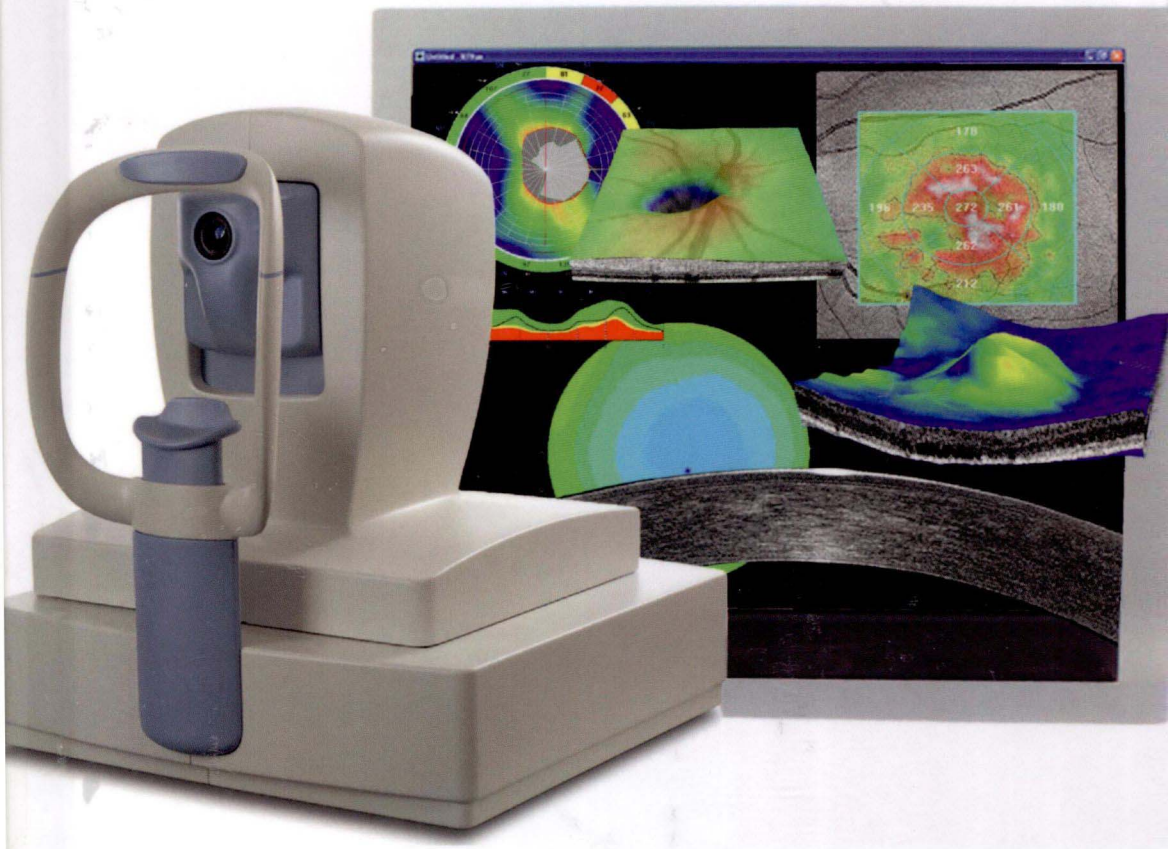
Optical Coherence Tomography

Steven Gray



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Preface

This book presents the state-of-the-art information regarding optical coherence tomography. Optical coherence tomography (OCT) is an imaging technique providing high-resolution cross-sectional images in several fields of engineering and medicine. OCT images are created by measuring the intensity of reflected or back scattered light which is scanned across the tissue and material. The aim of this book is to present elaborative information on OCT in a wide spectrum of fields including oncology, engineering, ophthalmology and atherosclerosis.

The researches compiled throughout the book are authentic and of high quality, combining several disciplines and from very diverse regions from around the world. Drawing on the contributions of many researchers from diverse countries, the book's objective is to provide the readers with the latest achievements in the area of research. This book will surely be a source of knowledge to all interested and researching the field.

In the end, I would like to express my deep sense of gratitude to all the authors for meeting the set deadlines in completing and submitting their research chapters. I would also like to thank the publisher for the support offered to us throughout the course of the book. Finally, I extend my sincere thanks to my family for being a constant source of inspiration and encouragement.

Editor

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Chapter 1

B-Scan and 'En-Face'Spectral-Domain Optical Coherence Tomography Imaging for the Diagnosis and Follow-Up of White Dot Syndromes

Benjamin Wolff, Alexandre Matet, Vivien Vasseur,
José-Alain Sahel and Martine Mauget-Faÿsse

Additional information is available at the end of the chapter

1. Introduction

The term 'white dot syndromes' (WDS) refers to several inflammatory diseases of the retina and choroid caused by immune dysregulation. They consist of the following disorders, with overlapping clinical features:

- Acute posterior multifocal placoid pigment epitheliopathy (APMPPE)
- Serpiginous choroidopathy
- Multiple evanescent white dot syndrome (MEWDS)
- Birdshot retinochoroidopathy
- Acute retinal pigment epitheliitis (ARPE)
- Multifocal choroiditis and panuveitis syndrome (MCP)
- Punctuate inner choroidopathy (PIC), and
- Acute zonal occult outer retinopathy (AZOOR)

These conditions usually occur following an influenza-like illness, but their patho-physiologic mechanism remains poorly understood. The white dot syndromes affect more frequently young females and individuals with mild myopia, and present as white or yellow, deep, round lesions in the central fundus. Their size and number can vary between each entity, as well as their uni- or bilateral involvement.

In addition to these clinical parameters, fluorescein (FA) and indocyanine green angiographies (ICGA) help in identifying the diagnosis [1]. They also help assess the level of inflammatory activity and detect complications.

The high resolution of the scans generated by Spectral Domain Optical Coherence Tomography (SD-OCT) offers a helpful tool in the management of WDS. SD-OCT allows a direct, non-contact visualization of involved retinal layers and thereby provides information concerning the:

- accurate location of the inflammatory process
- integrity of the photoreceptors inner segment / outer segment junction (IS/OS)
- course of the inflammatory process, leading to resolution or residual scarring
- presence of complications such as neovascularization

Moreover, the use of 'en-face' OCT for WDS allows a layer-by-layer view of the involved retina. This novel imaging technique generates frontal scans derived from SD-OCT.

The scans of "en face" OCT imaging of WDS were obtained by Spectral-domain OCT (Spectralis® Heidelberg Engineering, Heidelberg, Germany). For every case, the macula was analyzed using SD-OCT (Spectralis® Heidelberg Engineering, Heidelberg, Germany) and macular mapping consisting of 197 transverse sections in a 5.79 x 5.79 mm^2 central retinal area. Tridimensional reconstruction generated by the pooling of these sections provides a virtual macular brick, through which 496 shifting sections in the coronal plane result in the C-scan, or "en face" OCT.

In contrast, B-scans for conventional OCT are derived from sagittal and transverse sections. Enhanced depth imaging OCT (EDI-OCT) is a new tool that improves the sensitivity of the imaging in deeper layers of retinal tissue. The visualization of the choroid is increased and thus the obtained measurements are more accurate.

For each condition belonging to the WDS, we compared the results from SD-OCT "B-scan" and 'en-face' with data from classical retinal imaging, namely fundus photography and angiography.

2. MEWDS, Multiple evanescent white dot syndrome (figure 1)

MEWDS typically affects young females, and presents as a sudden visual loss with paracentral scotomas. In 80% of cases the condition remains unilateral. Fundus examination reveals small, discrete perifoveolar dots, very mild vitritis, and, in some cases, papillitis. On fluorescein angiography these dots appear hyperfluorescent, but are hypofluorescent on ICGA. The natural history leads usually to complete and spontaneous resolution within weeks.

- SD-OCT at the acute stage identifies the lesions in the outer retina as hyperreflective thickened lesions of the inner segment/outer segment (IS/OS) junction, alternating with

disruption of the IS/OS junction [2]. Small highly reflective dots involving the RPE inner layer, the IS/OS junction and the outer nuclear layer can be observed. EDI-OCT frequently demonstrates choroidal thickening.

- 'En-face' OCT shows multifocal involvement in the plane of the IS-OS junction, consisting of various round hyporeflective lesions alternating with large hyperreflective areas. Centrally, they may appear as confluent, which explains the "moth-eaten" appearance of the macula in some cases. Hypofluorescent spots on ICGA and IS-OS disruption zones on 'en-face' OCT are well correlated [3]. This correlation is also observed between SD-OCT B-scans and ICGA.

During follow-up, a progressive and complete restitution of outer retinal layers is observed. This observation is correlated with functional resolution [4]. However, focal gaps in IS/OS junction may persist in some cases and are associated with central visual field defects.

3. Acute posterior multifocal placoid pigment epitheliopathy (APMPPE) (figure 2 and 3)

In this bilateral, often asymmetrical condition, that presents in healthy young adults, with both male and female being affected equally, fundus examination reveals yellowish-white plaques of 1 to 2 disc diameters, scattered from the fovea to the equator [5]. They may be associated with mild vitritis. Their FA appearance in the acute stage is pathognomonic: early blockade hypofluorescence, followed by late hyperfluorescence caused by staining. ICGA shows multiple lesions that may be confluent, and that remain hypofluorescent during all angiographic stages.

In the acute stage, SD-OCT shows:

- On B-scan: hyperreflective lesions in outer retinal layers, some extending to Henle's fibers layer. Irregularities in IS/OS, external limiting membrane, and inner pigment epithelium layer are also visible around those highly reflective lesions [6]. In the acute phase, an elevation of the IS/OS junction with subretinal fluid located between this layer and the RPE may be observed. In severe cases, this hyporeflective space between the IS/OS and external limiting membrane can mimic an encapsulated serous retinal detachment. Hyperreflective intrachoroidal spots are seen on EDI mode, suggesting choroidal inflammation.
- On 'en-face' OCT: the extent of the selesions, located in the external nuclear layer, are well defined. These lesions perfectly match the hypofluorescent plaques seen on ICGA. In severe cases with encapsulated serous retinal detachment, 'en-face' OCT reveals a wide hyporeflective lesion with hyperreflective borders. These large hyporeflective lesions may contain tiny reflective deposits.

In the late stages, SD-OCT shows:

- On B-scans: retinal thinning with disruption of the IS/OS and inner pigment epithelium, located where hyperreflective lesions had been observed. Irregular or focal gaps in external

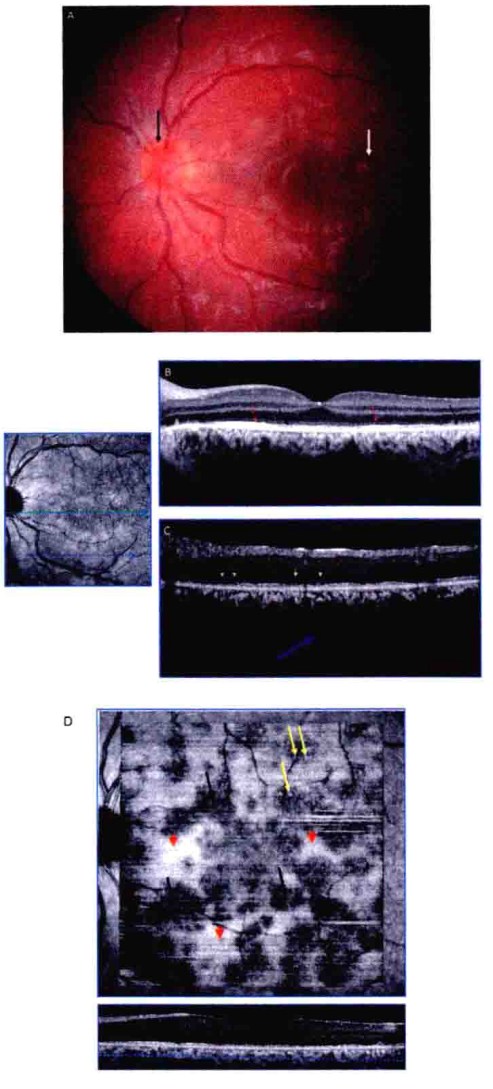

Figure 1. MEWDS.a) MEWD acute phase: color fundus photography. Unilateral (Left eye) discrete perifoveal dots (white arrow) with light papillitis(black arrow), b) MEWDS acute phase: SD-OCT B-scan. Visualization of large IS/OS segment disruptions (black arrow) in the posterior pole, mostly in the foveal region, alternating with few focal, highly hyperreflective, thickened IS/OS zones (orange arrows). c) MEWDS acute phase: SD-OCT B-scan. Tiny hyperreflective elevations (spicules) (yellow arrows) visible in the areas with IS/OS disruption. Note the significant choroidal thickening (blue arrow).d) MEWDS acute phase: En Face OCT. Multifocal involvement in the plane of the IS-OS junction, consisting of various round or oval coalescing hyporeflective lesions (black arrows) corresponding to areas of disrupted IS/OS junctions seen on B-scans, alternating with large hyperreflective areas (orange arrows). The « spicules » are imaged as very small hyperreflective spots (yellow arrows) within the hyporeflective zones of IS/OS junction disruptions.

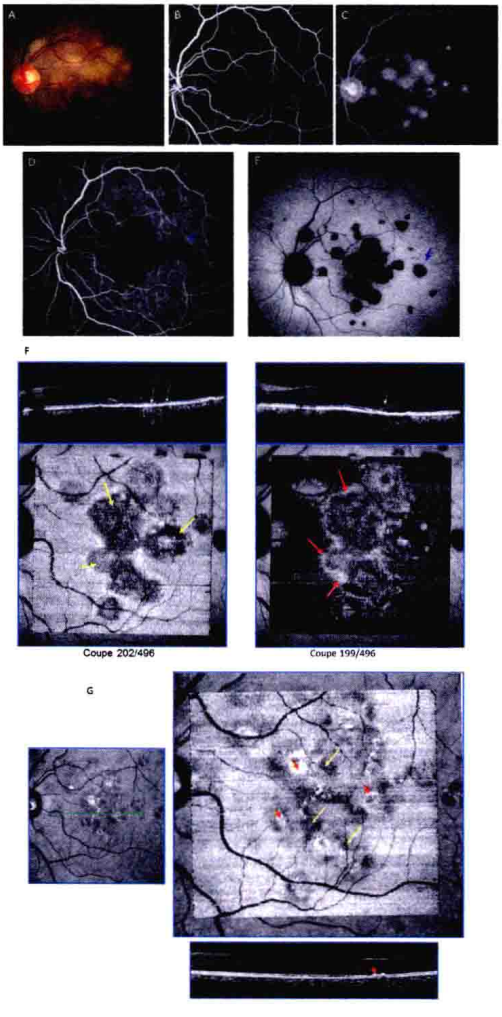

Figure 2. AMPPE.(a-e). AMPPE early phase: a: AMPPE typical presentation with yellowish-white plaques of 1 to 2 disc diameters, scattered from the fovea to the equator on color fundus photography. FA appearance in the acute phase is pathognomonic with early blockade hypofluorescence, (figure 2b)followed by late hyperfluorescence phase (figure 2c). ICGA shows multiple lesions that may be confluent, and that remain hypofluorescent during all angiographic phases (early phase: figure 2d) and late phase (figure 2e). f) AMPPE early phase: SD-OCT B-scan both images. Top: Hyperreflective lesions in the outer retinal layers, some extending to Henle's fibers layer. Irregularities in the IS/OS, external limiting membrane, and inner pigment epithelium layer are seen around the hyperreflective lesions (white arrows). Bottom: En face OCT. Left: Visualization of the hyporeflective lesions corresponding to the alterations in the IS/OS junction (yellow arrows). Right: Hyperreflective band within the outer nuclear layer (orange arrows) surrounding the hyporeflective lesions (corresponding to hypofluorescent spots on ICGA).g) AMPPE late phase.Left: SD-OCT B-scan. Areas of irregularly thickened pigment epithelium (orange arrow). Right: En face OCT. These irregularly thickened areas of pigment epithelium are visualized as hyperreflective zones (orange arrows).Hyporeflective areas are due to previous IS/OS junction involvement (yellow arrows).

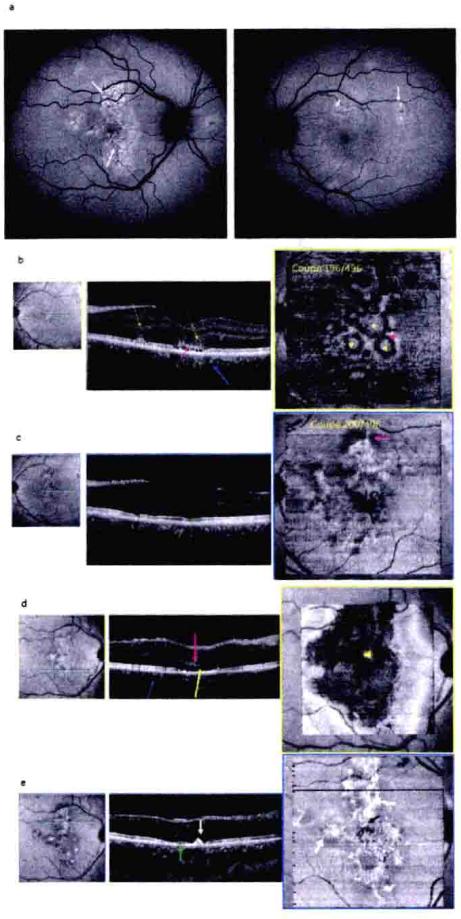

Figure 3. AMPPE.a) AMPPE early phase of a more severe case. Autofluorescence images: Irregular autofluorescent areas in both eyes (white arrows). b) AMPPE early phase, left eye. Left: SD-OCT B-scan. Hyperreflective lesions (yellow arrows) in the outer retinal layers, extending to Henle's fibers layer. Irregularities in the IS/OS, external limiting membrane, and inner pigment epithelium layers are visible around the highly reflective lesions. Subretinal fluid is observed located between the IS/OS junction and the RPE (pink arrow) as well as hyperreflective small spots within the choroid (blue arrows). Right: En face OCT. Round or oval coalescing moderately reflective lesions (yellow arrow head) bordered by a hyporeflective band (black arrows) located inside a hyperreflective area (pink arrow head). c) AMPPE late phase. Left: SD-OCT B-scan. Thinned IS/OS junction areas and RPE irregularities (green arrows) Right: En face OCT. Global improvement at the IS/OS junction plane with scarring represented by hyper- (pink arrows) and hyporeflective areas (black arrows) d) AMPPE early phase. Left: SD-OCT B-scan. Severe alterations of the whole outer retina (pink arrows) with IS/OS segment disruption (yellow arrow) and hyperreflective spots within the choroid (blue arrow). Right: En face OCT. Scan at the level of IS/OS segment plane: extensive hyporeflective lesions (yellow arrow head) corresponding to IS/OS segment disruption. e). AMPPE late phase. Left: SD-OCT B-scan. Outer retinal scar represented by alternation of thinning (green arrow) and thickening (white arrow) of the IS/OS and RPE tissues. Right: En face OCT. Global improvement at the IS/OS plane with the association of hyperreflective (white arrows) and hyporeflective areas (black arrow) of the scarring process in the IS/OS and RPE complex.