016.

5. Heussen FM, Tan CS, Sadda SR. Prevalence of peripheral abnormalities on ultra-widefield greenlight (532 nm) autofluorescence imaging at a tertiary care center. Invest Ophthalmol Vis Sci. 2012; 53: 6526-6531.
6. Khandhadia S, Madhusudhana KC, Kostakou A, Forrester JV, Newsom RS. Use of Optomap for retinal screening within an eye casualty setting. Br J Ophthalmol. 2009; 93(1): 52-5.
7. Kumar V, Surve A, Kumawat D, Takkar B, Azad S, Chawla R, Shroff D, Arora A, Singh R, Venkatesh P. Ultra-wide field retinal imaging: A wider clinical perspective. Indian J Ophthalmol. 2021; 69(4): 824-835.
8. Lotmar W. A fixation lamp for panoramic fundus pictures [author's transl]. Klin Monbl Augenheilkd. 1977; 170: 767-74.
9. Mackenzie PJ, Russell M, Ma PE, Isbister CM, Maberley DA. Sensitivity and specificity of the optos optomap for detecting peripheral retinal lesions. Retina. 2007; 27(8): 1119-24.
10. Mc Cannel CA. 2020-2021 Basic and Clinical Science Course, Section 12: Retina and Vitreous, American Academy of Ophthalmology. 2020; 29-39.
11. Quinn N, Csincsik L, Flynn E, Curcio C, Kiss S, Sadda SR, Hogg R, Peto T, Lengyel I. The clinical relevance of visualising the peripheral retina, Progress in Retinal and Eye Research. 2018; 83-109.
12. Saine P, Tyler M. Ophthalmic Photography. A Textbook of Retinal Photography, Angiography and Electronic Imaging. Boston, MA, Twin Chimney Publishing 1997.
13. Salmon J, Kanski JJ, Bowling B. Kanski's Clinical Ophthalmology; 9th edition, Elsevier. 2019; 558-568.
14. Sears CM, Hirano T, Nittala MG, et al. Ethnic variation in diabetic retinopathy lesion distribution. Invest Ophthalmol Vis Sci. 2018; 59(9): 468.
15. Silva PS, Cavallerano JD, Haddad NM, et al. Peripheral lesions identified on ultrawide field imaging predict increased risk of diabetic retinopathy progression over 4 years. Ophthalmology. 2015; 122(5): 949–956.
16. Spalton DJ. Atlas of Clinical Ophthalmology, 3rd edition, Elsevier Mosby. 2005; 408-412.
17. Turczyńska MJ, Krajewski P, Kęcik D, Kęcik D. Clinical application of the peripheral retinal angiography. Klinika Oczna. Acta Ophthalmologica Polonica. 2021; 123(4): 173-184.

18. Witmer MT, Kiss S. Wide-field imaging of the retina. Surv Ophthalmol. 2013; 58(2): 143-54.
19. Xu A, Chen C. Clinical application of ultra-widefield fundus autofluorescence. Int Ophthalmol. 2021; 41(2): 727-741.